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Creating Learner-Centered, Multidisciplinary Lessons from Scientific Articles:

A Training Manual for Teachers

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Cover Photo by Bob Hedlund

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Involving Children in Science and Making it Fun

The purpose of this manual is to provide a template and supporting information to help teachers translate scientific information into effective and fun lessons for students. Our manual includes information on how to incorporate scientific inquiry in the classroom, a template for creating a unit of lessons from a scientific article, and example lesson plans that illustrate the process described in the template. These lesson plans are based on SANREM CRSP research that has been summarized in the form of Research Briefs: short, non-technical summary 'articles' (see Appendix III).

We hope that the material in this packet can be used in a variety of educational settings and geographic locations. We stress that the lessons presented are *examples*; they have not been written to the curricular/education standards of any particular locale. The example lessons may be replicated by teachers but may not be appropriate in all cultural contexts; therefore, they should be modified to better reflect the local conditions and culture in which the teacher is working.

One of the assumptions of the authors is that students who enjoy exploring and observing their surroundings, and connecting what they think will happen with their observations (**science**), will likely become good problem solvers and decisions makers. The lessons and background information presented in this packet focus on *some* of the problems that tomorrow's decision makers might face – mainly those associated with natural resource management (NRM).

The template and lesson plans presented in this packet are an attempt to make it easier for teachers to involve students in science in a way that is fun and fulfilling (additional lessons to test student questions can be found in Appendix VII). The template will guide teachers in creating units of lesson plans based on scientific articles or reports

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(examples of scientific documents are given in Appendices III and V). Since a large portion of these lessons is guided by student questions it is important to remain flexible in creating actual lesson plans. Introductory lessons that encourage observation, questioning, and discussion and are based on standards that teachers are required to teach can be planned ahead of time. Once students develop questions to drive further investigation it is up to the teacher to work with the students' interests.

Some basic principles and concepts about natural resource management are presented in Appendix I of this manual. In Appendix II, we briefly introduce additional concepts, ideas, and working examples of models and lesson plans that helped to shape this project. The materials in these appendices may be used to aid in the development of other natural resource management lessons or to spur classroom discussion.

scientific method: a way to organize observations and direct inquiry in order to more easily and accurately find answers to questions

How can we teach hard science without making it harsh science?

The initial draft of the example lesson plans included in this manual was reviewed by a number of education experts from developing countries and the United States (see Appendix IV). Some feedback that we received is that the **scientific method** is too difficult and advanced for primary grade students in developing countries, and that using the scientific method is primarily a 'western' way of observing the world and solving problems. Although this is a common and sometimes accurate perception, it does not have to be true. While the scientific method *is* widely taught in the 'western' education, it need not replace local knowledge or learning styles. Rather it should complement these valuable resources by encouraging questioning and consideration of multiple points of view. As educators, it is important that we do not downplay the importance of cultural diversity by imposing one way of thinking. All cultures are different from one another and therefore have valuable, individual resources to offer. Instead, we should aim to provide a variety of teaching and learning tools to help broaden students' perspectives. The scientific method is just one of these tools.

Quite simply, **observation** is the key to unlocking the mysteries of science, and **science** is the comparison of what students look for and what they actually find. Children are naturally inquisitive, and the **scientific method** is one process to help them to organize their observations and direct their inquiry in order to more easily and accurately find answers to their questions. Facilitating this structured inquiry

requires flexibility and creativity on the part of the teacher. It does not, however, require that the teacher be an expert in any scientific field.

The scientific process: Creating learner-centered, multidisciplinary lessons from scientific articles

> The natural world, and its interactions with local social systems, provide a wide array of opportunities for ***observation.***

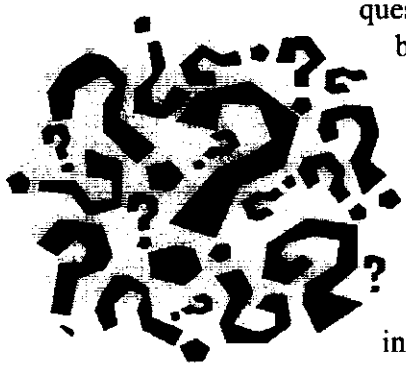
The following information will help you to better understand the template provided at the end of the Introduction.

As it is important to value the ideas and methodologies of different cultures, it is also important to value the same in an individual child. Rather than looking at a student as a blank page that needs to be filled, a teacher can instead draw from what the student already knows (before engaging in classroom lessons). In fact, no student is a blank page. All children have a wide array of beliefs and understandings that they have developed through their life experiences. Drawing *first* from students' existing knowledge will help them value what they have already learned from their culture, community, and family, and this will build their confidence and increase their desire to learn more.

One way to draw from what students already know and provide them with a sense of ownership in what they are about to learn is to present students with what will be observed and allow *them* (and their interests) to drive scientific inquiry. This can be done while meeting curriculum standards, maintaining order in the classroom, and incorporating the scientific method (process).

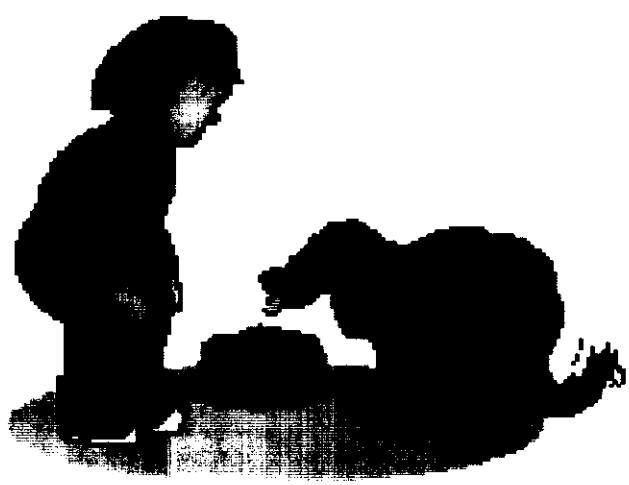
Observation is the first step in the scientific process. The natural world, and its interactions with local social systems, provide a wide array of opportunities for observation. To maintain adherence to curriculum standards this observation needs to be structured. For example, a teacher who needs to lead a lesson in the effects of different weather types on rocks will need to direct student observation in that specific direction. To do this, teachers may wish to develop a broad-based 'essential' question that defines and directs students to the main point of the study (i.e. *What happens when a rock is exposed to weather?* or *How does weather affect a rock?*) and then encourage students to make their own observations. The teacher should allow students to discover and draw conclusions without interjecting his or her personal opinions or prior knowledge.

After considering the essential question and observing interactions between natural and social systems in the local community, students will naturally develop additional questions (these questions may come easy to some students while others made need to be encouraged to ask them). **Questioning** is the second step in the scientific method. Student questions should be about the topic stated in the essential question but may include aspects of each student's personal interests. It is likely that many students in the class will come up with the same or very similar questions and can therefore work in groups to determine the answers to their questions. These questions can guide in-depth learning activities and lessons in which students determine the answers to their questions. By following the steps of the scientific method students will have ownership of their investigation questions and will have increased incentive for further study. Teachers can anticipate many student questions ahead of time and prepare lessons accordingly. This method of teaching requires that the teacher allow for flexibility in lesson plans and is familiar with resources available for addressing student questions. The example lessons presented in this manual, and the template for creating lessons, provide an example of how teachers can guide students through this observation and inquiry process.



Once students have developed questions it is important for them to determine what factors they would like to test. This is done by making a **hypothesis**. At this point many of you readers may be sighing, *"Ugh. A hypothesis. Surely primary school students cannot form a hypothesis."* However, forming a hypothesis is easy; it is a matter of determining what you are expecting as an answer. In many ways it can be compared to an assumption, or an intuitive response. Students older than the age of seven can generally reason enough to determine what they expect as an answer. As children grow they will refine their skills and provide more realistic, detailed, and testable hypotheses. One way to familiarize students with making hypotheses is to ask them to make guesses on a regular basis. Encourage them to guess about how many objects there are in a jar, or to guess the answer to a question based only on what they already know. Let students know that they do not have a limited number of guesses. That way they can learn from the guesses that were not correct. A wrong answer is a good answer in that it can be eliminated, and then the guesser is one step closer to a correct answer.

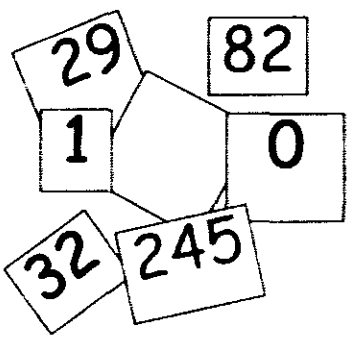
The step that is often perceived to be most difficult in the scientific method is designing a way to **test** a hypothesis. This does not need to be difficult, and for younger students it is not necessary for test methods to be completely flawless. The most important thing is that students understand that they *can* test a hypothesis and draw a conclusion.



Children have experience observing and testing as a regular part of their play. For example, a child may see a dog and wonder what would happen if s/he were to hold food out to it. The test is the act of holding the food out and seeing what happens. For the child to test a hypothesis s/he would have to state her/his expectations ahead of time. The child might expect the dog to come nearer when s/he holds out the food; this is the hypothesis. After holding out the food (the test) the child will discover the difference of what was expected to happen and what actually did happen.

As students learn they should be encouraged to recognize sources of **error** in tests. For example, in the test with the dog there are other factors that may have influenced the dog's behavior. Rather than coming closer because the food was held out, the dog may have come closer because it wanted to be closer to an object next to the child, such as the dog's water bowl. By repeating simple experiments like this one some of the error can be eliminated. The more times the experiment is run and the more times a result is demonstrated, the more likely it is that the result seen is a true explanation for why the dog is approaching the child. For example, if every time that the child holds out food to the dog, the dog approaches and sniffs or eats the food, then the child can be confident that the dog was coming close because s/he was holding out food.

By considering all of the possible factors that influence a situation students can learn to anticipate error ahead of time and to eliminate variables (or influencing factors) that might give an experiment poor results. For example, an older student might hypothesize that plant growth is affected by exposure to light. Plant growth is the variable that will be tested, and this growth will be related to light exposure. In an experiment to test this hypothesis, two trays of seeds can be planted in soil and set in a warm, dark place to grow. The first tray of seeds will receive no light throughout the experiment; this is called the **control group** because all factors/variables are controlled for and remain constant throughout the duration of the experiment. The second tray holds the **experimental group** of seeds, and this tray will be exposed to different amounts of sunlight. By duplicating all of the variables except one (in this case, amounts of sunlight) the student can be more certain that the change in plant growth is caused by a difference in exposure to sunlight and not to any other factor which may also influence plant growth (such as water availability or soil type).



By completing experiments and being encouraged to think about sources of error or other factors that can influence experiment results students will gradually design experiments with more accuracy.

Once students have tested a hypothesis they will need to determine what actually happened and if these results are what they expected; they need to **draw conclusions**. As with designing a test

for a hypothesis, this step can also become more complex as students reach higher grade levels. In simple tests run only one time (for younger students), a student can easily determine if what s/he expected to happen actually did; in the dog example it is easy for the child to test a hypothesis and draw a conclusion (i.e., what happened when s/he held food out to the dog). For older students, if this test was applied multiple times (to eliminate some sources of error) the student could determine what actually happened based on the number of times the dog did what was expected compared to the number of times the dog did not do what was expected. This is a great place in the scientific process to integrate math and graphing skills. As students become more advanced in making and testing hypotheses, they may naturally be drawn to **quantify** (i.e., use numbers to determine or explain) their results. For instance, every time the dog did what was expected a score of 1 could be marked, and when the dog did something unexpected a score of 0 could be marked. These scores could be added up and divided by the number of times the test was performed to determine an average number of times the dog did what was expected. By quantifying data students are using another "language" to analyze what they are observing. This will allow them to see patterns that they may not have otherwise noticed. Graphing is a way for students to visually analyze information and look for additional connections and patterns. Graphing techniques are discussed within the example lessons provided. Once conclusions are drawn, students can revise their experiment and re-run it, or use their conclusions to form new hypotheses.

Service learning is a common way to integrate the local community in student education while simultaneously improving the community.

The scientific method can be a useful tool for student learning. However, it should not be taught as the one and only way to collect and analyze information. Students should be encouraged to draw from additional sources of knowledge and to think critically about what they are learning. Just as they are asked to think of questions in the beginning of the scientific process, they should be encouraged to continue to think of questions throughout the process. Likely they will have more questions than answers when they are finished.

Making decisions when there are more questions than answers may seem like a daunting task to some students. Yet through investigating the world around them students will likely find a number of connections that they had not considered before. For instance, students may be aware that a polluted stream can cause sickness for those that drink its water. They may have also found through investigation that most pollution in a particular stream comes from soil washing away from a pig farm and into the stream. By understanding the links between the pig farm, the stream, and human illness, students will be better able to take appropriate actions to solve the problems at hand. For instance, trees could be planted between the pig farm and the stream to catch more of the water that enters the stream during a rainstorm. As more detailed information is learned, such as the specific bacteria in the water that is causing people to be sick, actions can be adapted to better suit the problem. If it was learned that the bacteria that contaminated

the stream could be killed by boiling the water, people downstream could be advised to boil their water before drinking. The key in allowing continued adaptation of solutions to problems is the continued questioning of the solution; students should learn to continually ask questions and to monitor the progress of their decisions (see Appendix IIA).

During investigations students may come up with good ways to help solve community problems, such as too much littering or ways to clean up a local river. Implementing these actions can become an additional learning experience for the students. Employing student ideas will also help students to feel confident and to understand that they can make a difference. **Service learning** is a common way to integrate the local community in student education while simultaneously improving the community. Service learning provides both services to the community as well as appropriate learning activities to the service provider (i.e. the student). Objectives and goals of service learning projects are developed collaboratively by community partners and service recipients to answer real community needs (see Appendix IIB for more information on service learning).

Teachers should assess student learning based on the standards taught as well as the students' personal understanding. Did the student sufficiently answer the question that s/he asked? What else did the student learn during the process? Examples of more in-depth techniques for assessment are listed in the example lesson plans. These assessments are only guidelines and should be modified to better assess specific curricular standards that were met through this activity. Teachers can also use these student assessments as a means to evaluate their teaching abilities on these new topics.

A well-prepared teacher will be able to expect the questions that students generate

with (as well as the resources available for addressing these questions) ahead of time. Regardless of the amount of teacher preparation, however, student learning will take place when students are allowed to observe and be 'wowed' by the world around them. If they are interested and amazed but what they observe, and are encouraged to discuss their observations, they are more likely to care about and to want to learn about what they see. Cultivating this sense of wonder will encourage students to continue learning and to develop environmental ethics that are in line with the students' experiences.

The template provided in this manual was created with the above concepts in mind. To summarize:

* The world is made up of natural and social systems that continually interact. These interactions between humans and nature can be observed every minute of the day, and they form the complex world around us. If a change occurs in one system, then the the other system is affected as well. Therefore, to study only one of the systems without the other would provide only part of the story.

* Allowing students to observe and be 'wowed' by the world around them is crucial to engaging children in science. If they are interested and amazed by what they observe, and are encouraged to discuss their observations, they are more likely to care about and to want to learn about what they see. Sometimes even the simplest occurrence, such as a bird building a nest or a tiny whirlpool of water forming in a stream, can lead to the most interesting and engaging questions and lessons.

* There are aspects of scientific research that are naturally interesting to students, and developing lessons based on these points of interest will generate further inquiry and desire to learn within students. This puts students at the center of learning. Building on their existing knowledge and allowing them to test their questions will help increase students' confidence in their knowledge and abilities to engage in scientific inquiry.

* Lessons developed based on students' interest can meet curricular standards of different subject areas. This can be done in the context of the natural and social systems included in the scientific document that you read while maintaining the interest of students and order in the classroom. Meeting these standards will require some flexibility and creativity on your part as these lessons will not likely be standard ones, but with a little extra thought and preparation, you should find that you can create the lessons to meet *your* goals as well as *students'* goals.

* Scientific research can be applied in a local context. The research that teachers read about may have been conducted in a geographic location far away, but the results of the research can be applied at home to make positive changes in a local community. The same can be said for the class lessons that you create from student inquiry.

* Remember, scientific research can lead to important discoveries, many of which can be beneficial to humans, plants, and animals. Testing questions that students have about their observations may lead to some exciting results that should not be regarded as unimportant just because they are from a class experiment. Scientific discoveries have to start somewhere, and your class may be able to apply the results that they uncover to benefit your local community.

This endeavor took multiple forms and attempts over the past year. Through trial and error, we developed and complied a number of materials as they related to training educators in learner-centered education methodologies as well as specific subject areas of natural resource management. Appendix VI provides some of these materials.

The next page illustrates a template that can be used to create learner-centered, multidisciplinary lessons from scientific articles or other documents. The template has been formulated to lead you through a series of steps that will help you generate lessons (from scientific documents) that introduce basic principles of natural resource management. Each step is followed by a series of questions that should be answered before moving on to the next step. If you are not familiar with creating lessons that are learner-centered or multidisciplinary, this template may take you some time to work through. It will also require you to be flexible and creative as you will be allowing students' interests to guide scientific inquiry. Allowing students to explore their interests while meeting curricular standards is sure to be a rewarding experience for both you and your students.

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Creating learner-centered, multidisciplinary lessons from scientific articles
A template for teachers

1. Read a scientific article and answer the following questions:
a) Are there any aspects of this research that make it naturally interesting to students?
b) Which curriculum standards can be taught in the context of the natural and social systems included in the research?

- If the answer to question a) is yes and you are able to determine curriculum standards can be taught in the context of the natural and social systems included in the research [question b)], continue to Step 2.
- If the answer to question a) is no OR you are not able to determine curriculum standards can be taught in the context of the natural and social systems included in the research [question b)], chose new scientific articles until you can continue to Step 2.

2. Answer or complete the following:
What was the main question/inspiration of the research?
Why was it important to answer this question?
What was the hypothesis?
What methods did the researchers use to answer the question?
What were the conclusions?
How can these research conclusions be applied in a local context?
Work with other teachers to include standards from varying subjects.

2a. The world is made up of natural and social systems that continually interact. Determine the natural and social systems that were explored in the research (i.e. the river ecosystem and the human health care system).
How do these systems interact?
What are some issues that arise from these interactions?

3. Develop a broad, "essential" question to be presented to and explored by the students. Base it on the interactions between the natural and social systems covered in the research brief and the curriculum standards that you would like to teach (i.e. How does the river ecosystem affect human health?).

4. Determine how you will introduce the essential question to students (i.e. tell a story about the research, take a walk to explore land use in an area, take simple measurements that are relevant to the question, etc.) and help them develop more specific questions of their own. Consider community resources that are available (i.e. land forms, people, information) that will help you to complete this step. Develop lessons to introduce the essential question and to facilitate student questions while meeting curricular standards.

5. List the specific questions that the students may come up with in response to the essential question.

6. Prepare a general plan to help students address their questions (actual projects should be determined by the students based on their questions). If you choose the scientific method, consider the following:
How will you facilitate the formation of hypotheses?
How will you help students to design an experiment?
What methods are available? What methods are most useful in the current circumstances?
What type of results might be generated?
How can the results be analyzed? Can these results be compared to the research results?
How will you help students reach a conclusion?
How can the information learned be applied in a local context?

7. Consider and list possible service learning projects in which students can take part to apply the knowledge that they gained during their investigations (actual service learning projects will be developed with the students' input).

8. Determine a method for assessing the students' mastery of the material and of the standard/s that was/were taught through this activity.

Exploring the Waters: Unit Overview

In this unit students will explore how water, a vital natural resource, can become polluted and how it can be protected.

The lessons provided in this unit were designed to build upon students' current knowledge and understanding of water quality. These lessons are examples of ways to help students take their knowledge one step further and see how it connects with new information. The lessons and assessment guidelines may need to be modified by teachers to better fit the needs of their class size, local culture, materials available, and learning environment (when possible, ways to modify activities are suggested).

To begin the unit, students explore an essential question (a broadly-focused question that is essential to the theme of the unit) through a combination of observation and measurement activities. Based on their observations and previous knowledge they will then formulate questions that will lead to further inquiry. These questions reflect students' interests about the topic of study.

Teachers can structure this student-generated inquiry by using the provided template and background information on the scientific method to create lessons that will help answer student questions. The lessons provided under *Activities to Address Student Questions* are examples of what lessons may look like.

Although teachers provide the general structure for inquiry activities, using *students'* questions for further investigation will enable them to combine previous knowledge that is valuable to them with new knowledge that they hope to gain. By helping students learn about topics that are interesting to *them*, they will gain a sense of ownership in what they are learning and will be more open to and excited about learning. The results of this synthesis will also help students to make more informed decisions about managing their natural resources (in this case, water).

Unit Outline

Essential Question: How is water quality affected by what we do and how does water quality affect our lives?

Ask your students this essential question and then talk about possible answers. Write the answers in a place where students can see them (or have students come to the board and add their words and answers; you can be in the background as a facilitator). Explain to students that in order to further answer the question, they will complete some observation activities. These activities will also help them to create more questions about water quality.

Observation activities to introduce the essential question

What We Know About Water
As a class, students will review the water cycle and discuss what they know about water, what they are unsure of about water, and what they do not know about water.

Story: The Muddy Water Police
Students will read about a project in which community members worked with scientists to measure water quality in a watershed in the Philippines.

What is a Watershed?
Students will build a model of a watershed using a piece of paper.

A Walk in a Watershed
Students will create a map showing land use in a local watershed. Students will observe and make note of the land use on a walk through the watershed.

During the completion of these introductory activities students will be thinking of and recording questions that they develop about the interactions between the water system and the social system in the local community. Students will choose their favorite question, write it on a slip of paper, and hand it in to the teacher.

Guidelines for questions

Teachers may wish to write all of the questions on the board so that the students may see them, compare them with other student questions, and know when their question has been addressed.

Teachers should place all of the questions on their desk and group the questions that are similar. Students with similar questions can work together in a group. One of the objectives of the next activities should be to address all of the students' questions.

Example activities to address student questions

A Water Watch
Students will follow the scientific process to answer physical, chemical, and biological questions about a body of water near their school. This lesson provides students with several tests that use the scientific method and that will help them to answer their questions about water quality.

Interview a Community Member or Elder
Students will use knowledge of people in their community to answer questions about existing water laws, how and why these laws were made, and who made them, perceptions about water quality, and /or the history of land use and water quality in the watershed.

Once students have explored the topic of water and their surrounding watershed and have found answers to their questions by using one of the methods suggested above or one of their own, they will be ready to apply what they have learned on a larger scale: in their community.

Ask your students what they consider to be the biggest problems with keeping water in their local community clean. What problems do they think are the most important? With their input, create a list of projects that the students could complete to protect water quality in their local communities. Help them choose one to start. Support their learning process by encouraging them to become involved in all aspects of setting up and completing the project.

Possible Service projects to improve water quality

*Plant trees along a stream bank to help slow down the rate of erosion
*Educate community members about steps to take to prevent getting sick from unhealthy water
*Educate the community about the importance of water quality and ways to protect water quality
*Create a pamphlet about the importance of planting crops along the contours of a hill

Once students have completed this unit, conduct an assessment to determine the level of understanding that they have gained. In the assessment, ask students to review the essential question and write an essay on the topic. To test their understanding of the scientific method, have students design an experiment that will answer a question about a topic similar to water quality. Include any local curriculum standards that need to be addressed. More information about assessment, along with suggested guidelines for evaluating student work, can be found after each activity.

What We Know About Water

Student age: Upper Primary/Early Secondary/Secondary
Location: Classroom
Objectives: Learners will:
1. determine what they know about water, what they are unsure of about water, and what they do not know about water

MATERIALS

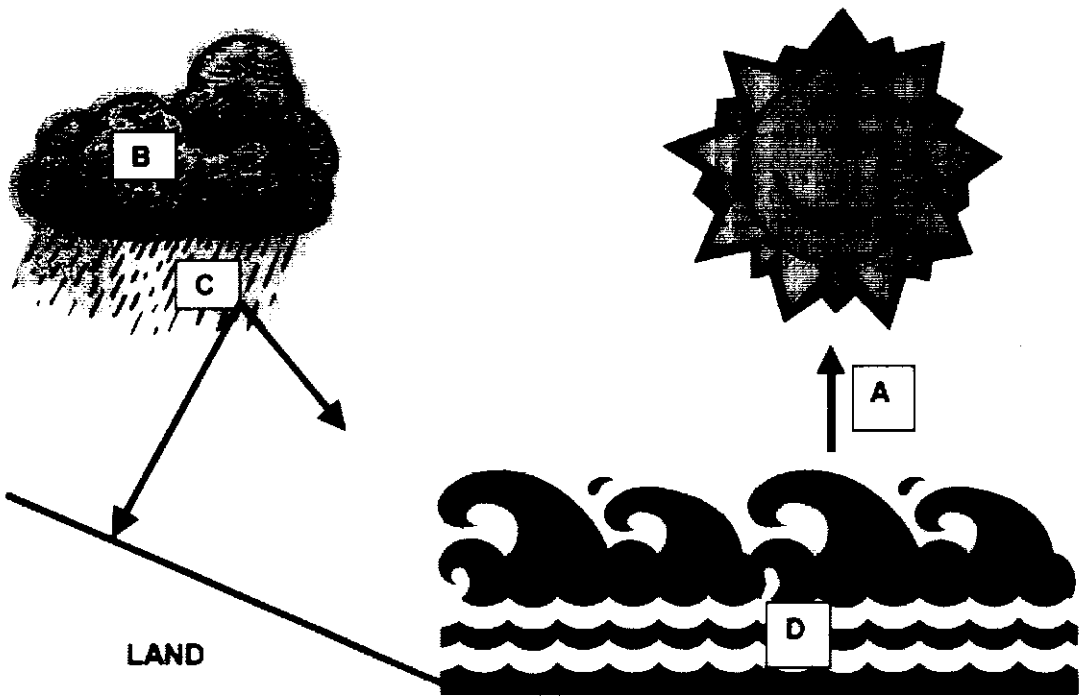
*clear glass
*water
*something on which to write student questions

Background Information: Water is essential to the lives of most living organisms. Humans use water for many purposes: drinking, bathing, cleaning, cooking, transportation, and raising animals, just to name a few uses. Other species use water as a vital part of their lives as well. Plants need water to grow, mammals and birds need water to drink and bathe, and fish need water for a home.

Before water gets to our faucet or pipe, it comes from somewhere else! Water can be found in many places such as rivers, streams, lakes, ponds, oceans, wetlands, and even small puddles. It also comes from the sky as rain, hail, or snow. But how come we can see it in both places? This is because of something called the **water cycle.**

Before you begin any of the activities, you may wish to review the water cycle (illustration on next page):

The water cycle has four main stages. The first stage is **evaporation** (A): when the sun warms a body of water such as a lake or ocean



and turns some of it into steam. That steam leaves the water and travels up into the air. Once the steam is in the air, the next stage can take place. The steam eventually gets cold from the air and changes back into liquid. This causes clouds to form and is called **condensation (B). Precipitation (C)** is the third stage, and it occurs when there is too much water that has condensed for the air to hold. This makes the clouds heavy, so water falls back to Earth as rain, hail, or snow. The rain may enter the lake or ocean from where it came, or it may fall on land. If it falls on land, it will soak into the ground and become part of "ground water" that plants and animals use for drinking or bathing. It may also run across the land and **collect** in the lakes or oceans (**collection (D)** is the last stage of the water cycle). When this happens, the cycle starts over again.

When water becomes polluted (dirty) with large amounts of dirt, chemicals, or manure, it creates a harmful environment in which to live, and the water also becomes unhealthy for humans to consume or use for bathing, cleaning ,etc. Some of this pollution may come from humans throwing trash into water, oils and chemicals from cars, chemicals sprayed on vegetables and other crops grown in gardens and on farms, chemicals from big factories, livestock manure that washes into the water, and many other places.

A lot of dirt and trash in water will slow water flow, sometimes to the point where it cannot flow at all. That means that the water that we are used to having in our homes or community might never reach us. Chemicals and animal manure in water can make animals and humans sick if it is consumed and sometimes if it its even absorbed into our skin. Fish, plants, and other organisms that live in polluted water may also become sick and eventually die. It is important to keep water clean so that all living organisms that depend on it stay healthy.

This activity is designed to determine what knowledge children have of water, either from personal experiences or from learning about water at home or in school.

Procedure:

1. Pour some water in a clear glass and ask students what it is. Ask them where they think it came from. Tell students what water makes you think about (e.g., swimming, drinking).

2. On the board, or aloud, ask students to finish the following sentences:

'When I think of water, I think of...'
'Water comes from...'
'Water can become polluted (dirty) and unhealthy if...'
'If water becomes polluted, then _____ might happen.'
'What I wonder about water is...'

It may help to organize these questions under three categories:

a. What students definitely know about water
b. What students are unsure about water
c. What students don't know about water

3. Congratulate students on their knowledge and explain to them that they are about to engage in a series of activities about water that will build upon what they already know as well as help them to explain some of the topics about water that they are unsure of or do not know anything about.

Time/length of activity: 30–45 minutes

Assessment:

Students should be assessed on their participation in the sentence-finishing activity and their understanding of the water cycle. After explaining the water cycle to students, ask them to repeat the four steps, in the correct order, and have them draw the water cycle. Assessment can be based on the following guidelines (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Understanding of the water cycle	Could not recall nor explain any of the four steps of the water cycle. Could not draw the water cycle.	Could remember the steps of the water cycle in minimal detail. Steps may not be in the correct order. Could draw the water cycle with some accuracy.	Could remember the steps of the water cycle in the correct order and could draw the water cycle with accuracy.
Participation in finishing sentences about water	Did not participate	Participated and was able to complete some sentences.	Participated and was able to complete all sentences.

The Muddy Water Police

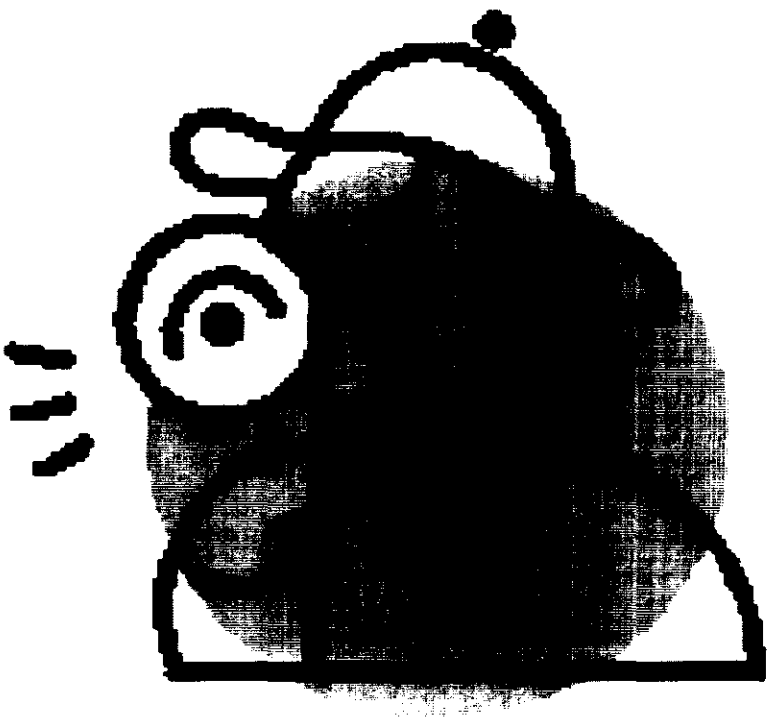
Student Age: Upper Primary/Early Secondary/Secondary
Location: Classroom or a quiet outdoor area where students can sit comfortably
Objectives: Learners will:
1. listen to a story that describes a research project and how the research results were used to help improve water quality in a community
2. consider the importance (or other applications) of a similar project in their own community

MATERIALS

* **story script:** Something Was Wrong in the Manupali Valley
* **optional:** paper and a writing tool for students' answers to questions

Background Information:
This story was adapted from a SANREM CRSP research brief: *Water Spirits and Citizens 'Action: Community-based Water Quality Monitoring in the Philippines* (SANREM CRSP, 2001. [See Appendix III]).

The brief describes a project in which local community members monitored water quality in their local watershed. The project gave community members a better understanding of water quality problems in their community and how they, as citizens, could improve water quality through changing their land use practices in their watershed.



This story is used to illustrate the practical applications of science in local communities. It reinforces the concept that activities in a watershed impact its water quality and it describes methods for monitoring and improving water quality.

Procedure:
1. Read the story aloud to students or have them read the story on their own as an in-class or homework assignment.

Follow up discussion:
Ask students the following questions and either discuss

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their answers or ask them to write their answers and hand them in for assessment.

1. What was the main question that inspired the community research?

2. Why was the water unhealthy?

3. How did the researchers measure the water?

4. Why was this project important?

5. How can the information that Boyton learned help your local community?

Time / Length of Activity: 30 minutes
Assessment:

Assessment can be completed either informally through discussion, or formally through collection of written student answers. Assessments should be based on students' understanding of the story and their ability to apply what they learned in the story to their own community.

The following guidelines can be used to assess student understanding of these points (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs Improvement	Satisfactory	Excellent
Understanding of the story	Answers to questions do not demonstrate an understanding of the story.	Answers to questions demonstrate understanding of the main points of the story.	Answers to questions demonstrate an understanding of the main points and most of the details of the story.
Application of the story	Does not mention applications of this research in a local context.	Mentions ways in which this research could be duplicated in a local context.	Mentions creative ways in which this research could be applied in a local context. Includes answers that go beyond duplicating the procedures used in the story.

Something Was Wrong in the Manupali Valley

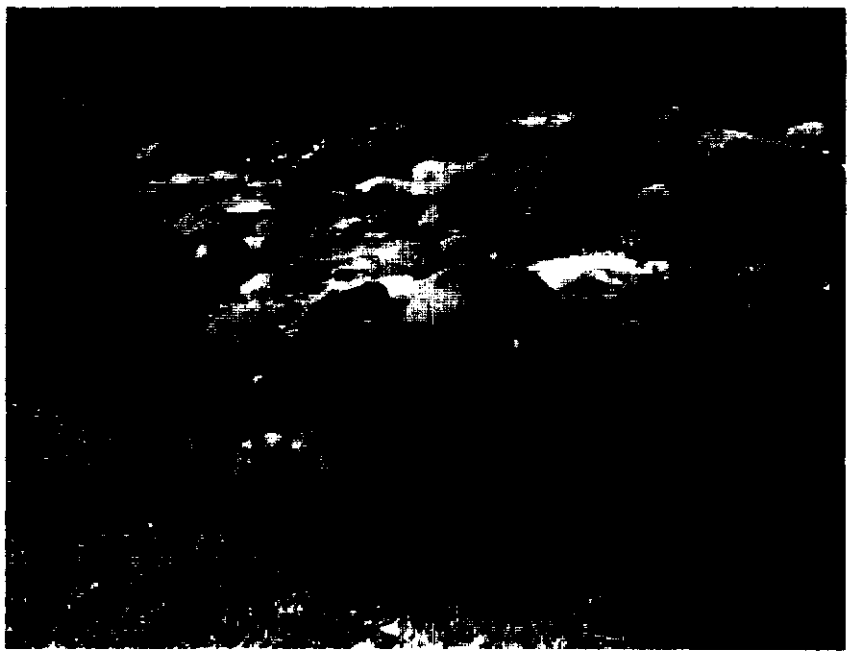
Boyton could remember when he first moved to the valley to start a farm; it was filled with forests. Few people lived there, so there were not many other farms. His family built a house near the river so that they could be close to water for irrigation, cooking, cleaning, and bathing. Boyton's carabao (water buffalo), that helped carry harvested goods and wet clothes that had just been washed, often waded in this same river; they drank from it, cooled off in it, and defecated in it. Back then, the weather was quite predictable: wet and rainy in May and August and dry in July and November. Boyton's farm was very productive. He grew corn, tomatoes, cabbage and other vegetables. His crops did very well in the first few years and his family grew.

Boyton had a large amount of land to farm. Sometimes, during the rainy season, the rain would cut ditches into Boyton's fields. After repeated rains, the ditches would get deeper and his crops would not grow as well. When this happened, Boyton had to clear a new field from the nearby forest and let the old one re-grow into grasses and small trees.

Boyton would occasionally travel further down in the valley to visit some of his family and to pick up supplies that were not available where he lived. In the lowlands there were irrigation canals that led water from the river into the many flat rice fields. The town officials also built a reservoir. Water leaving the reservoir turned a turbine to create electricity for the surrounding towns. Eventually that electricity reached Boyton's farm.

Things had changed in the valley over the years. Other families had followed in the footsteps of Boyton's family and had settled and started farms along the river. This movement of people started slowly but then became quite rapid as it became more and more difficult to make a living competing with the larger farms downstream. Boyton now lived in an area that resembled a small town and most of the

forests that he could remember were gone. People had cleared land for houses higher in the valley. When it rained the water seemed to run over Boyton's fields faster than when the forest trees were present to slow the flow of water. The force of the rainwater cut even deeper ditches. Boyton could see his soil eroding away, but there was no longer any area nearby that he could clear to make new fields. Instead Boyton had to pay money for chemical fertilizers, which he bought in town, in order to make his land continue to produce crops. While this helped bring money to his family, his crops were never as healthy or plentiful as they once had been.



Heavy rains now often flooded the river. The floods came quickly and unexpectedly, and people that lived near the river were not always ready for them. What made it all worse was that for the past couple of years the rainy and dry seasons were less predictable, and just as there were many floods, there were also many times that the river was nearly dry.

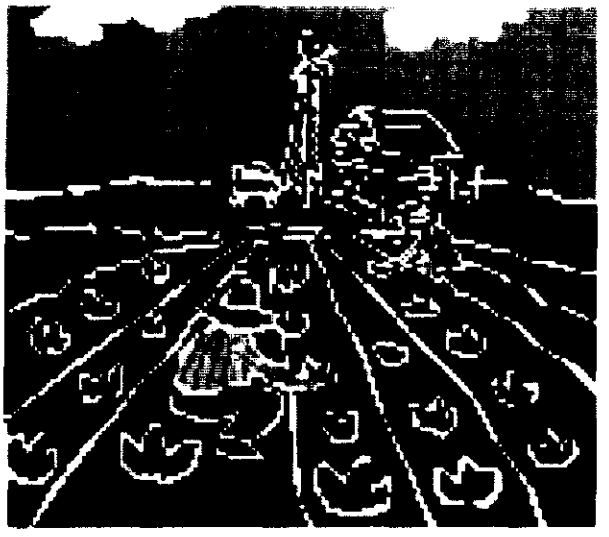
Boyton began to notice that his carabao were no longer as healthy. Even though they had enough food, they were thin, and last season one had died for reasons that Boyton could not understand. The scariest part was that the health of Boyton's family seemed to be decreasing. His children that still lived at home were often ill with stomachaches and fatigue, and they were not growing as quickly as his older children had.

Boyton was very worried about what was happening in his village and along the river. The electricity that came to Boyton's house from the turbine had become unreliable, so he often did not have electricity. Boyton had heard that many of the irrigation canals in the lowlands had filled in with mud and that it took a lot of time and energy for villagers to dig them out each year.

What do you think was wrong?

Boyton spent many hours thinking about all of these changes, and he had a strong idea about what was wrong. The illnesses, the erosion, the power loss, they all had one thing in common: the river. Boyton could clearly remember that the river once ran clear, and fish and other aquatic animals were plentiful in its waters. Now it was often muddy looking and Boyton could not remember when he last saw wild animals in or around it. It even sometimes had a funny smell. He was not the only person that thought that the river was sick; many other villagers had noticed and they all wanted to do something to help make the river better.

The concerned community members formed a group called Tigbantay Wahig (TW) or Water



Watcher. With the support of an area organization of researchers called SANREM (Sustainable Agriculture and Natural Resource Support Program), the TW got involved in measuring the quality of the water. By learning about the river and gathering scientific information, SANREM and the TW hoped that people in the community, and especially people that worked in the local government, would work to try and clean the water.

Before they started the TW asked permission to conduct their study from some tribal groups that lived on the river. These groups viewed the water as having spirits, and the TW wanted these beliefs to be respected and not undermined. The TW wanted this project to be important to everyone that lived along the river. The tribal groups granted the TW permission to study the river.
Members of the TW included men and women, farmers, teachers, and local government officials. With SANREM researchers, they visited different sites on the river two times a month to take scientific measurements. If it was raining very hard they would visit the sites every two hours and take extra measurements to help determine what happens during storms and floods.

The TW measured the amount of soil that washed into the river from farmers' fields (called TSS: total suspended solids). Farmers were very interested in measuring TSS because it could show them how much important soil they were losing. The TW also used simple tools to measure the amount of water in the river and the speed at which water was moving. This was important because it could help people better predict when there might be flash floods based on the amount of rain falling in the watershed and the speed of the river. Bacteria (germs) present in the water were measured, too. Bacteria, as well as agricultural chemicals, were thought to be responsible for causing illnesses in many people and animals. To reinforce their suspicions that the river might be sick, TW members also talked to other community members about their memories of the river and its health.

After collecting many samples of TSS, water levels, speed, and water germs and talking to many community members, the TW and SANREM determined that the local river was indeed unhealthy. The amount of bacteria in the river was too high. This meant that drinking water out of the river, as well as out of some springs, would make people sick. The TW also found that the water was cleaner in

the areas where there were fewer people. Even though these areas had steeper mountains, they lost less soil during rain than the areas that were farmed. They found that the more forest in an area, the less soil would wash away; if areas had less than 30% forest cover they would lose a lot of soil to erosion. It was determined that erosion in higher elevations had been clogging up the irrigation ditches and the reservoir downstream. Soil in the water also scratched and slowed the turbine that made electricity, causing it to be less reliable.

Boyton was pleased that the TW had learned so much about their water. The next important step, aside from continuing to watch, or monitor the water, was for the TW and SANREM to determine how they could use their new information and knowledge to improve the water.

Together, the TW and SANREM determined that farmers could plant crops so that their rows went across the hills instead of down the hills; this would help to keep ditches from forming when it rained. Farmers could also plant rows of trees between their rows of crops to help catch soil that was moving toward the river. Farmers liked this idea because if they lost less soil, they may not need to buy as many chemical fertilizers; this saved them money and helped decrease river contamination. The decrease in agricultural chemicals in the water might also help to improve people's health.

Boyton learned many things from his work with the TW and he plans to continue to work to clean up the river. The most important thing that Boyton learned was that he and his neighbors could make a difference in their communities. They could collect scientific information and then use it to influence the decisions that people made about how they treated their land and water resources. Boyton hopes that as the project continues the TW will see the return of health to the river and all of the people, plants and animals that depend on it.

What is a Watershed?

Student Age: Upper Primary/Early Secondary/Secondary
Location: Classroom or an outdoor area
Objectives: Learners will:
1. Define the term watershed
2. Build a model of a watershed

MATERIALS

* **scrap paper** (one piece per group of four students. If paper is not available a watershed model can be made in the soil outside. Students can create miniature landscapes with hills and valleys in the soil. They can then sprinkle water on the miniature landscape until it runs down the "hills".).
* **water** (ideal if it is in a spray bottle, otherwise it can be sprinkled from a bowl using your fingers).
* **Trays or basins for catching water** (these are for catching water and are not necessary if the activity is completed outside)
* **markers, pens or pencils**

Example Watershed

Background Information:
A **watershed** is an area of land upon which all surface water flows into **one common point.** Water travels from high elevations to lower elevations. Watersheds are separated by **ridgelines**. Water landing on one side of a ridge may flow into one watershed while water landing on the other side of the same ridge may flow into another watershed. Watersheds can be large and include all of the **tributaries** (streams that flow into larger streams) of a large river that empties directly into the ocean, or very small and include any small stream and the land around it that slopes toward the stream.

The concept of a watershed is critical in understanding the impact of our actions on water quality. This is because any activity that takes place upstream in a watershed, such as land use (i.e. agriculture, construction, logging, etc.) can impact the water quality downstream in the watershed. When dis-

cussing the concept of a watershed with your students, you can talk about *any* body of water: a river, lake, ocean, stream, pond, etc. It does not matter what size it is because all bodies of water are part of a watershed.

There are two types of pollution that can occur in a watershed. Pollution that comes from a variety of places and is picked up as water travels across the surface of the ground is called **non-point source pollution**. Pollution that comes from one place (that is clearly identifiable and can be pointed at) and is often dumped directly into the water is referred to as **point source pollution**. Both forms of pollution impact water quality at lower points in a watershed. In making decisions about natural resource management, especially land use, it is important for decision makers to consider the impact any action will have on the rest of the watershed. This can be referred to as thinking on a "watershed scale."

Procedure:

1. Ask students if they know what a watershed is. Explain that a watershed is the area of land on which surface water flows into one common point. For example, if rainwater were to fall on a mountain it would flow downhill and probably into a small river. That river would flow into a larger river and so on until the water eventually flowed into an ocean. Explain to the students that they will get the chance to build their own watersheds.

2. Break the class into groups of four students. Hand each group a piece of scrap paper; keep one piece for demonstrating the process.

3. Ask students to place the paper on a flat surface in front of them. Next, one student should crumple the paper into a ball. Another student can then carefully unfold the ball of paper, stopping before the paper is totally flat. The paper should resemble a mountainous landscape.

4. Explain to students that the crumpled paper represents a mountain range and there are many different watersheds on the landscape. With markers, pens or pencils, students should carefully draw a line where they think rivers and streams will be on their landscape (students may need to temporarily flatten the paper to draw on it and they can then bend it back when they are finished). Using a different color or type of writing utensil, students will then draw a line connecting the tallest parts of their landscapes (from one peak to another along the highest ridge). This line represents the ridgelines that separate watersheds.

5. Ask students to select a place on their landscape where they would like to put a house. Each of the students in a group can select a house site and draw an x or a box to represent their house on the landscape. When they are finished with this step they should set their landscape in an empty, dry tray or on the ground outside.

6. Spray or sprinkle each one with water while the groups watch. As the water moves across the landscape models students should determine where the real rivers and ridgelines are and if they correspond with the lines that they drew on their models. They should also determine if they chose a good location for their house site.

7. Ask students to point to the different watersheds on their models.

Follow up Discussion:

Have students draw a large X on a high area of their watershed model and explain that it represents a farmer's field. Ask students what would happen if pollution or soil from this field flowed into a stream or river. Ask students to point to the areas that would and would not be affected.

Time/length of activity: 25 minutes

Assessment:
Students should be assessed on two points: their understanding of the term watershed, and their participation in the activities, including determining accurate rivers and ridgelines on their models, accurate locations of house sites on their models, and identifying different watershed on their models. Ask students to write the definition of a watershed in a journal or on a piece of paper that you can collect. This definition should be their own definition and students should be allowed to write as much as they please to describe a watershed. Assessment can be based on the following guidelines (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	**Satisfactory**	**Excellent**
Definition of a watershed	Incorrect definition	Correct definition	Correct definition including descriptive details which aid in the readers' understanding.
Participation in the activities	Did not participate	Participated and was able to determine, with some accuracy rivers, ridgelines, house placement, and different watersheds on their models.	Participated and was able to fully determine rivers, ridgelines, house placement, and different watersheds on their models. Asked relevant questions.

A Walk in a Watershed

Student Age: Upper Primary/Early Secondary/Secondary
Location: Outside on school site or in the local community (access to a nearby stream is ideal)
Objectives: Learners will:
1. observe a local watershed
2. map features in a local watershed
3. determine which features in the watershed affect water quality

MATERIALS

* **blank paper and a writing utensil** for taking notes or making drawings of the watershed during the walk (one for each student if possible)
* **large blank paper** on which to draw the class map (the map can be drawn anywhere where all students can see it)
* **measuring stick** to measure the depth of bodies of water (could also use a dry stick and a measuring tape or string)

Background Information:
Water falls as rain on the landscape and then flows downhill toward a stream or river. Much of the water is either absorbed into the soil where it is used by plants, evaporated at the soil surface, or it continues to soak down through the soil into the ground water supply. The remainder of the water flows across the surface of the ground toward a stream or river. As water moves across the landscape it can become contaminated with eroded soil (soil that has washed away from its point of origin), or other pollutants such as agricultural chemicals, oil and gas from cars, or animal waste from nearby fields. Some plants and soil on the site will act as filters and absorb some of the pollutants out of the water. However, this natural filter system can stop working for several reasons including 1) if there are too many pollutants, 2) when there are not enough plants to act as water filters, or 3) when pavement or

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compacted (hardened) soil prevents water from being absorbed.

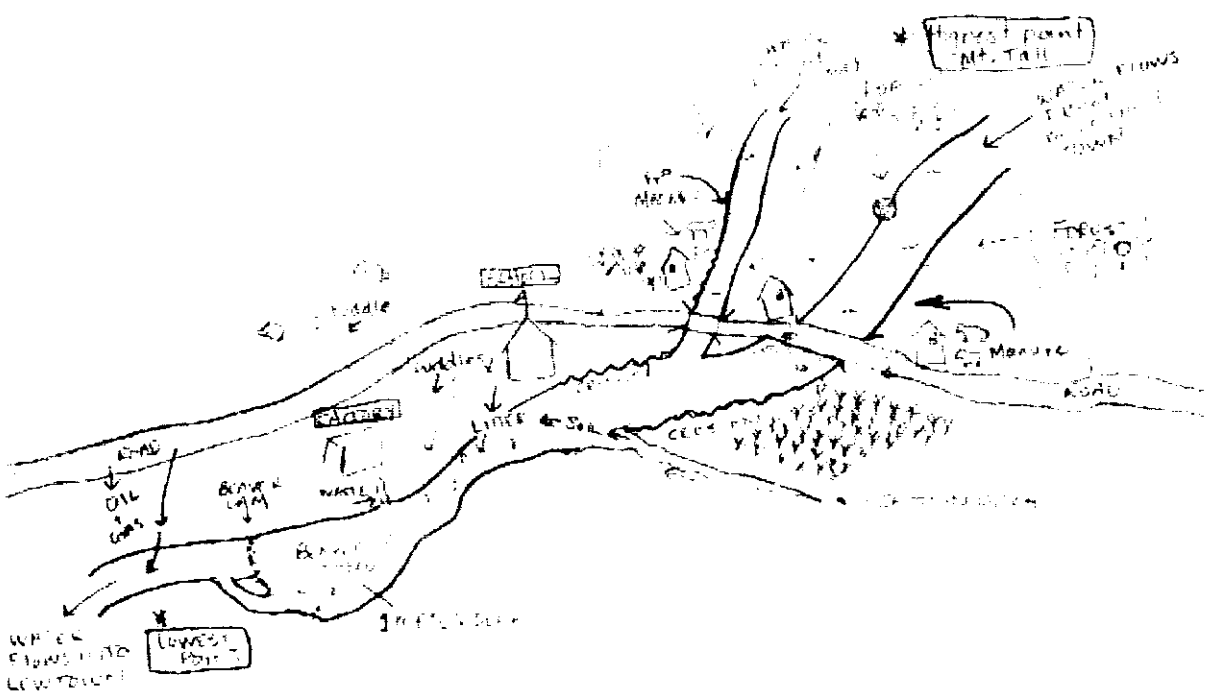
In this activity, students will observe and map their local watershed as well as possible factors affecting stream quality in their local community.

Procedure:

1. Ask students to think about water in nearby areas around the school or in their local community. Ask the following questions: *Where does water flow in your community? Is there water flowing into the community from another area? As the water flows, what kinds of materials might it pick up along the way (examples are eroded soils, agricultural chemicals, animal waste, gas or oil from cars, pollution from a factory, etc.)? Does the water moving over and through your community become cleaner or dirtier as it leaves your community and flows somewhere else?*

2. Explain that students will be taking a walk to make general observations about their local watershed and human activities that take place within it. Students should take notes or remember what they see during the walk so that when they return to the classroom they can combine their information with that of their classmates and create one complete map of the area. Students can walk with a partner. List the following features for which students should look:

* **Land use** (i.e., playing field, parking lot, forested area, field overgrown with plants, garden, house, business, farm field)
* **Highest point** in the area
* **Lowest point** in the area
* **Direction** in which **water flows** around and through the area
* Any evidence of **erosion**
* **Bodies of water** (for any bodies of water, record how deep they are and in which direction they flow; use the measuring stick for



small bodies of water and estimate the depths for large bodies of water), including wetlands, streams, ponds, lakes, etc.
* Places where **puddles** form when it rains
* **Storm sewers**
* **Ditches**

3. Walk around the local area with students. If there is a stream nearby, walk along side it. Stop when appropriate to mark and measure features.

4. When you return to the classroom, work as a group to compare and contrast students' maps and notes. Then, draw one large map that incorporates land features that students detected. If there are many features to put on the map, it may be easier to draw symbols for each feature and then one main list of what each symbol represents; this is called a **map legend**.

5. On the map, list possible pollutants that might be entering the water from different land uses. For instance, a farm might add chemicals, increased nutrients in the form of animal manure, or soil. A home might add soil, household cleaners and detergents, and general trash. Roads will probably add soil, or oil and gas that leaks from cars. Students might find evidence of other types of pollutants entering the water from various areas.

Time/ length of activity: 1 hour

Assessment:
Assessment of this activity should be based on student participation in the process of making observations, mapping skills, and understanding watershed features that affect water quality. The following guidelines may be used to aid in evaluation (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Student participation	Did not participate.	Participated and made basic observations of their local watershed, mapped local watershed features with some accuracy, and determined some watershed features that affect water quality with some accuracy.	Made detailed observations of their local watershed, mapped many local watershed features with accuracy, and determined many watershed features that affect water quality with accuracy. Asked relevant questions.

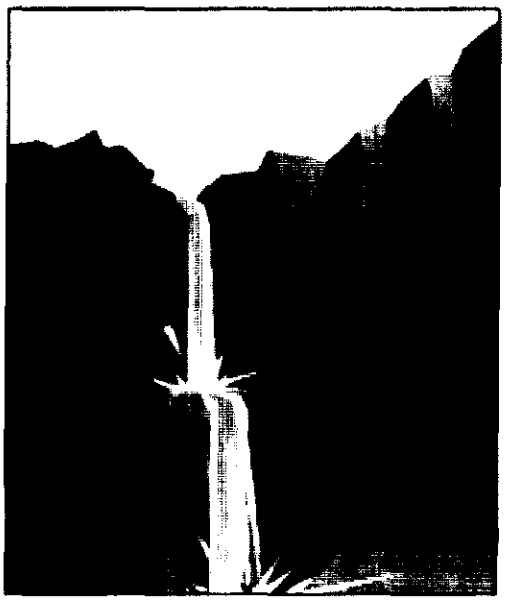
A Water Watch

Student age: Upper Primary/Early Secondary/Secondary
Locations: Outside near a body of water (this can be a stream, river, pond, lake, or even a ditch or large puddle).
Objectives: Learners will:
Study local water quality using the steps of the scientific method. Specifically, learners will:
1. determine questions that they would like to answer about local water quality
2. make hypotheses about local water quality
3. design or apply a method(s) for testing local water quality
4. implement the method(s)
5. collect data
6. organize results
7. draw conclusions about local water quality based on results
8. present results to a wider audience

MATERIALS

(materials specific to experiments are listed before each experiment in procedure #8)

* **paper and writing instruments** for each student (or somewhere that they can write/draw)
* **blackboard and chalk** (or somewhere that you can write/draw and all students can see)
* **poster paper** for students to display experiment results (or somewhere that students can write/draw so that all students can see)



Background Information:
There a number of ways for teachers to help students find answers to their questions created during the introductory observation activities (see *Water Unit Overview* for more information on helping students to formulate questions). Below we provide several suggested activities that employ the scientific method. The best method to use, however, will depend upon the specific question being asked by each student or group of students.

When scientists want to answer a question they follow a series of steps commonly referred to as the **scientific method**. This method is useful in organizing information to better answer specific questions. The scientific method includes observing, questioning, forming a

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hypothesis (a guess that that comes from an assumption), testing the hypothesis, analyzing the results of the test, and rejecting or accepting the hypothesis. *A Water Watch* was designed to demonstrate methods for monitoring water quality that can be completed without special equipment. Most of the methods described in Procedure 8 are taken from the United States Environmental Protection Agency's *Volunteer Stream Monitoring: A Methods Manual* and have been modified for classroom use. Procedures should be further modified to address other questions that your students may have, differences in materials available, etc. Test kits are available for testing important properties of water quality including bacteria levels, nutrient levels, dissolved oxygen, etc. (the procedures for these tests are not described in this lesson plan). Suppliers or resources for obtaining test kits are listed following this lesson plan.

The water quality tests described in this activity and in Appendix VIIA are only suggestions of ways that you can make observations about water in your community to try to answer student questions about water; your class could complete one or all of them. Above all, we encourage students and teachers to make scientific observations in the most appropriate way for their class.

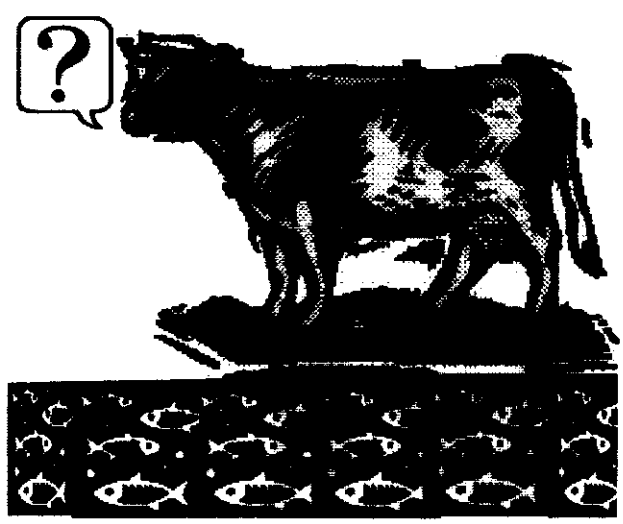
Whichever tests you use, we encourage you to complete the test multiple times in order to compare results. Comparing methods and results of different kinds of tests may help you to determine which test works the best, and comparing results of the same test done multiple times will help you to decide if your observations and conclusions are accurate ones. The more times that you can achieve the same results, the more likely that your are observing a true phenomenon and not something that just happened by chance.

Procedures:
Scientific Method

1. Record student questions generated from introductory **observation** activities on the board, or somewhere that all students can see (refer to the *Water Unit Overview* for more information).

2. Explain to students that they will have a chance to answer some of their questions using the scientific method.* The scientific method will help them to organize the information needed to objectively answer their questions about water. Answering their questions "objectively" means that they will try to answer their questions without letting their ideas interfere with their study. For instance, they may have an idea that a stream with a lot of trash in it will be a home for fewer living organisms than a stream with no trash in it, but they cannot allow their idea to lead them into reporting that result if it is not found through their study. Explain or write the steps of the scientific method on the board (see *Background Information*). Students have already made general observations about the water quality in the area. Now they will design some simple tests to learn more.

*Some student questions may be answered without by simple observation; no practical testing would be needed.



3. Determine which student questions can be tested using the scientific method (highlight them on the board, if possible). These questions need to be specific and detailed in focus. In other words, how can you test something you do not understand? Consider the following example:

Do fish like to live near cow fields?

It is impossible to determine what fish like or do not like because even though you can ask a fish what it likes or does not, it is not going to give you an answer! However one can determine the behaviors that fish exhibit in certain circumstances, and that could give an idea as to what a fish might prefer. The original question could then be reworded to ask a more specific one such as:

Do more fish live near cow fields than near forests?

This question is clear in what it is asking and depending on the test used, one may be able to conclude that fish prefer to live in one area to another.

Another example of a question that can be made more specific is:

Is our water clean?

This question can be qualified in the following ways:

Is our water clean enough to drink without us getting sick?

Or:

Is our water clean enough to support life?

With student participation, review each of the questions that can be tested using the scientific method, and make any changes needed so that questions become more specific, and therefore easier to test. This lesson plan will focus on the following questions:

* Is our water clean enough to support life?
* How fast does our water move?
* How much water is there in the lake, pond, etc.?
* What plants and animals live in our water?
* Does erosion and sedimentation (when soil present in the water sinks to the bottom) occur in our watershed?

A hypothesis is a temporary explanation for an observation or scientific problem that can be tested by further investigation. It can come from experience, previous research, or simply an assumption.'

4. After making the questions as testable as possible, ask students to think of **hypotheses**. Explain that an hypothesis is a temporary explanation for an observation or scientific problem that can be tested by further investigation. It can come from experience, previous research, or simply an assumption. Ask each student to think of an hypothesis for each question. There are many possible correct answers. Some examples follow:

* Our water is clean enough to support at least 20 different species of insect life.
* The water in our stream moves faster than 10 km/hr during the month of May
* The water in our stream moves faster in May than in July

* There are over 200 cubic meters of water in the lake.
* Salamanders live in our stream.
* There is a higher amount of erosion and sedimentation in our stream than in the stream in our neighboring community.

5. Depending on the hypotheses, a test may take place in one site or several sites, and it may need to be conducted more than once. For example, the hypothesis that water in a stream moves faster in March than in June would require testing in the stream during both May and June. Read the list of hypotheses with the students and as a group determine in how many places and the number or times each hypothesis needs to be tested.

6. Break the class into groups so that each group can focus on one hypothesis. Students should be placed in groups based on similarities in their questions derived from observation activities. Ask students to come up with ways to test the hypotheses. Give them a set amount of time to think of answers. After students have finished, (or earlier, if students are having difficulty) describe some of the test methods listed in Procedure 8. Let students compare their methods to the methods described and then decide which methods would best test their hypotheses. All of the students should be familiar with all of the questions / hypotheses and test methods.

7. Once each group of students has chosen the methods that they will use, determine sampling dates and times.

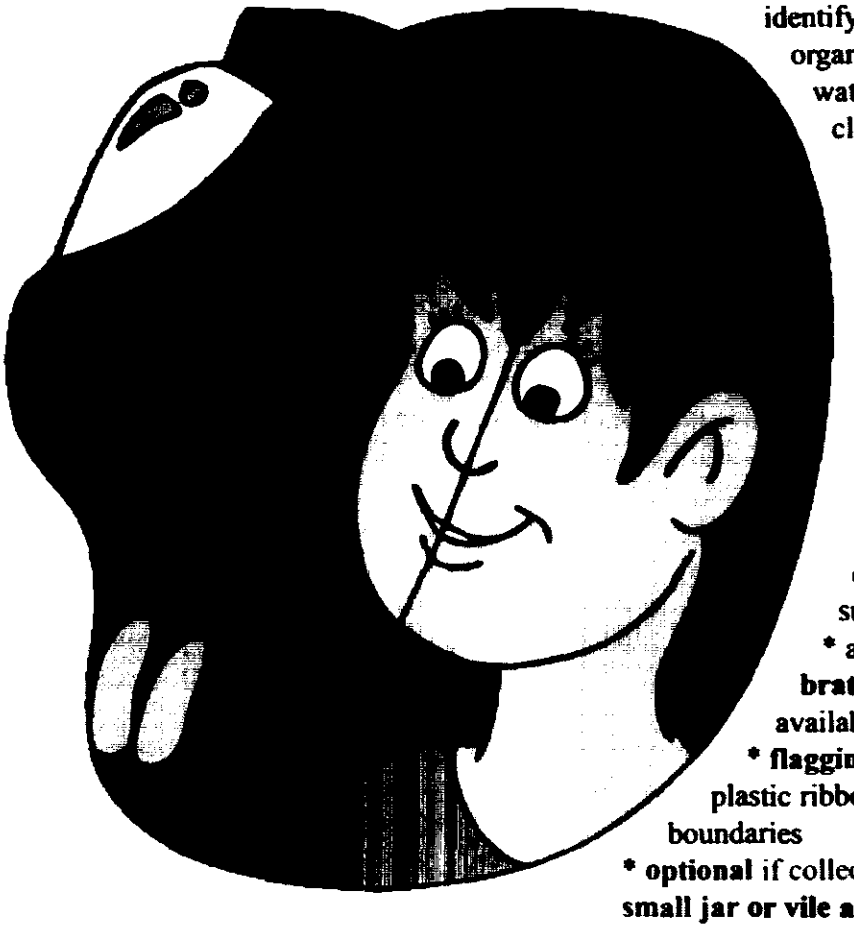
8. Implement the **tests***:
*For simplicity in this activity, we are providing one possible test of water quality below (**Macroinvertebrate biodiversity study**). Additional tests are provided in Appendix VIIA.

Macroinvertebrate biodiversity study

Studying biological factors, such as the diversity of organisms in a given area, can provide information about the environmental conditions of the area. This experiment is best done in streams that are shallow enough for students to wade in the water (the water in the stream or body of water should not exceed the height of the students' thighs). Many different organisms can be studied, including plants and fish. However, it is easiest for students to collect and study macroinvertebrates (animal organisms that are visible with the naked eye and that do not have backbones).

"Aquatic macroinvertebrates are good indicators of stream quality because:
* They are affected by the physical, chemical, and biological conditions of the stream.
* They can't escape pollution and show the effects of short- and long term pollution events.
* They may show the cumulative impact of pollution.
*They may show the impact from habitat loss not detected by traditional water quality assessments.
* They are a critical part of the stream's food web.
* Some are very intolerant of pollution.
* They are relatively easy to sample and identify." (USEPA, *Volunteer Steam Monitoring Manual*)

Generally a healthy, clean body of water will have a higher amount of macroinvertebrate diversity than a polluted body of water. Many organisms



are very sensitive to pollution. That means that pollution will bother them quickly; therefore, these organisms are less likely to survive in a polluted body of water. Other organisms are more tolerant of polluted water; they have better chances of surviving in it. Therefore, by sampling macroinvertebrate organisms in an area or several areas in a body of water, one can get a sense of the amount of pollution present, and therefore, how healthy the water is. (This sampling technique may not be as accurate for isolated bodies of water such as springs, stream headwaters, puddles or ditches. Species diversity may be low in these areas because of their isolation from other bodies of water.)

Explain the above background information to students and that they will be collecting and identifying macroinvertebrate organisms in a selected body of water to get a sense of how clean the water is.

Materials:

* **paper and pencils**
* **sieves or strainers**
* **screens**
* **tweezers** (if available)
* **cups, bowls, buckets, shallow trays or plates** for collecting and temporarily holding animals (must be able to hold enough water for animals to survive)
* an **aquatic macroinvertebrate identification book** (if available)
* **flagging** (i.e., pieces of cloth or plastic ribbon) to mark the sample area boundaries
* **optional** if collecting samples to identify: a **small jar or vile and isopropyl alcohol**

As a group, walk to the water sampling site. Use flagging to mark the section of stream that will be sampled (if there are multiple areas that will be sampled, mark each area). Students should record, describe, and name (if possible), each organism that they see. If an identification book is not available students should draw or collect a sample of each species. These can be identified later by asking people in the community . Students may use the following methods in looking for macroinvertebrates:

Rock-rubbing method. [Use this method in streams with riffle areas (patches of waves on water) and rocky bottoms.] Remove several rocks from within a riffle area of your stream site (e.g., randomly pick 1 rock from each side of the stream, 1 rock from the middle, and 1

rock from in between). Try to choose rocks that are under water during normal flow conditions. Each rock should be about 4-6 inches in diameter and should be easily moved (not embedded, or stuck in the stream bottom). Either inspect the rock's surface for any living organisms or place the rock in a light-colored bucket or shallow pan, add some stream water, and brush the rock with a soft brush or your hands. Try to dislodge any particles from the rock's surface. Also look for clumps of gravel or leaves stuck to the rock. These clumps may be insect houses and should be removed as well.

Stick-picking method. (Use this method in streams without riffles or without a rock bottom.) Collect several sticks (approximately 1 inch in diameter and relatively short) from inside the stream site, and place then in a bucket filled with stream water. Select partially decomposed (falling apart) objects that have soft wood, a lot of cracks and are found in the flowing water (not buried in the bottom). Pick the loose bark from the sticks to find organisms. Fill the shallow pan with water from the stream and remove one of the sticks from the bucket. Examine the stick making sure you hold it over the pan so no organisms are lost. Remember that the organisms will have sought shelter, and they could be hiding in loose bark or crevices. After examining the sticks, it might be helpful to break up the woody material. Examine each stick carefully. Using tweezers or a soft brush, carefully remove anything that resembles a living organism and place it in the pan. Also examine the bucket contents for anything that has fallen off the sticks.

Leaf pack-sorting method. (This method can be used in streams with or without a rock bottom.) Remove several handfuls of submerged leaves from the stream and place them into a bucket. Remove the leaves one at a time and look closely for the presence of insects. Using tweezers or soft brush, carefully remove anything that resembles a living organism and place it in a pan containing stream water. Also examine the bucket contents to see if anything has fallen off the leaves (slightly modified from USEPA, 1997).

Substrate sifting method. This method can be used in streams with muddy bottoms. Using a sieve, screen or net, scoop up some of the mud or sand on the bottom of the stream. Place the contents of the net into a bucket or a tray and sort through the mud for macroinvertebrates. If this method is used along a stream, make sure to begin sampling downstream and work your way upstream so as not to muddy the water ahead of where you have worked (slightly modified from USEPA, 1997).

After data is collected return organisms to the water (you may wish to keep a sample of each organism that was not identified so that it may be identified back in the classroom. In this case, place the organism in a vile or jar with isopropyl alcohol). Upon returning to the classroom, combine all of the data that students gathered.

Ask students to determine: How many of the organisms found are considered sensitive to pollution? Use the following key to determine the numbers of organisms found in each group (you may have to modify the example insects listed for each group to accurately represent the insects in your local area).

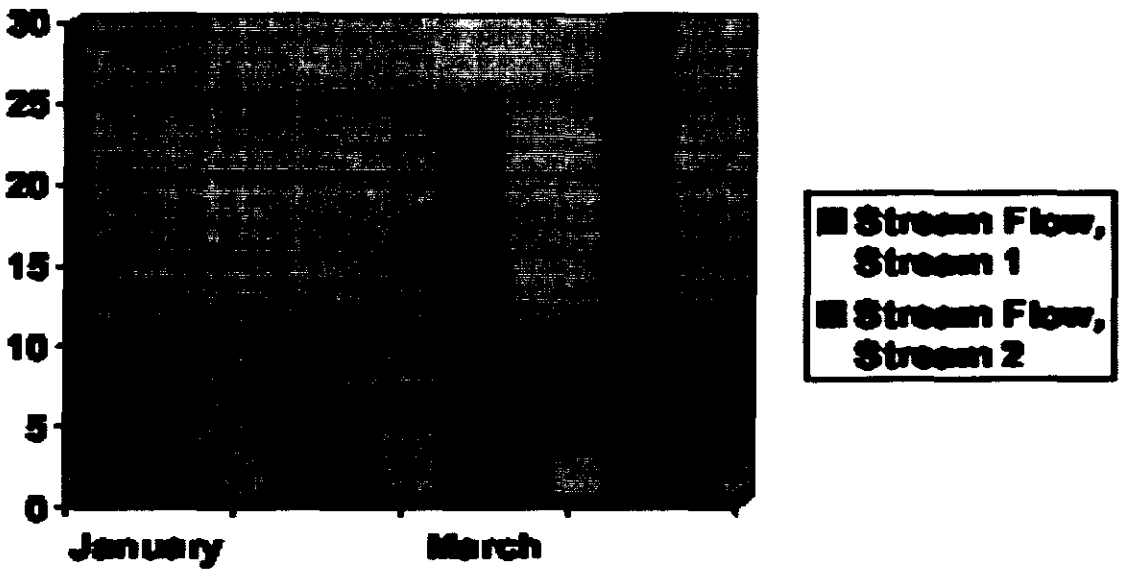
Generally, the three tolerance groups are as follows:

Group I (sensitive organisms) includes pollution-sensitive organisms such as mayflies, stoneflies, and non net-spinning caddisflies, which are typically found in good-quality water.

Group II (somewhat sensitive organisms) includes somewhat pollution-tolerant organisms such as net-spinning caddisflies, crayfish, sowbugs, and clams found in fair-quality water.

Group III (tolerant organisms) includes pollution-tolerant organisms such as worms, leeches, and midges, found in poor-quality water (USEPA).

Discuss whether students think that the water quality is high or low based on the diversity of organisms found. In general, the higher the diversity of sensitive organisms, the higher the stream quality.

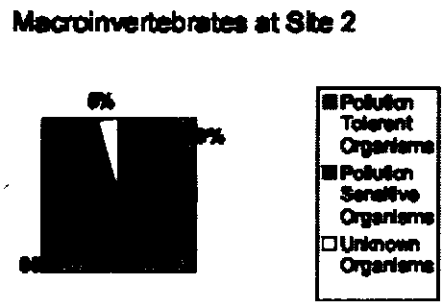


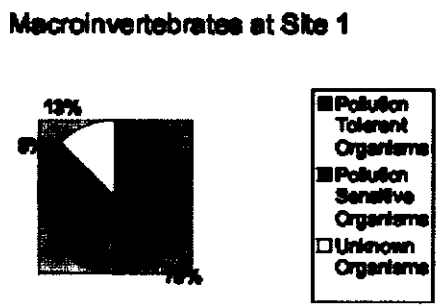
Example Bar Graph

(Please refer to Appendix VIA for additional activities to test water quality)

9. After completing data collection for this example water quality test, ask the students to revisit their hypotheses and think about how they can use their data to either accept or reject their hypothesis. Demonstrate some common graphs that can be used to compare data.

Line graphs or **bar graphs** can be used to compare measurements of the same variable taken at different times or different sites (for instance, comparing stream flow and TSS at different times (i.e., the rainy season versus the dry season) or comparing TSS or specific organisms at different sites).





Example Pie Graphs

Pie graphs can be used to show the numbers of pollution sensitive/pollution tolerant macroinvertebrates at different areas in the stream.

After demonstrating the use of graphs have each group of students prepare a graph to describe what they observed in their test. Students should present their graphs to the class.

10. Based on the information found, the class should decide if each hypothesis should be accepted, rejected, or if there is not enough information to form a conclusion. An important point to remember is that a rejection is not a bad result. A rejection actually eliminates one variable that could be causing problems with water quality and brings you one step closer to the right answer.

11. Discuss the results of the entire activity with the class. Ask students if they were satisfied with their results. Do they think that their results were accurate? What would they do differently next time? Did they come up with new questions as they were trying to answer the original question?

12. The class should work together to create a presentation of all lessons learned about the body of water that they studied. Arrange a time when students can present this information to a larger audience that may include parents and community members, or other students at the school. The important information learned/discovered about sources of pollution should be presented to a wide audience so that it might influence the behavior of those involved in land use around the body of water. Students should present their information orally, as well as visually using charts, graphs, and pictures.

Time/ Length of activity: Varies depending on activity or multiple activities that you complete.

Assessment:
Students should be assessed based on their participation in the activities, their understanding of the scientific method and the information gathered during activities, and their overall understanding of the topics covered. Participation should be evaluated throughout the project. Assessment of student presentations and an exam that focuses on using a similar process to

answer a different question can be used to evaluate their understanding of the scientific method and the information gathered during activities as well as their overall understanding of the topics covered. The following guidelines can be used to assess student work (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Participation in the activities	Did not participate.	Participated.	Participated and asked relevant questions.
Understanding of the Scientific Method	Did not demonstrate understanding of the scientific method. Did not differentiate between questions that could be answered and could not be answered using this method. Did not demonstrate the formulation of a testable hypothesis. Lacked accuracy in collecting data. Did not display data relevantly. Had trouble following the same process to answer a new question.	Demonstrated an understanding of the scientific method. Differentiated between questions that could and could not be answered using this method. Formed a basic hypothesis for a variety of questions. Collected data accurately. Displayed data in a way that supported the acceptation or rejection of a hypothesis. Could relate most of the steps of the process to a new question.	Demonstrated a detailed understanding of the scientific method. Differentiated between questions that could and could not be answered using this method and transformed questions that could not be answered into those that could. Formed specific hypotheses for a variety of questions. Collected data accurately and suggested methods for improving accuracy. Displayed data in a variety of ways that supported the acceptation or rejection of a hypothesis. Could relate all of the steps of the scientific method to a new question.
Understanding of the Topic Studied	Recognized less than half of the factors that were tested by the class in this project. Did not recall the conclusions to the study. Could identify less than half of the methods used for data collection. Did not relate water quality to land use issues in the area.	Recognized the factors that were tested by the class in this project. Recalled the conclusions to the study. Could identify most of the methods used for data collection. Related water quality issues addressed to land use issues in the area.	Gave a detailed explanation of the factors tested by the class and how they relate to each other. Recalled the conclusions of the study and how they were reached, including all of the methods used for data collection. Related the water quality issues studied to land use in the area.

Works Cited:

USEPA. 1997. Volunteer Stream Monitoring: A Methods Manual, EPA 841-B-97-003. November. United States Environmental Protection Agency, Office of Water, Washington D.C. 20460.

Resources for Water Quality Monitoring Equipment*:

LaMotte Corporation produces water quality testing kits as well as lesson plans for teachers to use with the testing kits. Information online at: http://www.lamotte.com/pages/edu/watermon.html

Carolina Biological Supply offers all types of tools for teaching the sciences to students. Find them online at: http://www.carolina.com/

Another supplier of science supplies for the classroom, Ward's Natural Science can be accessed online at: http://wardsci.com/Default.asp?

Science Stuff also offers water quality testing kits. These can be ordered online at: http://www.sciencestuff.com/Merchant2/merchant.mv?Category_Code=En-s

* Many other companies offer water monitoring equipment and can be found on the World Wide Web by searching for "water monitoring equipment."

Interview a Community Member or Elder

Student Age: Upper Primary/Early Secondary/Secondary
Location: Classroom or meeting area that facilitates a question / answer dialogue
Objectives: Learners will:
1. listen to a local person's perspective on water quality in the area
2. ask questions about water quality in the area and how it relates to quality of life
3. understand how natural resource issues such as water quality are dealt with in the local community

MATERIALS

* **something on which to write or record questions and answers** (i.e., paper, pencil)

Background Information:
Information to help answer student-generated questions about water quality in the community may be obtained by talking with a community member that is involved with, and therefore affected by, water quality on a local level. Students may use the knowledge of their interviewee to answer questions on such topics as water policy, perceptions about water quality, or history of land use and water quality in their local watershed. Interviews with multiple people may be necessary to answer student questions.

Tours of local water facilities may also be available and could provide students with first-hand accounts of how water is managed in their community.

Some people to consider interviewing are: workers who are involved in managing water resources, community members who have volunteered to test water quality, or community members that are affected by water quality issues (i.e. farmers, fishermen, people living next to a body of water, or health care workers and providers).

Procedure:
1. Based on students' questions (see *Water Unit Overview* for more information on helping students to formulate questions), ask the class to come up with a list of people that they could ask about water quality. Ask students if they know any one on the list. This will be helpful in finding out how to contact different people.

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2. Contact people on the list to set up interviews. First contact the people that could potentially answer the most questions. Explain what you are doing and how you would like them to help. It is important to make clear that you would like the students to conduct the interview, so the speaker will need to be comfortable with this format. Be sure to ask the speaker if they are comfortable being tape recorded, if you would like to use this interview technique. The speaker may also wish to give an additional presentation or talk. Some people may not be able to participate because of scheduling conflicts. If one person on the list is not available, call others until you have enough speakers lined up to answer student questions. Set times for meeting the various speakers.

3. Tell students in advance who will be speaking and what the speakers' roles are in the community. Remind students that they are trying to obtain information that will help them answer their questions about water. Ask students to consider the speakers' roles in the community when thinking of questions to ask that might help answer their questions about water. You may wish to make sure that each student has a relevant question to ask (by relevant, we mean that the question may elicit information that will help answer the students' questions about water).

4. Set a format and rules for the interview. Explain to students that they are to listen carefully to what each speaker has to say and to not interrupt them as several of the interviewees' answers may help a student answer his/her question about water. Students may wish to take notes each time the interviewee answers a question, or a different student or group of students could be assigned to take notes on each interview question response. Students should listen carefully to determine if the speaker has answered their questions so that they do not ask the same question twice. Students may ask questions one at a time, or they may ask questions spontaneously as topics are discussed. Also, encourage students to avoid jumping from topic to topic, a common problem in group interviews (a 'mock' or rehearsal interview might be a good idea), as this can be confusing for the speaker and interrupt his/her natural train of thought. It is important that the format used encourages all of the students to participate in asking questions.

5. On the day of the interview welcome the speaker and introduce her or him to the class. Allow as much time as needed or available for student questions and any other presentation by the speaker. Following the interview, offer a round of applause. It may be appropriate to offer a small gift of thanks to the speaker. Discuss this with the students and ask them to help create or purchase the gift.

6. After the interviews, ask students to recall what they have learned and how this information might apply to their questions about water.

Time/ Length of Activity: Varies

Assessment:
Assess students on their level of participation, their ability to formulate relevant interview questions (questions that may elicit information to help answer student questions about water), and their understanding of how natural resource issues such as water quality are dealt with in the local community. Assessments can be based on pre-interview activities (i.e., interview question formation), performance during the interview (i.e., participation and attention levels), and post-interview performance (i.e., a test assessment of local water quality issues).

Use the following guidelines (found on the next page) to evaluate student participation (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs Improvement	Satisfactory	Excellent
Participation	Did not participate in the interview or any class discussions leading up to the interview.	Participated in the interview and the discussions leading up to the interview. Prepared relevant questions. Recalled information from the interview.	Participated in the interview and the discussions leading up to the interview. Volunteered time and ideas in preparation for the interview. Prepared relevant questions based on the topic being discussed. Recalled information from the interview and could apply it to situations in their community.
Ability to formulate relevant interview questions	Did not prepare questions or prepared questions that were not relevant to the subject being discussed.	Prepared relevant questions.	Volunteered time and ideas in preparation for the interview. Prepared relevant questions based on the topic being discussed. Recalled information from the interview and could apply it to situations in their community.
Understanding of how natural resource issues such as water quality are dealt within the local community	On test or other given assessment, did not demonstrate understanding of how natural resource issues such as water quality are dealt within the local community.	On test or other given assessment, demonstrated basic understanding of how natural resource issues such as water quality are dealt within the local community. Recalled some information from the interview.	On test or other given assessment, demonstrated strong understanding of how natural resource issues such as water quality are dealt within the local community. Recalled most information from the interview and was able to use that information in responding to test questions.

Saving Soils: Unit Overview

In this unit students will discover the importance of fertile soils and explore the causes of, and methods for, preventing soil erosion.

The lessons provided in this unit were designed to build upon students' current knowledge and understanding of soil quality. These lessons are examples of ways to help students take their knowledge one step further and see how it connects with new information. The lessons and assessment guidelines may need to be modified by teachers to better fit the needs of their class size, local culture, materials available, and learning environment (when possible, ways to modify activities are suggested).

To begin the unit, students explore an essential question (a broadly-focused question that is essential to the theme of the unit) through a combination of observation and measurement activities. Based on their observations and previous knowledge they will then formulate questions that will lead to further inquiry. These questions reflect students' interests about the topic of study.

Teachers can structure this student-generated inquiry by using the provided template and background information on the scientific method to create lessons that will help answer student questions. The lessons provided under *Activities to Address Student Questions* are examples of what lessons may look like.

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Although teachers provide the general structure for inquiry activities, using *students'* questions for further investigation will enable them to combine previous knowledge that is valuable to them with new knowledge that they hope to gain. By helping students learn about topics that are interesting to them, they will gain a sense of ownership in what they are learning and will be more open to and excited about learning. The results of this synthesis will also help students to make more informed decisions about managing their natural resources (in this case, soils).

This particular unit of activities is the most technical of the units provided and is therefore geared towards secondary school students. The authors encourage all teachers to review it and decide if the lessons could be used for their students, regardless of grade level. Lower grade level teachers can use this unit as an example of how to make a different unit more technical.

Unit Outline

Essential Question: How might human actions, such as land use, lead to the loss of fertile soil, and how does that loss affect us?

Ask your students this essential question and then talk about possible answers. Write the answers in a place where students can see them (or have students come to the board and add their words and answers; you can be in the background as a facilitator). Explain to students that in order to further answer the question, they will complete some observation activities. These activities will also help them to create more specific questions about soils and soil erosion.

Observation activities to introduce the essential question

What We Know About Soils
As a class, students will discuss what they know about soils, what they are unsure of about soils, and what they do not know about soils.

Soil, Plants and Animals: A Natural Connection
Students will observe a soil profile and form conclusions about the formation of soil in an undisturbed ecosystem. They will also discuss the nutrient cycle.

Soil Erosion Demonstration
Students will learn about SANREM research on soil erosion, demonstrate the process of soil erosion, and attempt to use methods that help prevent soil erosion using a mountain landscape model.

During completion of these introductory activities students will be thinking of and recording questions that they develop about the interactions between the soil system and the social systems in the local community. Students will choose their favorite question, write it on a slip of paper, and hand it in to the teacher.

Guidelines for questions

Teachers may wish to write all of the questions on the board so that the students may see them, compare them with other student questions, and know when their question has been addressed.

Teachers should place all of the questions on their desk and group the questions that are similar. Students with similar questions can work together in a group. One of the objectives of the next activities should be to address all of the students' questions.

Activities to address student questions

A Soil Study
Students will follow the scientific process to answer physical, chemical, and biological questions about soils and soil erosion near their school. This lesson provides students with several investigation methods that will help them to better understand soils.

Interview a Community Member or Elder
Students will use knowledge of people in their community to answer questions about soil erosion, gather perceptions about soil erosion, and learn about the history of land use and soil erosion in their watershed.

Once students have explored the causes and prevention of soil erosion and have found answers to their questions by using one of the methods suggested above or one of their own, they will be ready to apply what they have learned on a larger scale: in their community.

Ask your students what they consider to be the biggest problems with keeping soils in their community clean and intact (non-eroding soils). What problems do they think are most important? With their input, create a list of projects that the students could complete to protect soil quality in their local community. Help them choose one to start. Support their learning process by encouraging them to become involved in all aspects of setting up and completing the project.

Possible service projects to reduce soil erosion

* Educate the community on soil erosion through pamphlets or a presentation
* Plant trees or other types of vegetation in vulnerable areas
* Help farmers to plant rows of trees in pastures or helping to plant crops in ways that minimize soil erosion
* Start a community composting project

Once students have completed this unit, conduct an assessment to determine the level of understanding that they have gained. In the assessment, ask students to revisit the essential question and write an essay on the topic. To test understanding of the scientific method, have students design an experiment that will answer a question about a topic similar to soils. Include any local curricular standards that need to be assessed. More information about assessment, along with rubrics for judging student work, can be found after each activity description.

What We Know About Soils

Student age: Upper Primary/Early Secondary/Secondary
Location: Classroom
Objectives: Learners will:
1. determine what they know about soils, what they are unsure of about soils, and what they do not know about soils

MATERIALS

***soil samples**
***something on which to write student questions**

Background Information: How often do you stop and think about why soils are important? You may see soil every day of your life, but do you ever wonder why someone would want to study it, or protect it?

Without soil, the world would be a pretty boring place at which to look, and also an unhealthy one. Soils enable plants to grow, whether they are trees, grasses, or flowers. Soil also provides a habitat (home) for many organisms to live. When soils are moved or destroyed (disturbed) these plants and soil-dwelling organisms may die. Humans can also be affected. For instance, if soils are contaminated with chemicals sprayed on food crops (perhaps to kill insect pests), then the food we eat will also contain those chemicals, and that can make us sick. Also, when heavy rains fall on hillsides, soils are often washed into water systems. This can contaminate the water, and if any organism drinks that water (such as a human or other mammal), sickness can occur.

When soil becomes polluted (dirty) with large amounts of chemicals or trash, it creates a

harmful environment in which to live and grow. If humans grow vegetables in this soil, the pollutants can be absorbed into the food which we, in turn, consume. Some of this pollution may come from us throwing trash onto the ground, from oils and chemicals from cars, from chemicals sprayed on vegetables and other crops grown in gardens and on farms, from chemicals from big factories, and from many other places. It is important to keep soil clean so that all living organisms that depend on it stay healthy.

This activity is designed to determine what knowledge children have of soils, either from personal experiences or from learning about soils at home or in school.

Procedure:

1. Pour some soil from your soil samples on a table. Allow students to observe the samples for color, texture, and moisture. Ask them where they think the samples were taken from. Tell students what soils make you think about (e.g., plants growing, worms)

2. On the board, or aloud, ask students to finish the following sentences:

"When I think of soils, I think of..."
"Soils can become polluted (dirty) and unhealthy if..."
"If soils becomes polluted, then _____ might happen."
"If it rains really hard, I notice that soils _____."
"What I wonder about soils is..."

It may help you to organize these questions under three categories:

a. What students definitely know about soils
b. What students are unsure about soils
c. What students don't know about soils

3. Congratulate students on their knowledge and explain to them that they are about to engage in a series of activities about soils that will build upon what they already know as well as help them to explain some of the topics about soils that they are unsure of or do not know anything about.

Time/length of activity: 30-45 minutes

Assessment:

Students should be assessed on their participation in the sentence-finishing activity and their general understanding of why soils are importnat to many organisms and what happens to these organisms when soils become polluted. Assessment can be based on the following guidelines (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Understanding of why soils are important to many organisms and what happens to these organisms when soils become polluted.	Could not recall or explain any reasons why soils are important to many organisms and what happens to these organisms when soils become polluted.	Could recall or explain one or two reasons why soils are important to many organisms and what happens to these organisms when soils become polluted.	Could recall or explain in detail numerous reasons why soils are important to many organisms and what happens to these organisms when soils become polluted.
Participation finishing sentences about soils	Did not participate	Participated and was able to complete some sentences.	Participated and was able to complete all sentences.

Soil, Plants, and Animals: A Natural Connection

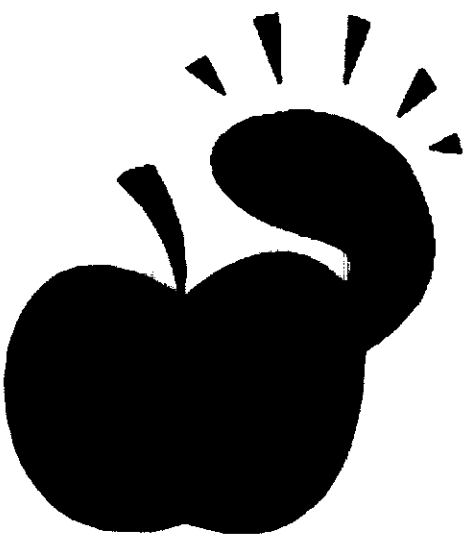
Student age: Secondary
Locations: In the classroom and outside
Objectives: Learners will:
1. Observe layers of soil from different places near the school site
2. Form conclusions about how soils form and erode
3. Discuss the nutrient cycle and its importance in making and maintaining soil

MATERIALS

* A **shovel** or different item to dig down into soil
* **Paper and pencils** for students (if available)
* A little **water**

Background Information:
This activity introduces students to the importance of fertile soils and the ecological processes that create, maintain, and destroy soils.

Soils are formed over time as weather conditions break down inorganic **parent material** (underlying rock) and **organic materials**. Organic materials come from matter that was once living (i.e., plant or animal). Inorganic materials are those that were never living and did not come from living matter. In an undisturbed environment (one in which soil has accumulated naturally over time and has not been lost to factors such as extreme weather or human agricultural efforts) soils will form separate layers called **horizons** which are distinct in color, particle size, and texture. Observing these layers of soil can provide clues about how the soil formed and about possible ways that the soil was disturbed over time. An undisturbed **soil profile (a visual example of soil layers)** might look like the picture on the last page of this activity (an explanation of the layers accompanies the illustration).



Soil is constantly changing due to events that occur in nature. For example, water running through the soil (say, from rain)

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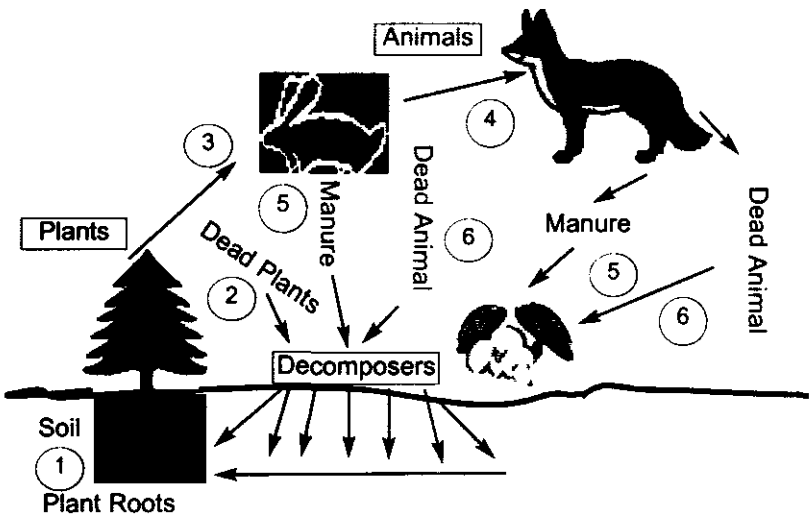


removes nutrients and deposits them deeper in the soil where they are less available to many plants. Also, nutrients in the organic matter in the top layers can **oxidize** (break down after reacting with oxygen) due to contact with the air. Plants are constantly removing nutrients from the soil for food. In order to support plants and other life, soil must balance this nutrient loss by adding new nutrients. These are added as new organic matter from dead plants and animals that have decomposed. In a system where soil has not been disturbed (for example, from human activity such as farming) soil is constantly maintained by the decaying of organic matter and the continued weathering of rocks.

It is important to understand how soil is naturally maintained in an undisturbed system before studying a disturbed system such as an agricultural field. Nutrients are constantly cycling through the soil and through the plants and animals that depend on it. Plants take up soil nutrients through their roots and use them to form the structure of their cells (1). When plants die (2), or shed their leaves, most of the nutrients in them are returned to the soil. If an animal eats the plants (3) (or eats another animal that ate the plants (4)) the nutrients are used by the animal and are returned to the soil in the animal's waste (5) or in the animal's body once it dies (6).

This process of reusing nutrients is called the **nutrient cycle.** A healthy ecosystem will maintain a balance of nutrients moving through the soil, plants, and animals. The nutrient cycle is broken when one of the components (soil, plants, or animals) is removed and its nutrients are not allowed to return to the soil. This happens in agricultural or forestry systems when plants or animals are harvested and removed from the local system. In the case of an agricultural system, farmers usually add nutrients to the soil to make up for the nutrients lost when they harvest plants. Other common interruptions in the nutrient cycle occur when there are not enough **decomposers** (organisms that decompose, or break down organic matter; for example, bacteria or fungi such as mushrooms) in the soil. This can happen due to extremely dry weather conditions or due to lack of insects from pesticide application (often times when pesticides are applied to agricultural crops to kill insect pests, reduce plant disease, or stimulate plant growth, beneficial insects and decomposers are inadvertently killed). **Erosion** (the removal of soil by wind or water) is another threat to the nutrient cycle. In situations where there is erosion, soil may wash away faster than it is formed; this causes problems for the plants and animals that depend upon it. If the topsoil is totally removed in situations of erosion, it can be very difficult for plants to begin growing in that soil again. So, not only will a number of plants be lost, but also the animals that depend on them will have trouble finding food, and therefore surviving.

Procedure:

1. Before class, find two or three areas close to the school where students will be able to observe both disturbed and undisturbed soils.

2. Ask students what they know about how soil is formed. Write the answers on the board. Explain that students will be observing soil from different areas, discussing the differences, and drawing conclusions about how soil is formed and maintained.

3. Visit the sites with students.

4. Using the shovel remove a section of soil from each site. If possible, break students into small groups and have each group remove a section of soil from each site. It is important to try to keep the layers of soil in their natural formation on the shovel; you do not want the layers of soil to crumble and mix with one another. If this is difficult you may instead dig a small soil pit. To do this dig a hole that is deep enough and wide enough to let students observe the soil horizons.

5. Students should draw and/or describe each of the soil layers. They may wish to smear, with some water, a little dirt from each horizon on their drawings to show soil color at the different sites. Students should draw as many horizons as they can see.

6. Upon returning to the classroom discuss the main differences between sites. Draw (or describe) a diagram of a generic soil profile (*see diagram in Background Information*) for students to see and label the different horizons.

7. Did each of the sites visited have the same horizons? Which site had the most topsoil, or the most organic matter? Which site had the least of these? Ask students why there were differences between the sites. What do they think caused there to be more soil at one site and what do they think causes soil to disappear, or never appear?

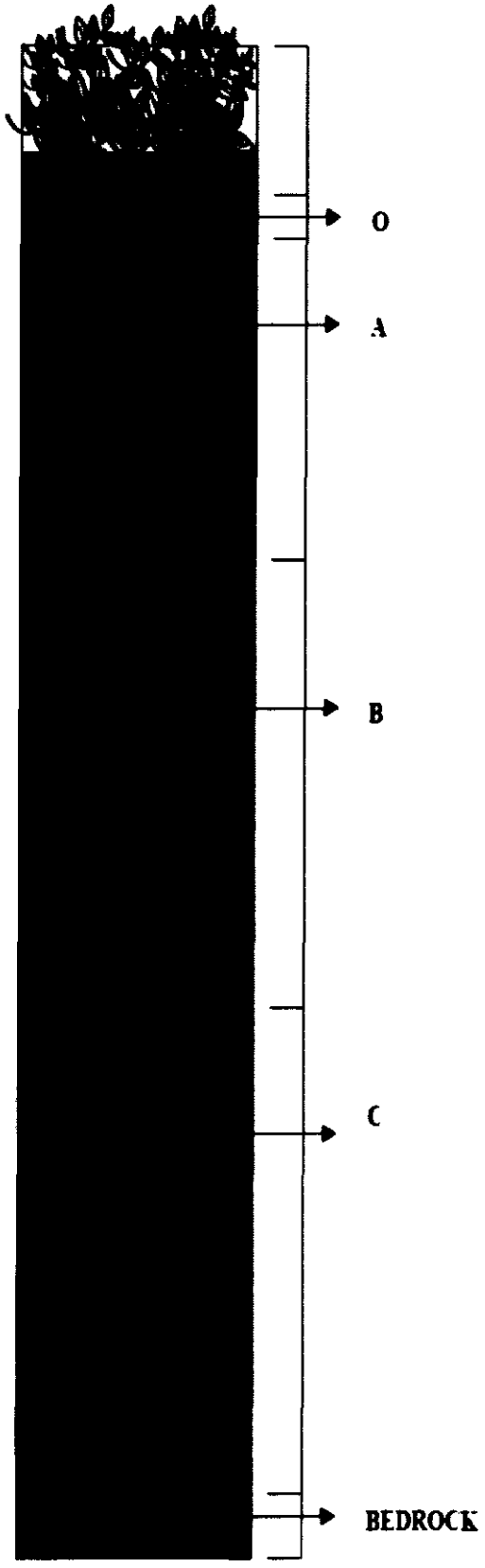
8. Draw a diagram of the nutrient cycle (*see diagram in Background Information*) on the board. Explain to students what is happening in the diagram. You may wish to use local plant and animal names for examples. Discuss this diagram in relation to what students just observed. Did they observe a healthy ecosystem or one that displayed missing soil? If soil was missing, discuss why this might have happened (*use information from Background Information above to help the discussion*)?

9. Discuss situations when the nutrient cycle is broken. What happens when there are no plants? What happens when plants are harvested? What could be done to repair the nutrient cycle? What other threats are there to soil?

Time / Length of Activity:
1-3 hours (includes site visits)

Assessment:
Students should be assessed based on their participation in the activity and discussions as well as their understanding of how soils form and erode and the importance of the nutrient cycle in making and maintaining soils. The following guidelines can be used to judge student participation. Teachers should also determine how to assess curricular standards that were met through this activity.

	Needs Improvement	Satisfactory	Excellent
Participation	Did not participate in the activity or discussions about the activity.	Participated in the activity and discussions.	Participated in the activity. Asked relevant questions and contributed frequently to discussions.
Understanding of how soils form and erode	Did not demonstrate an understanding of how soils form and erode.	Demonstrated a basic understanding of formation of soils and soil erosion.	Was able to provide accurate responses to questions and discussion about soil formation and erosion.
Understanding of the nutrient cycle and its importance in making and maintaining soils	Did not demonstrate an understanding of the nutrient cycle and its importance in making and maintaining soils.	Demonstrated a basic understanding of the nutrient cycle and its importance in making and maintaining soils.	Was able to provide accurate responses to questions and discussion about the nutrient cycle and its importance in making and maintaining soils.



The top layer is made up of both organic material that has not yet broken down and living plants. For example, in a forest this layer might consist of leaves, and in a grass ecosystem this may be a layer of dead grass that has stuck together (thatch). Underneath the layer of fresh organic matter will be a layer of organic material that has been breaking down over time. In the diagram, these two layers are represented by the increment above the letter 'O.'

Below these layers is a dark layer of decomposed (broken down) organic matter. Scientists refer to this layer as the "O" horizon.

One might think that soil would continue to build this way as plants and animals decompose and become part of the soil. However the organic matter mixes with the inorganic matter that comes from weathering of the parent material. This mixing occurs due to the actions of insects and earthworms that live within and travel throughout the top layers of soil; they digest and move the soil as they travel.

The layer of dark soil beneath the O Horizon is called **topsoil**. Soil scientists call this layer the "A" horizon. This layer is rich in nutrients so plants live happily here. You may see many plant roots in both the O and A horizons.

As water falls and flows down through the soil, it will pick up (or **leach**) nutrients in the top layers of soil and deposit them lower in the soil. As this happens the soil often changes color. The subsoil layer, also referred to as horizon "B," is an area where nutrients have been leached out of the soil. Plants with deep roots, such as trees, use this soil layer.

These nutrients are then deposited deeper in the soil at the "C" horizon. Like the B Horizon, plants with deep roots use this soil layer.

At the very bottom of a soil profile is the parent material, also called **bedrock**.

Soil Erosion Demonstration

Student age: Secondary
Locations: Classroom and an outside area near the school
Objectives: Learners will:
1. Listen to a description of a SANREM research project about soil erosion prevention
2. Observe soil erosion on a model of a mountain landscape
3. Attempt to prevent soil erosion on the mountain model
4. Compare the results of different soil erosion prevention methods on the model

MATERIALS

* **SANREM Research Brief** Saving Soil: Integrating Erosion Control in Upland Agricultural Systems (Mindanao Island, Philippines). SANREM CRSP, 2001. [See Appendix III for Brief]
* **List** of soil vocabulary words
* **Situation cards**
* A **shallow tray or wooden box** filled with soil
* A **brick** or other object that can be placed under the soil tray to form an incline (a slant)
* **Water** (ideally in a **spray bottle**)
* **Small sticks and twigs** (to represent trees in the model)
* **Cut grass** and **leaf litter**
* **Rocks**
* **Moss** or another substance (to represent hedges in the model)

Background Information:
Students will listen as the instructor summarizes a scientific document (called a 'Research Brief') called *Saving Soil: Integrating Erosion Control in Upland Agricultural Systems (Mindanao Island, Philippines)* (SANREM CRSP, 2001). The document discusses a research project in which researchers studied different methods of controlling soil erosion. The researchers also studied how willing farmers in the Manupali Watershed (Philippines) were to use the different methods. Since no one will pay the farmers to use these methods, the methods had to provide results that the farmers would like as well as not cost the farmers a lot of time and money to use them.

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This Research Brief illustrates how the process and results of science can be used in local communities. It also reinforces the idea that some of the methods used for farming can leave soils at risk for erosion. The story discusses some methods that can decrease soil erosion as well as some farming methods that cause soil erosion.

After listening to the Research Brief students will further explore erosion prevention by testing erosion control methods on a model mountain landscape.

Procedure:

1. Before class begins place soil in the tray or wooden box and form small 'hills' of soil. These can represent mountains.

2. Ask students to describe what they know about soil erosion.

3. Explain that you are going to summarize a Research Brief about soil erosion prevention. A Research Brief is a paper describing scientific research. Some of the words may be unfamiliar to the students, but they should try to listen for the main ideas in the Brief.

4. Read and/or summarize the Research Brief aloud.

5. After reading the Brief, list new vocabulary words on the board. Ask students to guess the meaning of each word. Present the correct definition. If paper is available, have students record the definitions on a sheet of paper.

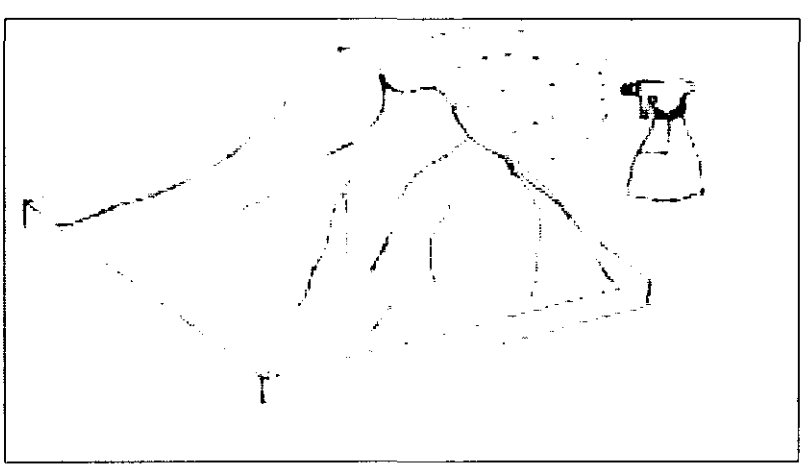
6. Carry the tray of soil outside. Prop one end of the tray on a brick or other object so that it is on an incline.

7. Ask the students to gather around the box observe what happens when you spray water on the soil.

8. Using the spray bottle, spray the soil with water until the water begins to run down the soil into the tray (see illustration below). Explain that this is erosion (the removal of soil by wind or water). When erosion takes place, small gullies may form. As water continues to flow, the gullies may become even deeper. Students will observe that soil at the top of the hills is removed and deposited lower in the landscape (at the bottom of the soil mountains).

9. Show students the materials that represent trees, shrubs, grass, rocks, leaf litter, etc. These are items that can slow soil erosion. Explain that the students will work in groups and use these items to attempt to slow soil erosion in the mode.

10. Each group will be given a Situation Card (found on last page of this activity) that describes a situation that the students must imagine. Each card describes goals that the students must keep in mind while trying to determine the best way to prevent soil erosion (i.e., the need to grow crops, etc.).



11. Allow each group five minutes to read their Situation Card and decide what they will do.

12. Each group will then read their situation to the rest of the class and use the model to demonstrate their solutions (this will take at least 5-10 minutes per group, so this final step of the activity may need to be broken up over several classes). Students will place their erosion prevention "tools" (i.e., the sticks) in the tray of soil "hills" and "mountains" and then spray the model with water to determine the success of their solutions. Did their placement of material help prevent soil erosion? (The soil in the tray should be smoothed after each use. If the soil becomes difficult to work with new soil should be added to the tray. Make sure that the soil added is similar to the original soil in the tray. Different types of soil may react differently to the same experiment.) Remind students of solutions that were tried in the Research Brief and ask students to talk about the success of these methods.

Follow up discussion:
Discuss the successes and failures of the different methods that were attempted in the Research Brief and in class. Ask students which methods might be easy to use in real life, such as in farms in their community, and which would be difficult. Are there benefits to some of the more difficult methods (e.g. planting rows of trees may take time but the trees can be harvested for additional income for the farmer)? Ask students if soil erosion seems to increase or decrease with the amount of vegetation present in the model. Why does this happen? Remember that in real life trees have roots that make them better at holding soil (and therefore preventing erosion) than the simulated trees in the model. Discuss other similarities/differences between the model and what happens in real life. Ask students if what they learned from the Research Brief and from the class demonstration could help prevent soil erosion in their local community.

Time / Length of Activity:
2-3 hours

Assessment:
Assessment should be based on students' understanding of the main points of the SANREM Research Brief and the new vocabulary words, participation in the activity, and understanding the benefits of different soil erosion prevention methods. A written test or discussion can be used to assess student understanding of the main points. The following guidelines will help in judging students' understanding and participation. Teachers should also determine how to assess curricular standards that were met through this activity.

	Needs Improvement	Satisfactory	Excellent
Understanding of the research brief	Does not demonstrate an understanding of the research.	Demonstrates an understanding of the main points of the research.	Demonstrates an understanding of the main points and many of the details of the research.
Understanding of new vocabulary words	Demonstrates an understanding of little or none of the new vocabulary words.	Can give a basic definition of the new vocabulary words.	Can define the new vocabulary words and has attempted to use them in context.
Participation	Did not participate in the activity or any class discussions about the activity.	Participated in the activity and discussions.	Participated in the activity. Asked relevant questions and contributed frequently to the discussions.
Make comparisons of different soil erosion prevention methods	Did not make comparisons.	Was able to make general comparisons.	Made comparisons specific in detail that demonstrated benefits to different types of soil erosion prevention methods.

Soil Research Brief Vocabulary Words

Agro-forestry system: a system in which agricultural crops (i.e. foods) are grown with trees.

Canopy cover: the thickness (density) of tree leaves and branches. A dense canopy cover will protect soil better than one that is less thick.

Ecological: refers to ecology – the study of plants and animals as well as their interactions with each other and their surrounding environments (including living and non-living aspects).

Economic: refers to the economy and the related social system of trade and commerce.

Efficacy: capacity or power to produce a desired effect.

Environmental stress: continued disruption of an ecosystem caused by human actions.

Erosion (erosive): the movement (and potential loss) of soil caused by water or wind moving across a landscape.

Fallow land: land that is not planted for a season in an attempt to rebuild nutrients in the soil (or in the least, to not diminish soil nutrients).

Hedgerow: a row of bushes or small trees that when planted on the contour of a hill will slow water moving down the hill and decrease soil erosion.

Leaching (leached out): a chemical reaction in which soil chemicals separate and drain away from water; these soil particles are eventually removed from the soil.

Organic matter: materials in the soil that came from living plants or animals and contain the element Carbon.

Planting on the contour: planting across a hill rather than up and down the hill. This practice slows soil erosion by blocking or slowing water as it moves down the hill.

Population pressure: the effect of an increasing population of organisms on a limited number of resources on which the population depends (i.e., food, shelter).

Rotate crops/Crop rotation: a practice in which farmers do not plant the same crop in the same place year after year but rather plant different crops in the same area year after year. This is done so as not to deplete the soil of particular nutrients or so as to build up soil between growing seasons.

Siltation: the natural process of eroded materials, such as silt, lying down along a stream or other body of water.

Situation Cards

You are a farmer who grows tomatoes and cabbage in a rotation. You usually grow your crops up and down the slope of your hill to let water flow down the slope. However you are losing a lot of soil to erosion. You are not able to support your family on fewer crops. What can you do to decrease soil erosion in your fields?	You are a farmer who grows corn in a field on a hill. You have problems with soil erosion. You are also getting older and would like to make money without having to work so hard. What can you do to 1) decrease soil erosion on your land and 2) decrease your workload without decreasing the amount of money that you make? Can you achieve both of these goals at the same time?
You are a new farmer with fields on a very steep slope. Your soil could easily wash away without multiple soil erosion prevention measures. You are not sure what crops you would like to grow. What can you do to avoid soil erosion on your land?	Your home is on the bank of a stream. The banks of the stream are very eroded. If nothing is done, the stream water may continue to erode the soil at the bank and put your home in danger. What can you do to prevent this from happening?
You own forested land and are trying to figure out the best way to grow food crops while preventing soil erosion. Your choices are to plant rows of crops on the contour of the slope with hedgerows and rows of trees separating the crops; or you could not plant crops on the sloped forest land and instead put crops on forest land that is flatter. Which would you choose to decrease soil erosion?	You are a farmer trying to decide if you should plant crops or graze cattle on a steep piece of land. Which would you choose to decrease soil erosion on your land?
You have a small field on a hill. You just prepared the soil for planting but must wait a few weeks before you can begin. You are worried that it might rain before you get a chance to plant your crops and this could cause erosion on the unprotected soil. What can you do to protect the soil in the next couple of weeks and while the new plants are growing?	You would like to build a house. To do so you will need to clear some land and level out the soil. What can you do ahead of time to keep the soil that you moved from eroding when the rainy season begins next month?

A Soil Study

Student age: Secondary
Locations: Outside on the school grounds or in the local community
Objectives: Learners will:
Study soils and soil erosion in the area using the steps of the scientific method.
Specifically, learners will:
1. Determine questions that they would like to answer about soils and soil erosion
2. Make hypotheses about soils and soil erosion
3. Design or apply a method(s) for testing and soils and soil erosion
4. Implement a method(s)
5. Collect data
6. Organize results
7. Draw conclusions about soils and soil erosion based on results
8. Present results to a wider audience

MATERIALS

(materials specific to experiments are listed before each experiment in procedure #8)

* **Paper and writing instruments** for each student (or somewhere that they can write/draw)
* **Blackboard and chalk** (or somewhere that you can write/draw and all students can see)
* **Poster paper** for students to display experiment results (or somewhere that students can write/draw and all students can see)

Background Information:
There a number of ways for teachers to help students find answers to their questions created during the introductory observation activities (see *Soil Unit Overview* for more information on helping students to formulate questions). Below we provide several suggested activities that employ the scientific method. The best method to use, however, will depend upon the specific question being asked by each student or group of students.

When scientists want to answer a question they follow a series of steps commonly referred to as the **scientific method**. This method is useful in organizing information to better answer specific questions. The scientific method includes observing, questioning, form-

ing a hypothesis (a guess that comes from an assumption), testing the hypothesis, analyzing the results of the test, and rejecting or accepting the hypothesis.

This activity was designed to demonstrate methods for measuring and monitoring soil characteristics and soil erosion. These methods are useful in comparing soils at an eroded site to those at a non–eroded site. Some or all of the methods (listed in Procedure 8) may be used to test soil quality in an area. All of the tests may be completed at the same sites.

Students may have additional questions that are not covered in this lesson plan. Using the methods outlined, students should be able to design other experiments or tests to answer these questions. A list of additional resources for testing soils follows this lesson plan. The soil tests described in this activity and in Appendix VIIB are only suggestions of ways that you can make observations about soil in your community to try to answer student questions about soil; your class could complete one or all of them. Above all, we encourage students and teachers to make scientific observations in the most appropriate way for their class.

Whichever tests you use, we encourage you to complete the test multiple times in order to compare results. Comparing methods and results of different kinds of tests may help you to determine which test works the best, and comparing results of the same test done multiple times will help you to decide if your observations and conclusions are accurate ones. The more times that you can achieve the same results, the more likely that your are observing a true phenomenon and not something that just happened by chance.

Procedure:

1. Review the introductory **observation** activities that the students have completed. Record any student questions on the board, or somewhere that all students can see (Refer to the *Soil Unit Overview* for more information).

2. Explain to students that they will have a chance to answer some of their questions using the scientific method.* The scientific method will help them to organize the information needed to objectively answer their questions about soils. Answering their questions "objectively" means that they will try to answer their questions without letting their ideas interfere with their study. For instance, they may have an idea that soil from an undisturbed forest plot may contain more nutrients than soil used for agriculture, but they cannot

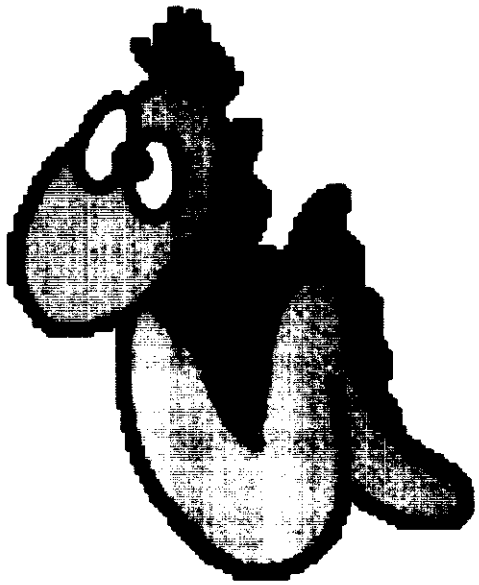
allow their idea to lead them into reporting that result if it is not found through their study. Explain or write the steps of the scientific method on the board (see *Background Information*). Students have already made general observations about the soil quality in the area. Now they will apply a simple test to learn more.

*Some student questions may be answered without practical testing but instead by simple observation.

3. Determine which student questions can be tested using the scientific method (highlight them on the board, if possible). These questions need to be specific and detailed in focus. In other words, how can you test something you do not understand? Consider the following example:

Do earthworms *like* to live in topsoil?

It is impossible to determine what earthworms like or do not like because even though you could ask an earthworm what it likes or does not, it is not going to give you an answer! However one can examine the behavior that earthworms exhibit in certain circumstances, and that could give an idea as to what an earthworm might prefer. The original question could then be reworded to ask a more specific one such as:



Do more earthworms live in topsoil or in muddy water near streams?

This question is quite clear in what it is asking and depending on the test used, one may be able to conclude that earthworms prefer to live in one area or another.

Another example of a question that can be made more specific is:

Is our soil healthy?

This question can be qualified in the following ways:

Is our soil healthy enough to support new crops each year or Is our soil healthy enough to support plants that need a lot of nutrients?

With student participation, review each of the questions that can be tested using the scientific method, and make any changes needed so that questions become more specific and therefore easier to test. This lesson plan will focus on the following questions:

* What is a "natural" rate of soil erosion and how does it compare to the rate of soil erosion on a typical agricultural field?
* How do eroded and non–eroded soils differ in depth and texture?
* How do eroded and non-eroded soils differ in their capacities to absorb and hold water?
* How do eroded and non-eroded soils differ in the number and diversity of soil organisms present?
* How do eroded and non-eroded soils differ in levels of acidity?
* What plants protect the soil more in a rain event?

4. After making the questions as testable as possible, ask students to think of **hypotheses**. Explain that an hypothesis is a temporary explanation for an observation or scientific problem that can be tested by further investigation. It can come from experience, previous research, or simply an assumption. Ask each student to think of an hypothesis for each question. There are many possible correct answers. Some examples follow:

* The rate of soil erosion in an agricultural field is greater than the "natural" rate of soil erosion.
* Eroded soils are not as deep as non-eroded soils and they contain more sand and small rocks.
* Non-eroded soils can absorb and hold more water than eroded soils.
* Non-eroded soils contain more soil organisms (i.e., worms, decomposers) than eroded soils.
* Non-eroded soils have a higher level of acidity than eroded soils.
* During a rain event, corn protects soil more effectively than tomatoes.

5. Depending on the hypotheses, a test may take place in one site or several sites, and it may need to be conducted more than once. For example, the hypothesis that during a rain event, corn protects soil more efficiently than tomatoes would require testing in dry and in rainy conditions. Read the list of hypotheses with the students and as a group determine in how many places and the number or times each hypothesis needs to be tested. Many of the above hypotheses can be tested in two or three eroded and non-eroded sites.

6. Break the class into groups so that each group can focus on one hypothesis. Students should be placed in groups based on similarities in their question derived from observation activities. Ask students to come up with ways to test the hypotheses. Give them a set amount of time to think of answers. After students have finished, (or earlier, if students are having difficulty) describe some of the test methods listed in Procedure 8. Let students compare their methods to the methods described and then decide which methods would best test their hypotheses. All of the students should be familiar with all of the questions/hypotheses and test methods.

7. Once each group of students has chosen the methods that they will use, determine sampling dates and times.

8. Implement the **tests***:

*For simplicity of this activity, we are providing one possible test of soil quality (**Measuring soil erosion rates**). Additional tests are provided in Appendix VIIB.

Measuring soil erosion rates

Soil erosion occurs all of the time. Even in an undisturbed ecosystem soils are constantly being eroded and deposited into new areas. However, in an undisturbed ecosystem the rate of soil erosion is much slower. Plant roots hold the soil in place and a thick layer of leaves protects the soil from the force of raindrops. Using the following method, students can compare the rates of soil erosion on different plots of land. Students may wish to compare the rate of erosion on an undisturbed plot to that of a cleared plot. Other possible comparisons include plots with different slopes, plots with different ground covers (vegetation that covers the ground), or a plot that has been plowed on a contour and a plot that has not.

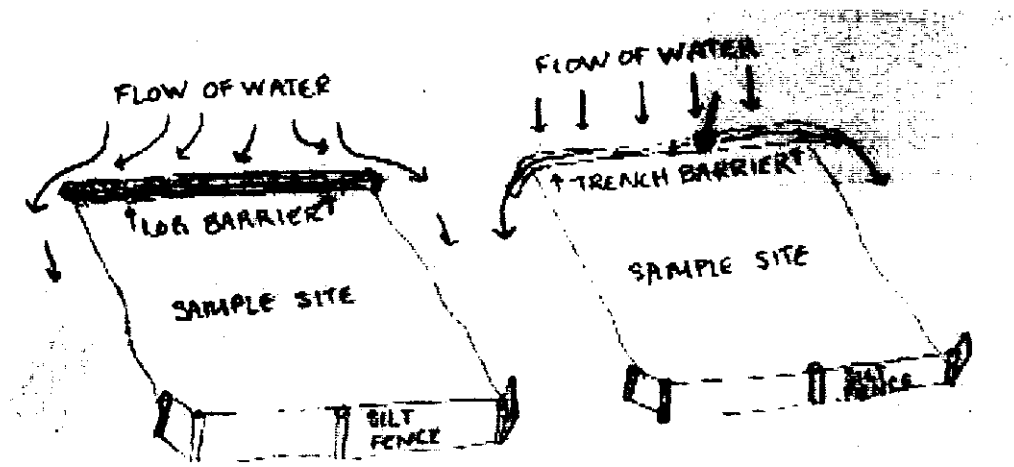
Soil erosion and soil erosion rates are complicated to measure on a large scale. The following method is adapted from a United States Department of Agriculture, Forest Service Publication on using silt fences to measure soil erosion rates (USDA, *Silt Fences, An Economical Technique for Measuring Hillslope Soil Erosion*). Silt fences are simple fences that are made of a thick fabric that are placed towards the bottom of a hillside slope. When the soil on the slope is disturbed, such as when it rains, the soil washes down the slope and is caught by the silt fence. Silt fences help prevent the soil from being deposited at the very bottom of the slope, which is often a water source, such as a stream. The technique described requires that students study small plots of land during several rain events (depending on how often it rains, this technique make take a period of weeks or months). If it is not possible to study agricultural land, students may wish to simulate a small plot of cultivated land for this study. A plot that is only three or four-square meters is a good size with which to work.

Materials:

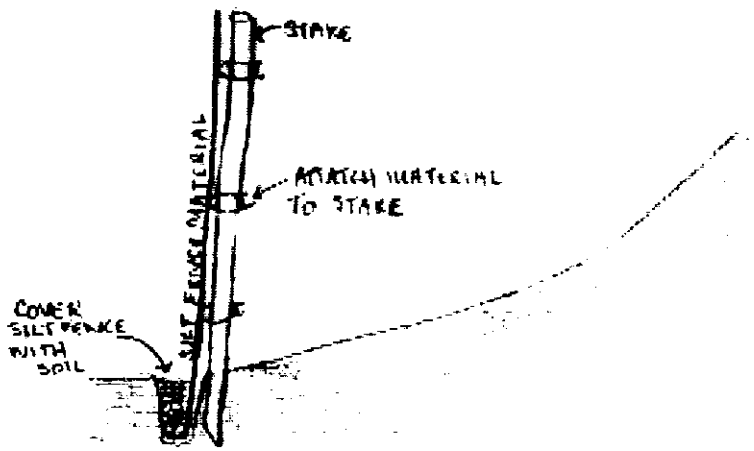
* A supply of **silt fence** (actual silt fence is made from geotextile fabric, but similar cloth such as burlap or feed sack material will also work, as long as the same type of fabric is used at each site. If fabric is unavailable, woven grasses or reeds may also work. Looser knit fabric will allow more soil particles to pass through than tighter knit fabric. However, fabric that is too tightly knit may not allow water to pass through quickly and this may cause the fabric to rip or the stakes to fall over.)
* **A scale or balance** that can be used to measure the weight of the accumulated sediment. (If these are not available the sediment can be measured using buckets)
* **Stakes or posts** (thick sticks will work) to hold up the silt fence; nails and a hammer or wire/string to fasten the fabric to the stakes
* A **shovel** or other digging tool
* **Paper and pencils** for recording data
* Optional: thin layer of cloth

Choose two sites to compare the amounts of erosion from different agricultural practices or ground covers. The areas should be similar in size (3 or 4 square meters) and soil composition (the types of soil present).

Students should dig a small trench or place a log at the top of each site to keep soil above the measured site from moving into the site.

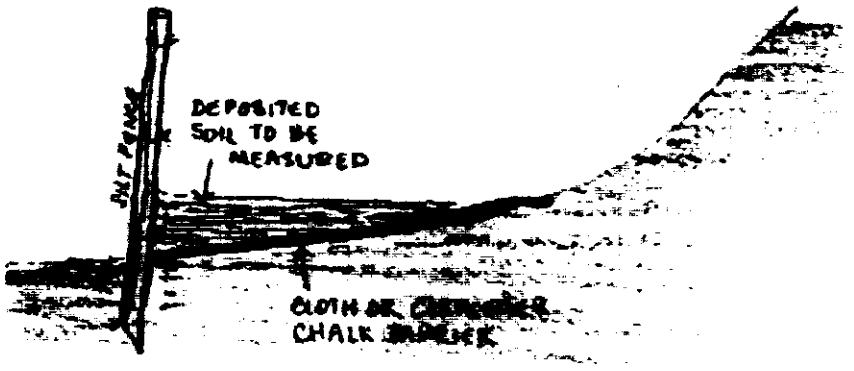


At the base of the site students will need to set up a silt fence to catch sediment. To set up the silt fence, dig a small trench (about 15 centimeters (cm) deep) and place one end of the fabric in the trench. Bury the end of the fabric with dirt so that it is held firmly in the ground. Place stakes in the ground at regular intervals and attach the fabric to the stakes with string or wire. You will probably need to put small holes is the silt fence material so that you can put the wire or string through it, in order to tie the material to the stakes.



Setting Up a Silt Fence

After a set period of time or a single rain event, visit the plots and measure the amount of soil that eroded and was deposited at the bottom of the hill. To measure the amount of sediment collected at each site, students will remove the sediment with a shovel and weigh it in the hanging scale (see following page for diagram). If a scale is not available measure the soil based on the number of buckets of soil removed. Students should record the weights on a piece of paper.



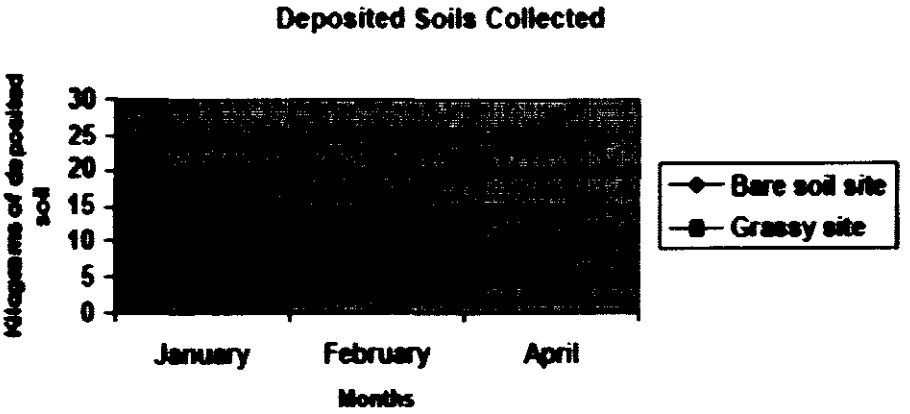
Deposited Soil To Be Measured

Return to the classroom and compare the results at the different sites. Ask students to graph the results on a bar graph to compare the amounts of soil collected. Were the results similar to what they expected? Discuss any problems with their soil erosion study. What could the students have done differently?

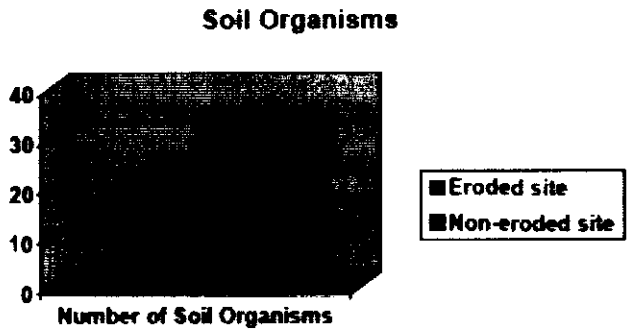
(Please refer to Appendix VIIB for additional activities to test soil quality)

9. After completing data collection for this example soil quality test, ask the students to revisit their hypotheses and think about how they can use their data to either accept or reject their hypothesis. Demonstrate some common graphs that can be used to compare data.

Line graphs or **bar graphs** can be used to compare measurements of the same variable taken at different times or different sites (for instance, data collected at both eroded and non-eroded sites or data recorded for the amount of soil deposited in one area over time).



Example Line Graph



Example Bar Graph

After demonstrating graphs have each group of students prepare a graph to describe what they observed in their test. Students should present their graphs to the class.

10. Based on the information found, the class should decide if each hypothesis should be accepted, rejected, or if there is not enough information to form a conclusion. A rejection actually eliminates one variable that could be causing problems with soil quality and brings you one step closer to the right answer.

11. Discuss the results of the entire activity with the class. Ask students if they were satisfied with their results. Do they think that their results were accurate? What would they do differently next time? Did they come up with new questions as they were trying to answer the original question?

12. The class should work together to create a presentation of all lessons learned about the soil that they studied. Arrange a time when students can present this information to a larger audience that may include parents and community members, or other students at the school. The important information learned/discovered about sources of erosion should be presented to a wide audience so that it might influence the behavior of those involved in land use. Students should present their information orally, as well as visually using charts, graphs, and pictures.

Time/ Length of activity: Varies depending on activity or multiple activities that you complete

Assessment:
Students should be assessed based on their participation in the activities, their understanding of the scientific method and the information gathered during activities, and their overall understanding of the topics covered. Participation should be evaluated throughout the project. Assessment of student presentations and an exam that focuses on using a similar process to answer a different question can be used to evaluate their understanding of the scientific method and the information gathered during activities as well as their overall understanding of the topics covered. The following guidelines can be used to assess student work (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Participation in the activities	Did not participate	Participated	Participated and asked relevant questions
Understanding of the scientific method	Did not demonstrate an understanding of the scientific method. Did not differentiate between questions that could be answered and could not be answered using this method. Did not demonstrate the formulation of a testable hypothesis. Lacked accuracy in collecting data. Did not display data relevantly. Had trouble following the same process to answer a new question	Demonstrated an understanding of the scientific method. Differentiated between questions that could and could not be answered using this method. Formed a basic hypothesis for a variety of questions. Collected data accurately. Displayed data in a way that supported the acceptation or rejection of a hypothesis. Could relate most of the steps of the process to a new question. Demonstrated a detailed understanding of the scientific method.	Differentiated between questions that could and could not be answered using this method and transformed questions that could not be answered into those that could. Formed specific hypotheses for a variety of questions. Collected data accurately and suggested methods for improving accuracy. Displayed data in a variety of ways that supported the acceptation or rejection of a hypothesis. Could relate all of the steps of the scientific method to a new question.
Understanding of the topic studied	Recognized less than half of the factors that were tested by the class in this project. Did not recall the conclusions to the study. Could identify less than half of the methods used for data collection. Did not demonstrate recognition of the importance of healthy soils.	Recognized the factors that were tested by the class in this project. Recalled the conclusions to the study. Could identify most of the methods used for data collection. Demonstrated recognition and understanding of the importance of healthy soils.	Gave a detailed explanation of the factors tested by the class and how they relate to each other. Recalled the conclusions of the study and how they were reached, including all of the methods used for data collection. Demonstrated recognition and understanding of the importance of healthy soils and the threats to healthy soils.

Works Cited:

Robichaud, Peter R. and Robert E. Brown. *Silt Fences: An Economical Technique for Measuring Hillslope Soil Erosion*. General Technical Report RMRS-GTR-94. USDA Forest Service, Rocky Mountain Research Station. 2002.

Resources for Soil Testing Materials*:

LaMotte Corporation produces soil testing kits as well as lesson plans for teachers to use with the testing kits. Information online at http://www.lamotte.com/pages/edu/soil.html.

Carolina Biological Supply offers all types of tools for teaching the sciences to students. Find them online at http://www.carolina.com/

Another supplier of science supplies for the classroom, Ward's Natural Science, can be accessed online at http://wardsci.com/Default.asp?

Science Stuff also offers soil testing kits. These can be ordered online at http://www.sciences-tuff.com/Merchant2/merchant.mv?Category_Code=En-s

*Many other companies offer soil-testing equipment and can be found on the World Wide Web by searching for "soil-testing."

Interview a Community Member or Elder

Student age: Secondary
Locations: Classroom or meeting area that facilitates a question/answer dialogue
Objectives: Learners will:
1. Listen to a local person's perspective on soils and soil erosion in the area
2. Ask questions about soil quality in the area and how it relates to quality of life
3. Understand how natural resource issues such as soil erosion prevention are dealt with in the local community

MATERIALS

* **something on which to write or record questions and answers** (i.e., paper, pencil)

Background Information:
Information to help answer student-generated questions about soils and soil erosion in the community may be obtained by talking with a community member that is involved with, and therefore affected by, soils on a local level. For example, students may use the knowledge of their interviewee to answer questions about history of land use and soil quality in their local watershed. Interviews with multiple people may be necessary to answer student questions.

Tours of farms may also be available and could provide students with first-hand accounts of how soil is maintained and prevented from eroding in the community.

Some people to consider interviewing are: farmers who are concerned about healthy soil and soil erosion and who have tried different erosion prevention measures; community workers who help farmers use better ways to manage and protect soil; or community members who are affected by soil erosion and the resulting siltation of local streams and other water sources.

Procedure:
1. Based on students' questions (see *Soils Unit Overview* for more information on helping students to formulate questions), ask the class

to come up with a list of people that they could ask about soils and soil erosion. Ask students if they know anyone on the list. This will be helpful in finding out how to contact different people.

2. Contact people on the list to set up interviews. First contact the people that could potentially answer the most questions. Explain what you are doing and how you would like them to help. It is important to make clear that you would like the students to conduct the interview, so the speaker will need to be comfortable with this format. Be sure to ask the speaker if they are comfortable being tape recorded, if you choose to use this interview technique. The speaker may also wish to give an additional presentation or talk. Some people may not be able to participate because of scheduling conflicts. If one person on the list is not available, call others until you have enough speakers lined up to answer student questions. Set times for meeting the various speakers.

3. Tell students in advance who will be speaking and what the speakers' roles are in the community. Remind students that they are trying to obtain information that will help them answer their questions about soils. Ask students to consider the speakers' roles in the community when thinking of questions to ask that might help answer their questions about soils. You may wish to make sure that each student has a relevant question to ask (by relevant, we mean that the question may elicit information that will help answer the students' questions about water).

4. Set a format and rules for the interview. Explain to students that they are to listen carefully to what each speaker has to say and to not interrupt them as several of the interviewees' answers may help a student answer his/her question about soil. Students may wish to take notes each time the interviewee answers a question, or a different student or group of students could be assigned to take notes on each interview question response.

Students should listen carefully to determine if the speaker has answered their questions so that they do not ask the same question twice. Students may ask questions one at a time, or they may ask questions spontaneously as topics are discussed. Also, encourage students to avoid jumping from topic to topic, a common problem in group interviews (a "mock" or rehearsal interview might be a good idea), as this can be confusing for the speaker and interrupt his/her natural train of thought. It is important that the format used encourages all of the students to participate in asking questions.

5. On the day of the interview welcome the speaker and introduce her or him to the class. Allow as much time as needed or available for student questions and any other presentation by the speaker. Following the interview, offer a round of applause. It may be appropriate to offer a small gift of thanks to the speaker. Discuss this with the students and ask them to help create or purchase the gift.

6. After the interviews, ask students to recall what they have learned and how this information might apply to their questions about soils.

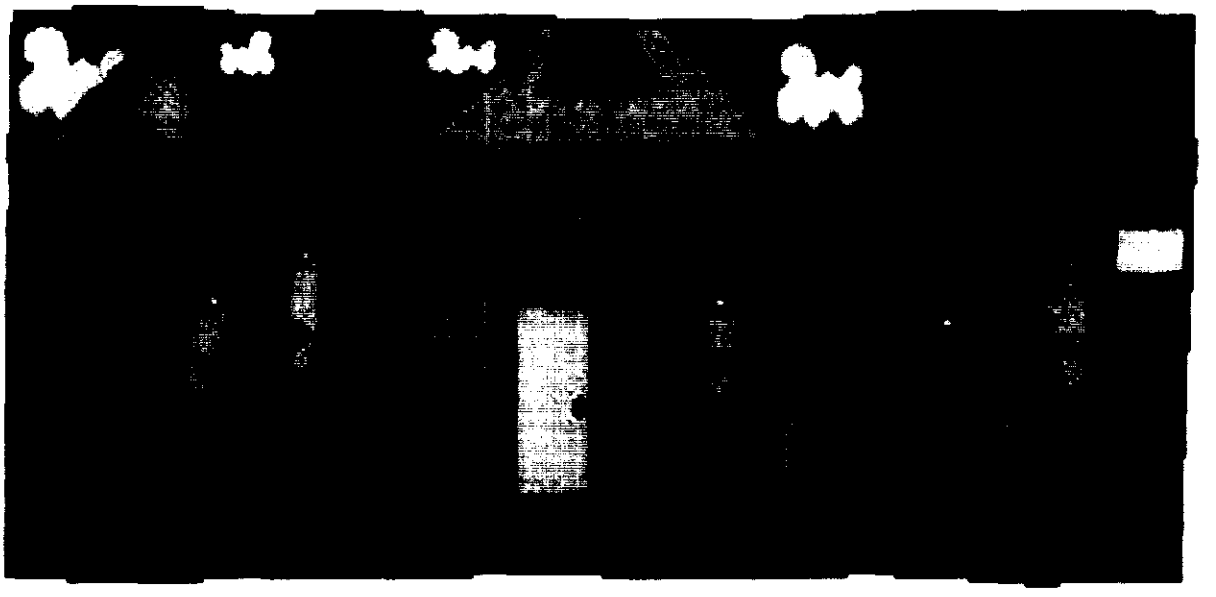
Time/ Length of Activity: Varies

Assessment:
Assess students on their level of participation, their ability to formulate relevant interview questions (questions that may elicit information to help answer student questions about soil), and their understanding of how natural resource issues such as soil erosion are dealt within the local community. Assessments can be based on pre-interview activities (i.e., inter-

view question formation), performance during the interview (i.e., participation and attention levels), and post-interview performance (i.e., a test assessment of local soil quality issues). Use the following guidelines (found on the next page) to evaluate student participation (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs Improvement	Satisfactory	Excellent
Participation	Did not participate in the interview or any class discussions leading up to the interview.	Participated in the interview and the discussions leading up to the interview. Prepared relevant questions. Recalled information from the interview.	Participated in the interview and the discussions leading up to the interview. Volunteered time and ideas in preparation for the interview. Prepared relevant questions based on the topic being discussed. Recalled information from the interview and could apply it to situations in their community.
Ability to formulate relevant interview questions.	Did not prepare questions or prepared questions that were not relevant to the subject being discussed.	Prepared relevant questions.	Volunteered time and ideas in preparation for the interview. Prepared relevant questions based on the topic being discussed. Recalled information from the interview and could apply it to situations in their community.
Understanding of how natural resource issues such as soil erosion prevention are dealt within the local community	On test or other given assessment, did not demonstrate understanding of how natural resource issues such as soil erosion prevention are dealt within the local community.	On test or other given assessment, demonstrated basic understanding of how natural resource issues such as soil erosion prevention are dealt within the local community. Recalled some information from the interview.	On test or other given assessment, demonstrated strong understanding of how natural resource issues such as soil erosion prevention are dealt within the local community. Recalled most information from the interview and was able to use that information in responding to test questions.

Local Lenses: Unit Overview



In this unit students will explore how the cultural values shape interactions with, and opinions of, the environment.

The lessons provided in this unit were designed to build upon students' current knowledge and understanding of cultural values and their affect on attitudes towards the environment. These lessons are examples of ways to help students take their knowledge one step further and see how it connects with new information. The lessons and assessment guidelines may need to be modified by teachers to better fit the needs of their class size, local culture, materials available, and learning environment (when possible, ways to modify activities are suggested).

To begin the unit, students explore an essential question (a broadly-focused question that is essential to the theme of the unit) through a combination of observation and measurement activities. Based on their observations and previous knowledge they will then formulate questions that will lead to further inquiry. These questions reflect students' interests about the topic of study.

Teachers can structure this student-generated inquiry by using the provided template and background information on the scientific method to create lessons that will help answer student questions. The lesson provided under *Activities to Address Student Questions* is an example of what a lesson may look like.

Although teachers provide the general structure for inquiry activities, using the *students'* questions for further investigation will enable the students to combine previous knowledge that is valuable to them with new knowledge that they hope to gain. By helping students learn about topics that are interesting to *them*, they will gain a sense of ownership in what they are learning and will be more open to and excited about learning. The results of this synthesis will also help students to make more informed decisions about managing for their natural resources.

UNIT OUTLINE

Essential Question: How do local values and ideas about the environment affect people's management of natural resources?

Ask your students this essential question and then talk about possible answers. Write the answers in a place where students can see them (or have students come to the board and add their words and answers; you can be in the background as a facilitator). Explain to students that in order to further answer the question, they will complete some observation activities. These activities will also help them to create more specific questions about values and attitudes as they relate to managing the natural environment.

Observation activities to introduce the essential question

Seeing Through Others' Eyes
Students will read a story about how values affect decisions, and they will listen to a project summary in which researchers attempt to measure community members' perceptions of the natural environment.

Your Own Eyes
Students will write a personal essay in which they explore a value of their own and how it relates to their attitudes towards the natural environment.

A Picture is Worth One Thousand Words
Students will ask community members to tell short stories and will determine how the stories reflect attitudes, wishes, thoughts, and interests.

During completion of these introductory activities students will be thinking of and recording questions that they develop about the value systems of their community and natural resource management decisions. Students will choose their favorite question, write it on a slip of paper, and hand it in to the teacher.

Guidelines for questions

Teachers may wish to write all of the questions on the board so that the students may see them, compare them with other student questions, and know when their question has been addressed.

Teachers should place all of the questions on their desk and group the questions that are similar. Students with similar questions can work together in a group. One of the objectives of the next activities should be to address all of the students' questions.

Activities to address student questions

Studying Society: The Importance of Stories
Students will use the scientific method to address questions about their local culture. They will conduct and record oral history interviews to gather data from community members.

Once students have explored their local 'culture' and have found answers to their questions by using the method suggested above or one of their own, they will be ready to apply what they have learned on a larger scale: in their community.

Ask your students what they consider to be the biggest environmental problems in their community. How might community members' values affect these problems (e.g., do values create behaviors that enhance the problems?) With student input, create a list of projects that the students could complete to determine how people with different perspectives and values could work together to solve some of the problems and improve the natural environment. Help them choose one to start. Support their learning process by encouraging them to become involved in all aspects of setting up and completing the project.

Possible service projects to improve understanding of community members' perspectives on the importance of the natural environment

* Give a brief performance (e.g., play, puppet show) about how different values affect the use of natural resources
* Organize a group of people of diverse backgrounds (e.g., age, job) to take part in a community clean-up project
* Create a flier or pamphlet that reflects the community's perceptions of why the environment is important

Once students have completed this unit, conduct an assessment to determine the level of understanding that they have gained. In the assessment, ask students to review the essential question and write an essay on the topic. To test their understanding of the scientific method, have students design an experiment that will answer a question about a topic related to cultural and personal values and their influences on natural resource management decisions. Include any local curriculum standards that need to be addressed. More information about assessment, along with suggested guidelines for evaluating student work, can be found after each activity.

Seeing Through Others' Eyes

Student age: Upper Primary/Early Secondary/Secondary
Locations: In the classroom or an outside area that is suitable for reading and group discussion
Objectives: Learners will:
1. Listen to a story about people with different perspectives and values
2. Learn about research on how to measure and quantify local values
3. Consider the importance of different perspectives and values within their own community

MATERIALS

* **Story script**: Seeing Through Others' Eyes
* **SANREM CRSP Research Brief**: Looking at the Landscape Through Local Lenses: Integrating Community Values and Variation in Indicators of Sustainability. SANREM CRSP, 2001.[See Appendix IIII for Brief]
* **SANREM CRSP Research Brief Summary**
* Optional: **paper** and **writing tool** for students to answer questions

Background Information:
Parts of the story script *Seeing Through Others' Eyes* are adapted from the SANREM CRSP research brief: *Looking at the Landscape Through Local Lenses: Integrating Community Values and Variation in Indicators of Sustainability* (SANREM CRSP, 2001).

The story script includes 1) a fictional account of how two people with different perspectives and values attempt to reach the same goal and 2) a summary of a research project in which SANREM researchers quantified community members' values using a series of tests.

Both the story and the project summary present students with information about why it is important to consider all perspectives and values when making natural resource management decisions.

Procedure:
1. Read the story *Seeing Through Others' Eyes* aloud to students or have them read the story

on their own as an in-class or homework assignment.

2. Pause at the appropriate points in the script so that students may answer questions listed in the script. You may wish for them to respond verbally or to write their answers on a piece of paper to be collected for evaluation.

3. Once students have answered the questions continue reading the story.

Follow up Discussion:
1. Briefly discuss the story with the students. What did students learn from the story? Have students experienced similar situations in their own communities?

2. Read the SANREM CRSP Research Brief Summary to the students. Discuss how this project may be useful in making decisions about protecting natural resources.

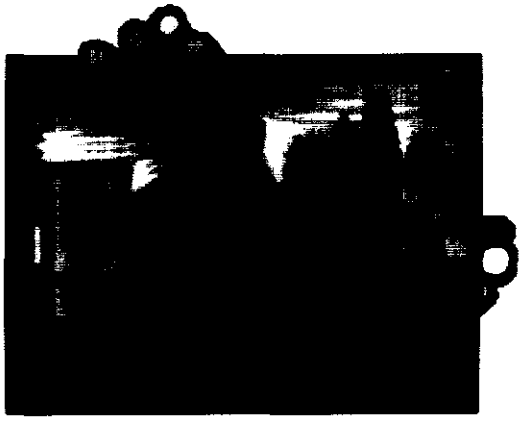
Time/ Length of Activity: 30 minutes

Assessment:
Assess students on their level of participation, their ability to differentiate between the two types of data collection methods discussed, and on their recognition of the importance of measuring different perspectives and values of individuals when making natural resource management decisions Assessments can be based on responses to the story questions and follow-up discussions. Using the following guidelines (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Listened to story about different perspectives and values	Did not listen.	Listened and participated in answering questions.	Listened, participated in answering questions, and asked relevant questions.
Learned about research on how to measure and quantify local values	Did not differentiate between the two types of data that a researcher can gather.	Demonstrated a basic understanding of the two types of data that a researcher can gather and the benefits of each.	Demonstrated a detailed understanding of the two types of data that a researcher can gather and the benefits of each. Gave relevant examples of each type of data and the benefits of each.
Considered the importance of different perspectives and values within their own community	Did not recognize why it is important to measure and include different perspectives and values of individuals when making natural resource management decisions.	Demonstrated a basic understanding of why it is important to measure and include different perspectives and values of individuals when making natural resource management decisions.	Gave a detailed explanation of why it is important to measure and include different perspectives and values of individuals when making natural resource management decisions.

Seeing Through Others' Eyes

Eduardo and Mauricio both lived in the Manupali valley of the Philippines. Eduardo and his family lived on the outskirts of the forest. They were a family of craftsmen who valued the forest for many reasons. Fallen branches from forest trees provided them with firewood for heat and for cooking. Other trees provided them with timber to build a home and furniture for it. Wood and seeds harvested from the forest were used to make jewelry and bowls that were later sold in town. The money that they earned helped them buy clothes and medicine. Eduardo's family was able to live on a modest income because they relied on the land and the forest for many of the things that they needed. Much of the food that they ate came from the forest in the form of animals that they hunted as well as fruits and seeds that they collected. The family also treasured the forest for its coolness, its fresh air, its bountiful birds and insects, the stream that ran through it, and as a place for the children to play. They used the stream for irrigation as well as drinking and bathing water. Eduardo and his family depended on the forest, and they knew that it was not limitless. Eduardo knew that as the population of the village grew, more people would need wood and food from the forest and there would be less to go around.



Mauricio and his family also lived on the outskirts of the forest, and like Eduardo's family, they also valued and depended on the forest. Mauricio, as his father, was a logger. He and his sons had paying jobs from a company in the city: they drove large trucks and cut down areas of forest for timber that was sold all over the world. Their boss gave them a good reason to work hard: he paid them by the number of forest trees they could cut and clear. The more they cut, the more money they made. For Mauricio, the forest was not just a place to live; the trees also meant a salary for his family. Mauricio's family was not rich, but if they worked hard, they could afford to buy all of the things that they needed from the store in town. They also could afford running water that the family used for bathing and drinking. Mauricio and his family depended on the forest, and they knew it was not limitless. Mauricio knew that trees took a long time to grow back, and often after he had cleared a piece of land the soil would wash away. He also knew that the more trees he cut, the fewer he would be able to cut later.

Often times, Mauricio's and Eduardo's families would see each other in the forest and

their children would play in the stream. Eduardo and Mauricio had grown up together and were friends even though they felt that they shared few values. Eduardo knew what Mauricio did for a living and he disapproved. He did not understand why Mauricio and his family could not live without cutting valuable forest. Eduardo often remained silent when the family would talk about jobs because he did not want to start an argument.

Mauricio knew that Eduardo disapproved of what he did for a living but he could not give up his income. He was also careful to avoid an argument.

Although the two men avoided arguing for many years, the tension between them built, and both families worried that they might lose their friends.

Student Questions

Both Eduardo and Mauricio were raised to value natural resources differently; they both needed the forest, but for very different reasons.

1. Why did Eduardo and his family need the forest? Why did Mauricio and his family need the forest?
2. Who had a better reason for needing the forest?
3. What do you think would happen if Eduardo and Mauricio discussed each other's family needs?

Tired of their families being upset and worried, and with encouragement from their wives and children, Eduardo and Mauricio decided to talk about the forest. Rather than talking about what they thought the other person was doing wrong, they agreed to only talk about what they valued and what they worried about. By not accusing each other, they were able to avoid an argument, and they realized that they actually valued the same thing – the forest. Both relied on the forest for a variety of reasons, and both were very worried about the loss of the forest and its valuable resources. On day they decided to talk about it. Eduardo and Mauricio realized that they could work together to save the forest that they both depended upon. Eduardo told Mauricio about some loggers in another valley that did not cut all of the trees in an area at the same time, and this effort protected the soil from washing away and allowed new trees to grow more quickly. Mauricio decided that he would talk with his boss about ways that they could change their operation so that they would be able to continue cutting trees without destroying all of the forests. Mauricio told Eduardo about how he had seen some people planting useful trees closer to their homes so that they did not deplete all of the wild fruits and seeds, and Eduardo thought this was a very good idea. Both Eduardo and Mauricio knew that it would be difficult to make changes, but they were happy to keep their friendship and to share values.

SANREM CRSP Research Summary

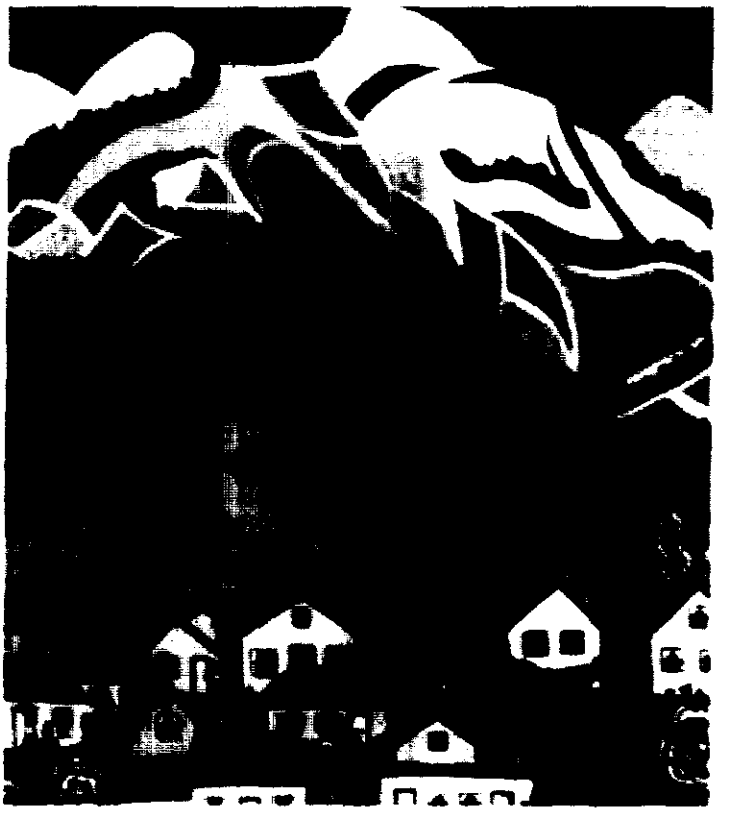
The land in the Manupali watershed in northern Mindanao, Philippines, has recently undergone tremendous deforestation as a result of population growth in the area. Much of the deforested land is now used for agricultural production. This has resulted in increased levels of soil erosion and water quality degradation. While agriculture and forestry have brought income to the people living in this watershed, they have also brought destruction to the land. Although many people are pleased with the new crops that are growing, no one wants to see the land ruined.

People value land and natural resources for a variety of reasons including:

* **Economic value** – the resources provide money
* **Use value** – the resources are useful as a food, medicines, building materials, fuel, etc.
* **Aesthetic value** – the resources provide beauty or pleasure
* **Politics** - the availability and quality of resources affect family health and social class and they may create other life difficulties
* **Spiritual value** - the resources play an important role in one's religious or spiritual beliefs
* **Biological/Ecosystem value** – the resources are important for the rest of the ecosystem (all of the organisms and all of their interactions in a specific physical environment)

It is important when making a natural resource management decision, such as deciding to protect the water source that a community uses for drinking or cooking, that varied needs and values of the people affected by the decisions be considered. Scientific research can help people make more informed decisions about how to protect natural resources. There are several methods for collecting and interpreting research data. Some researchers describe and interpret data using numbers; this is called **quantitative** data. For example, if a researcher wished to study who used more trees for their job, Eduardo or Mauricio, they would count the number of trees each used over a given period of time.

However, not everything can receive a number value and make sense. For instance, if someone asked Eduardo why he valued the forest, do you think he would respond by saying 'ten'? In this case, a numerical answer would not make much sense. Instead, he might respond 'I value the forest for the shade and food that it provides.' In attempting to elicit Eduardo's attitudes towards the forest, it does not make sense to describe his values in terms



of numbers. Data that is described and interpreted using words is called **qualitative** data.

Both quantitative and qualitative methods can be used together to describe and analyze the values of people, and this is how Dr. Virginia Nazarea and other SANREM–Andes researchers conducted their research (described in the research brief *Looking at the Landscape Through Local Lenses: Integrating Community Values and Variation in Indicators of Sustainability*). These scientists created research projects to understand how local communities valued the natural environment. Instead of assuming, as many scientists do, that communities only value their local natural environment because it can provide a source of income, Dr. Nazarea's team worked to understand *all* of the values that community members consider when deciding to protect it, including aesthetics, emotions, moral reasons and spiritual considerations. These researchers sought to obtain a holistic view of how one community valued their natural environment. Holistic refers to viewing nature in terms of interacting 'wholes' (e.g., living organisms) rather than the sum of their parts.

In their research, the SANREM-Andes team worked with community members of the Manupali watershed in the Philippines (Southeast Asia). Dr. Nazarea was interested in understanding the community members' "whole picture view" of their watershed environment. She and her team of researchers took a test that is traditionally used to understand a person's personality traits and slightly modified it so that it could be used to evaluate peoples' attitude towards natural resources. The traditional test collected quantitative data, but Dr. Nazarea's approach used data collection and analysis techniques that combined both quantitative (numerical scores) and qualitative (values described verbally by themes and categories) methods. After performing this test with 51 community members of different ages, gender, and ethnicities (and a few other qualitative methods such as recording oral histories), SANREM researchers identified a number of values of local environment beyond economic interest. The values observed tended to be different depending on gender, age and ethnicity. The data can be used to integrate a variety of perspectives into environmental monitoring and decision-making.

Your Own Eyes

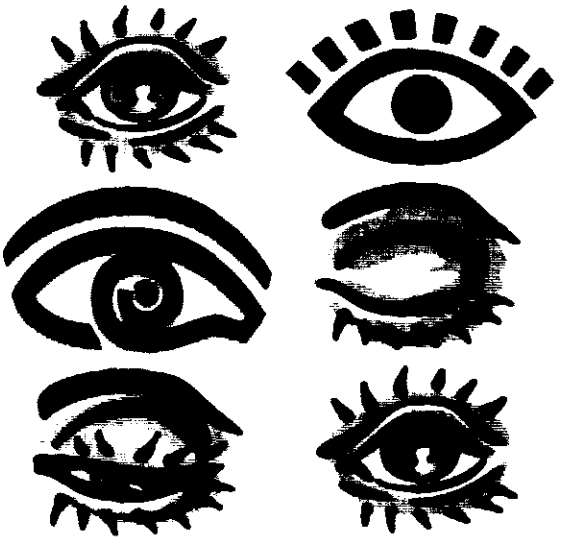
Student age: Upper Primary/Early Secondary/Secondary
Locations: In the classroom or an outside area that is suitable for reading and group discussion
Objectives: Learners will:
1. Write a personal essay in which they explore a value of their own and how it shapes their opinion of the natural environment

MATERIALS

* **Paper**
* **Writing tool**
* **Worksheet**: Major Categories Discovered in SANREM CRSP Research on Values in the Manupali Valley of the Philippines

Background Information:
Humans make decisions for a variety of reasons, including what we have been taught and what we believe. We often make these decisions without ever really knowing why.

In this activity, students will be asked to write a personal essay that helps them explore their own value system.



Procedure:
1. Engage students in a discussion about **values**. Here is a suggestion on how to introduce this topic:

Have you ever thought about why you like something and dislike something else? Sometimes the answer is simple. For instance, you may value Saturdays because it means no school and that you can see your friends. Sometimes, though, the answer is not that simple. When you have to make a decision, what do you think about before you decide?

Values are the principles, standards, or qualities that you consider to be meaningful or desirable. You may have very different values depending on the situation. For instance, how much do you value good health? How much do you value delicious food? How much do you value trees?

2. Read the following scenario to the students.

You live with your family in a small house that is surrounded by forest. Your father and mother have jobs in the city that pay them enough money for everyone in your family to have food and clothing. Besides giving you a place to play, your family collects some food and other

materials for your home from the forest. One day, a man from the city comes to visit your home. He wants to cut down the trees that surround your home and sell them to people who build houses. He offers your parents more money than what they would make in 6 months to cut down the trees. What should your family do?

3. Ask students to write an essay addressing the following questions.

* After hearing the story, how important is the forest for you and your family in terms of providing you with money, clothing, food, and materials for your home? Do you think that in a different situation, you might value the forest differently (for example, what if you relied on the forest for all of your food)?

* What other values did you consider in making your decisions?

* What experiences in your life have shaped your values?

Follow up Activity:
Share the worksheet, *Major Categories Discovered in SANREM CRSP Research on Values in the Manupali Valley of the Philippines*, with students. Explain that SANREM CRSP research in the Manupali Valley showed people's values fitting into four major categories. Have students compare the values that they wrote about in their essay with the values described on the worksheet. How are they similar and different?

Length of Activity: 30 minutes

Assessment:
Assess students on their level of participation in class and follow-up discussions as well as personal essay writing. Assessments can be based on performance during the story questions, follow-up discussion, and from the quality of the personal essay. Assessment can be based on the following guidelines (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Participation	Did not participate during story questions or follow-up discussion. Did not write personal essay.	Answered some story and follow-up discussion questions. Completed the personal essay and answered all questions listed in Procedure 3.	Answered most story and follow-up discussion questions. In these answers and in their essay, demonstrated a detailed understanding of what values guided their decision during the essay activity and how they compared to the values described on the worksheet.

Major Value Categories Discovered in SANREM CRSP Research on Values in the Manupali Valley of the Philippines

In a research study about people's values as they relate to natural resource management in the Philippines, 32 themes were identified in answers collected during a modified Thematic Apperception Test (TAT) (previously described in *A Picture is Worth a Thousand Words* and in *seeing Through Others' Eyes*). The 32 themes were clustered into the following four categories. Example responses from participants in the study are included below each category.

a. **Aesthetic value** (i.e., beauty, harmony, sense of place, etc.)

Sample Responses
What I can say is that the trees in the environment are all very beautiful... this can make us feel cool and we get fresh air...

When there are lots of fruits, there are also a lot of birds that feed on it and their voices or humming are good too.

b. **Usefulness** (i.e., usefulness of resources, but also a concern for using them sustainably, etc.)

Sample Response
The trunks can also be used as posts for houses and are more comfortable than bamboo... The leaves can be used as roof for the nursery...

c. **Economic** (i.e., how natural resources can be used for profit, economic success, etc.)

Sample Response
The sugar cane here is nearing harvest, they are healthy...I think they will get plenty of money.

d. **Politics** (i.e., family health, social class and other life difficulties)

Sample Response
This house indicates that the owner is poor. Because sometimes owners of houses like these are being oppressed by the rich.

A Picture is Worth One Thousand Words

Student age: Upper Primary/Early Secondary/Secondary
Location: Classroom for student interviews; a place most suitable for community member interviews
Objectives: Learners will:
1. use TAT cards to elicit community members' values and attitudes towards natural resources

MATERIALS

* **TAT cards** (pictures of people interacting with natural resources; the pictures chosen should help students to address the questions that they created. These can come from magazines, newspapers, books, the Internet, or can be drawn by the instructor)
* **Paper**
* **Writing instrument** to record answers
* **Tape recorder or video camera** to record answers (use only if respondents have given permission to be recorded by either or both means)

Background Information:
TAT refers to something called a 'thematic apperception test.' This is a test that **psychologists** (scientists who study the mind and behavior of humans and other animals) often use to study a person's personality traits, such as happiness, shyness, or other emotions. TAT tests evaluate a person's personality based on how that person responds to a series of pictures, often depicting at least one human figure, sometimes two or three. The pictures show different social situations and are vague enough in detail that they can be interpreted in many ways. A person is shown TAT cards and then asked to tell a story about what each card shows.

In this activity students will use TAT cards to interview members of their community. Following the research methods of Dr. Virginia Nazarea (see *Seeing Through Others' Eyes*), students will modify the TAT test used by psychologists to try to elicit cultural features such as attitudes, wishes, thoughts, interests, motives, and conflicts rather than personality features.

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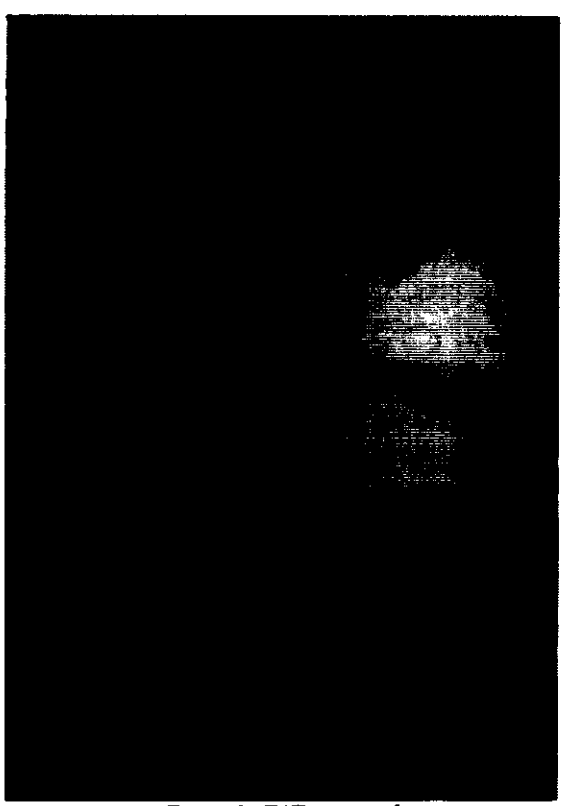
Procedures:
The goal of this activity is to use TAT cards to collect data about people's values. In order to be able to analyze data, all students must use the same pictures and must record the same basic information about the person they are interviewing (e.g., age, gender, ethnicity, socioeconomic status, education, etc.).

1. With students, choose pictures to be used for the TAT cards. Assign a number to the back of each card. Pictures should display people interacting with natural resources. Remove or cover any text on or around the picture so that interviewees are looking only at pictures. Each picture should be numbered and duplicated so that all students use the same pictures for their interviews.

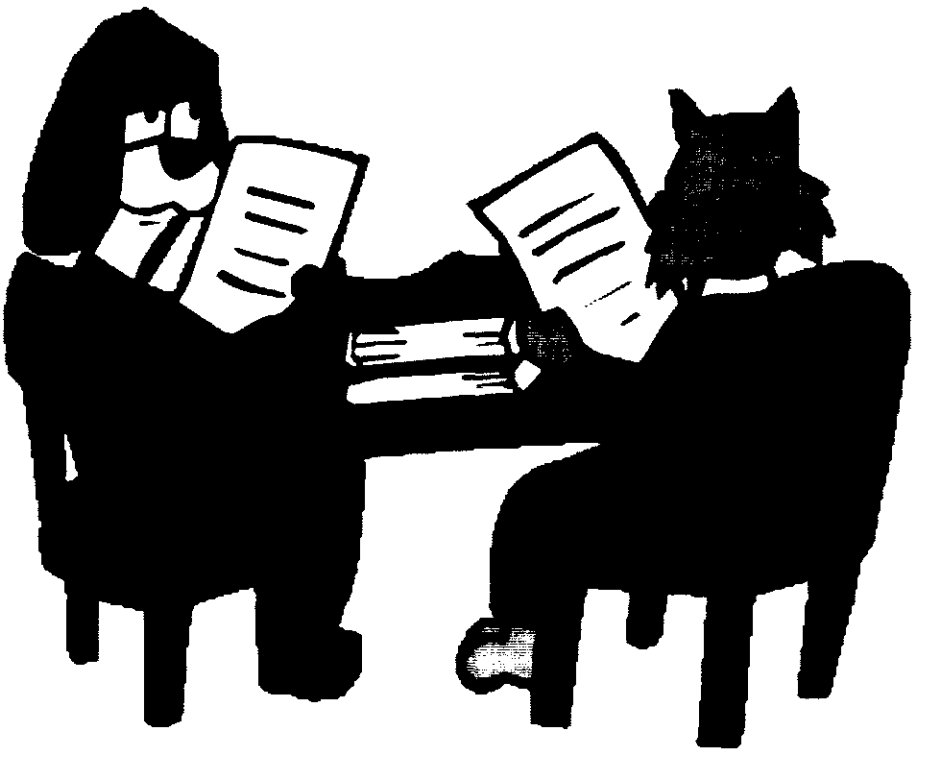
2. As a group, determine the basic information that should be collected from each interviewee. This information is valuable data that you may wish to use in subsequent activities that involve forming a class hypothesis. Examples of this information include age and gender of respondents, size of family, type of work, etc.

3. Students should practice using the chosen pictures by interviewing another classmate. One student should hold a card and the other should tell a short story describing the picture. The person holding the card should write down the story and the number of the card as well as any other basic information collected to test the hypothesis. Students should then switch roles so that every student has an opportunity to view a card and tell a story about it. If more practice is needed, students can practice with more than one TAT card.


Example TAT test card

4. Before testing others in the community, students should review answers from their practice interviews with classmates to determine if the class hypothesis was proven or disproven. TAT cards may be added or removed based upon their usefulness in the process of testing the hypothesis, as the next step will be to for student to use TAT cards with members of the local community. Each student should choose one or two people to interview. The people chosen should be adults and can be family members or friends of the students.

5. Instead of assuming that someone will want to be interviewed, students should call or visit the people that they would like to interview in order to introduce themselves and explain their project. The students should be sure to tell the interviewee why they want to talk to him/her. Students should also be sure to tell the interviewee that the



information from the interview will be added to classmates' interview data so that there are many pieces of information to analyze and compare. Interviewees should be allowed to choose if they want their names included with their responses or if they prefer to remain anonymous.
* **Important!:** Some people may not understand why someone is interested in their stories. They may be asking *"Interview me? I haven't done anything significant or important."* If this happens, students may need to spend extra time explaining the point of the class project and that interviewees' stories are helping to contribute important information that is often not considered when law makers make decisions that affect their community.

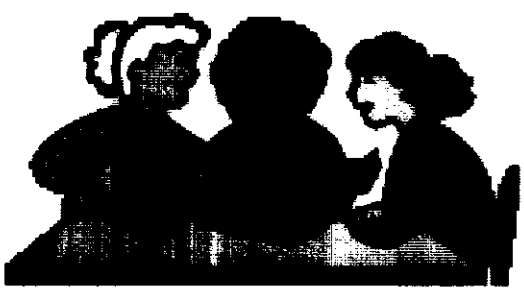
6. If the community members agree to the interview, students should then set the time and place according to the interviewees' convenience. If the students have access to a tape recorder or videotape, they should ask the interviewees if they would be comfortable with their interview being recorded and/or videotaped. Also, students should inform interviewees about how long the interview is to last.

7. Students will each conduct their interviews and record their data.

8. The collected stories should be sorted based upon the class hypothesis. For example, if we return to the class hypothesis that men and women have different values in relation to the environment, then stories can be separated into two piles: stories that men told and stories that women told. Students should then analyze their stories and determine the main themes of each. One way to do this and include all students' input is to have everyone read his or her story aloud. You may wish to start with one TAT card and then have each student read the story that

they collected for that card. After a story is read, decide as a class the main themes of the story. Then, continue this process with all of the other cards. Some themes might include usefulness of resources, family health, government control, beauty, etc. List the themes somewhere where all students can see them. Determine if some of these themes are similar enough that they can be lumped together into the same theme 'category' (e.g., health).

9. Depending on the class hypothesis, you may need to determine the most or least common themes. To determine this information, students should start with the first theme listed. Have them reread the stories that they collected. If the theme is represented in a story, record a X next to the theme. Students should do this for all of the themes and all of the stories. To determine the total score for a theme category, add all of the X's for that theme. The theme with the most X's is the most dominant (common) theme.



10. Discuss the most and least common themes, and compare the information found with the class hypothesis. Does the information support or disprove the hypothesis in any way? Students may find it interesting to determine if there are differences in responses to TAT cards based on age or gender (e.g., for a particular TAT card, all women mentioned 'health' and all of the men referred to 'economic concern').

Time/ Length of activity: Varies

Assessment:
Students should be assessed based on their class activity participation including helping to determine what data should be collected and engaging in practice TAT card interviews, their establishment and conduction of TAT card interviews with community members, and their analysis of data. These forms of assessment can help teachers gauge students' understanding of the importance of how TAT cards help to elicit values and ideas about natural resources. The following guidelines can be used to assess student work (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Participation in class activities	Did not participate.	Participated.	Participated and asked relevant questions.
Establishment and conduction of TAT card interviews with community members	Did not establish or conduct any interviews with community members.	Established and conducted one interview with a community member with the assistance of another student, the teacher, or a parent. Developed interview questions and collected and analyzed data with assistance.	Established and conducted one interview with one or two community members without assistance. Developed interview questions and collected and analyzed data without assistance.
Analysis of data	Did not analyze data.	Able to analyze some data from interviews and relate it to support or rejection of the class hypothesis.	Analyzed all data collected and was able to accurately determine if it supported or rejected the class hypothesis.

Studying Society: The Importance of Stories

Student age: Upper Primary/Early Secondary/Secondary
Locations: Possible locations include classroom environment or home environment
Objectives: Learners will learn about values using the steps of the scientific method. Specifically, learners will:
1. Determine questions that they would like to answer about how values influence people's behaviors and attitudes towards protecting the local environment
2. Make hypotheses about how values influence peoples' behaviors and attitudes towards protecting the local environment
3. Apply the oral history method to elicit community values
4. Implement the method
5. Collect data
6. Organize results
7. Draw conclusions about how peoples' behaviors and attitudes towards protecting the local environment based on test results
8. Present results to a wider audience

MATERIALS

(materials specific to experiments are listed before each experiment in procedure #8)

* **Paper and writing instruments** for each student (or somewhere that they can write/draw)
* **Blackboard and chalk** (or somewhere that you can write/draw and all students can see)
* **Poster paper** for students for displaying experiment results (or somewhere that students can write/draw and all students can see)

Background Information:
There a number of ways for teachers to help students find answers to their questions created during the introductory observation activities (see *Culture Unit Overview* for more information on helping students to formulate questions). Below we provide one suggested method that employs the scientific method. The best method to use, however, will depend upon the specific question being asked by each student or group of students.

When scientists want to answer a question they follow a series of steps commonly referred to as the **scientific**

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method. This method is useful in organizing information to better answer specific questions. The scientific method includes observing, questioning, forming a hypothesis (a guess that comes from a "gut" feeling), testing the hypothesis, analyzing the results of the test, and rejecting or accepting the hypothesis.

The following activity was designed to demonstrate a simple method for measuring and monitoring the values that influence how people make decisions. These methods are useful in accounting for all possible reasons that may drive a person to make a decision, in this case, about protecting natural resources. The method described in this activity (listed in Procedure 8) may be used to elicit and assess values within a community. Students should use this method, or a variation of it, in a class experiment.

Students may have additional questions that are not covered in this lesson plan. Using the methods outlined, students should be able to design other experiments or methods to answer these questions.

Whether you use the method provided and/or modify it, we encourage you to complete the test multiple times in order to compare results. Comparing methods and results of different kinds of tests may help you to determine which test works the best, and comparing results of the same test done multiple times will help you to decide if your observations and conclusions are accurate ones. The more times that you can achieve the same results, the more likely that your are observing a true phenomenon and not something that just happened by chance.

Procedures:

1. Review the introductory **observation** activities that the students have completed. Record any student questions on the board, or somewhere that all students can see. (Refer to the

Local Lenses: Unit Overview for more information).

2. Explain to students that they will have a chance to answer some of their questions using the scientific method.* The scientific method will help them to organize the information needed to objectively answer their questions about soils. Answering their questions "objectively" means that they will try to answer their questions without letting their ideas interfere with their study. For instance, they may have an idea that women value forest for health reasons more than men, but they cannot allow their idea to lead them into reporting that result if it is not found through their study. Explain or write the steps of the scientific method on the board (see *Background Information*). Students have already made general observations about the soil quality in the area. Now they will design some simple tests to learn more.

*Some student questions may be answered without practical testing but instead by simple observation.

3. Determine which student questions can be tested using the scientific method (highlight them on the board, if possible). These questions need to be specific and detailed in focus. In other words, how can you test something you do not understand? Consider the following example:

Do people value the forest?

It is not clear from this question *who* the group of people of interest is. The question should be reworded to be more specific. For example:

Do different people in my community appreciate the forest for its beauty or for money that it can bring from selling its trees?

This question is quite clear in what it is asking, and depending on responses from community members, one may be able to conclude that community members value forest for its beauty more than for economics.

Some questions will be difficult to test as there may not be one thing that is valued as 'most important' by all community members. In this case, a question such as:

What do all community members value most?

might need to be rephrased as:
What are the most commonly mentioned values of the members of my community?

With student participation, review each of the questions that can be tested using the scientific method, and make any changes needed so that questions become more specific and therefore easier to test. As a class, students should select one question that they would most like to answer. This can be determined by voting on a question or by discussing the questions and coming to a consensus decision.

4. After making the questions as testable as possible, ask students to think of **hypotheses**. Explain that an hypothesis is a temporary explanation for an observation or scientific problem that can be tested by further investigation. It can come from experience, previous research, or simply an assumption. Ask each student to think of an hypothesis for each question. There are many possible correct answers. Some examples follow:

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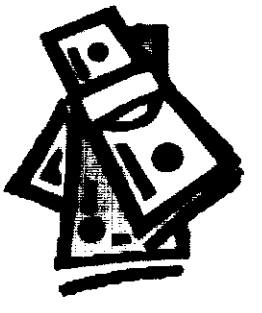


* Most people in my community value natural resources

* A community member's personal values affect the decisions that s/he makes

* A community member's personal values about certain topics are the same as those of his or her parents, chief, or religious leader

* The people who pass laws in my community take values of all social groups in the community into consideration when they make their decisions

* Members of my community will only protect the natural resources if they derive economic benefit from this protection

5. Make a list of all of the hypotheses and decide, as a class, which hypothesis to test.

6. Ask students to come up with ways to test the hypotheses. Give them a set amount of time to think of answers. After students have finished, (or earlier, if students are having difficulty) describe the method listed in Procedure 8 (Oral Histories). Let students compare their methods to the TAT test then decide which *one* method would best test their hypotheses.

7. Once students have chosen the method that they will use, determine when the tests will take place, the questions that students should ask, and how to apply the method chosen (details for the Oral Histories test are given in Procedure 8).

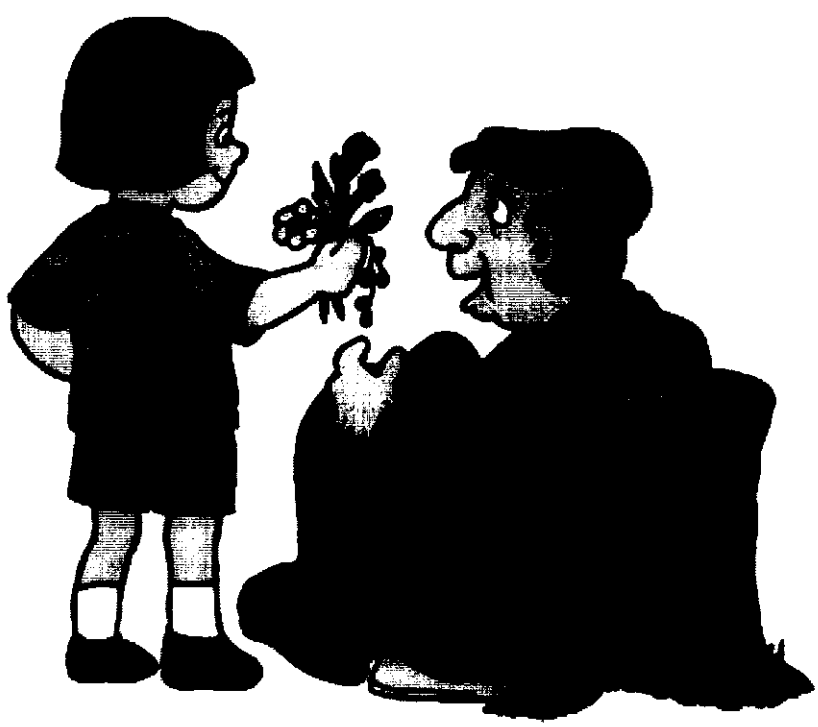
8. Implement the test:

Oral Histories

Oral history is a way for people to learn about history, but not through reading! Instead, it comes through stories that people tell. Oral history is probably the oldest method for rewording history. Oral histories may emerge while sitting around a fire and telling stories, or they may be a result of a more structured format such as an interview. Oral histories are the stories of people's lives, and they help us to understand their experiences and perspectives. By collecting many stories, we can begin to see concepts and values that appear most often; these are the concepts and values that are shared in a culture.

Materials:
* **Paper and writing instrument** to record answers
* **Tape recorder or video camera** to record answers (optional)
* **List of questions** (described below)

The goal of this activity is to collect data, through oral histories. This is one method to show how values are distributed in the com-



munity. In order to be able to compare and analyze data from different interviews, students must all have the same set of questions to ask their interviewees.

Based on the class hypothesis, decide the topic on which you will interview community members. Then, as a class, decide what questions each student should ask their interviewee. Each student should have a list of the same questions. The points below may help formulate good interview questions.

*** You want to ask questions that will provide background information about the interviewee** (e.g., how their life experiences have shaped their values)

*** Think about the topics that you want to cover.** Examples might be:

Family: Do the interviewees have any brothers and sisters, are they married, do they have any children?

Daily Activities: What work do they do everyday, what do they do at home, with family, socially, etc.?

What They Do For Fun: Story telling, walking, time with families, etc.

Schooling: Did they go to school and for how long?

Place that they live: Where did they grow up?

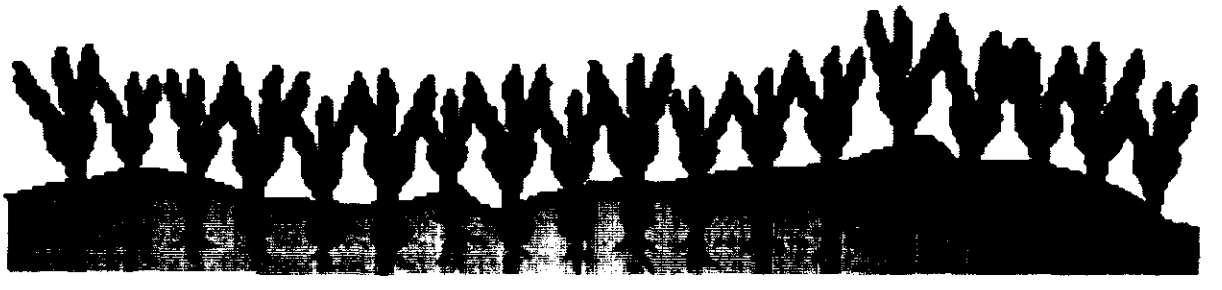
How the interviewee feels about the use of natural resources: Make questions specific, such as "*have you noticed a difference in the landscape over your lifetime?*" and "*how have water use regulations affected you?*"

Make sure to ask enough questions to have useful results, but not so many questions that you tire your interviewee.

*** Design the wording of your questions:** This may be the hardest part. You want to make sure that you ask questions that are 'open-ended.' That is, you do not want to pose questions that suggest what answer you expect or desire because this might induce the interviewee to answer as expected. This is called creating **leading questions**.

For instance, if you disapproved in using pesticides to grow vegetables because these chemicals pollute drinking water, and you want to know how your interviewee views using pesticides, you should ask the question in a way that elicits open and honest answers.

In this case, a leading question might be: "*Since pesticides pollute the water we drink and make us sick, do you think farmers should use them?*" This question reveals your opinions, and, since you are conducting and controlling the interview questions, your interviewee answer the question by agreeing with you than stating his/her true opinion. Rather, you should ask "*How do you feel about pesticides?*"



Ask the class to come up with a list of people that they could interview.

With students' assistance, contact people on the list to set up interviews. First contact the people that could potentially answer the most questions. Explain what you are doing and how you would like them to help. It is important to make clear that the students will be conducting the interview, so the speaker will need to be comfortable with this format. Be sure to ask the speaker if they are comfortable being tape recorded, if you choose to use this interview technique. Some people may not be able to participate because of scheduling conflicts. If one person on the list is not available, call others until you have enough speakers lined up to answer student questions. Set times for meeting the various speakers.

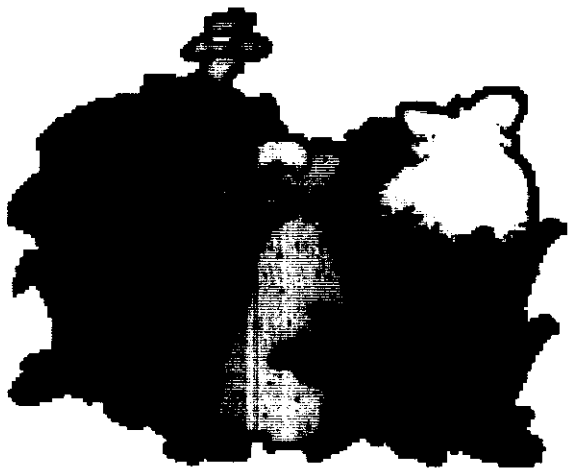
Students will each conduct their interviews on their own time and record their data. Here are some helpful tips to make interviews run smoothly:

If you have time, try a "pre-interview" with your interviewee. Asking simple questions during this time may help you to design your interview questions. For example, you may wish to ask what kind of work that they do or if they live or on a farm.

End your interview with *"Is there anything else that you would like to tell us?"*

It is very important to thank the interviewee for time. Ask if they would be interested in learning about the results of the class project. If your class is planning an event to bring all of the interviewees together to learn about the class results, make sure to invite your interviewee.

Discuss and compare oral histories that students collected. What interesting information



did interviewees add at the end of the interview? Did this information help to identify interviewees' values? After listening to the interview responses from each other's interviews, are the students able to determine common values (or value themes) amongst community members? If not, why do values appear to be so different? How can this information be used in making decisions about natural resource use?

Depending on the class hypothesis, students may group responses according to the specific question (i.e., compare all of the answers to questions #1). To determine the main themes of each set of responses, students should take turns reading their responses to Question #1 aloud. After an answer is read, decide as a class the main themes of this response. Then, continue this process with all of the other responses to Question #1. Some themes might include usefulness, family, government, and beauty. List the themes somewhere where all students can see them. Determine if some of these themes are similar enough that they can be lumped together into the same theme 'category.'

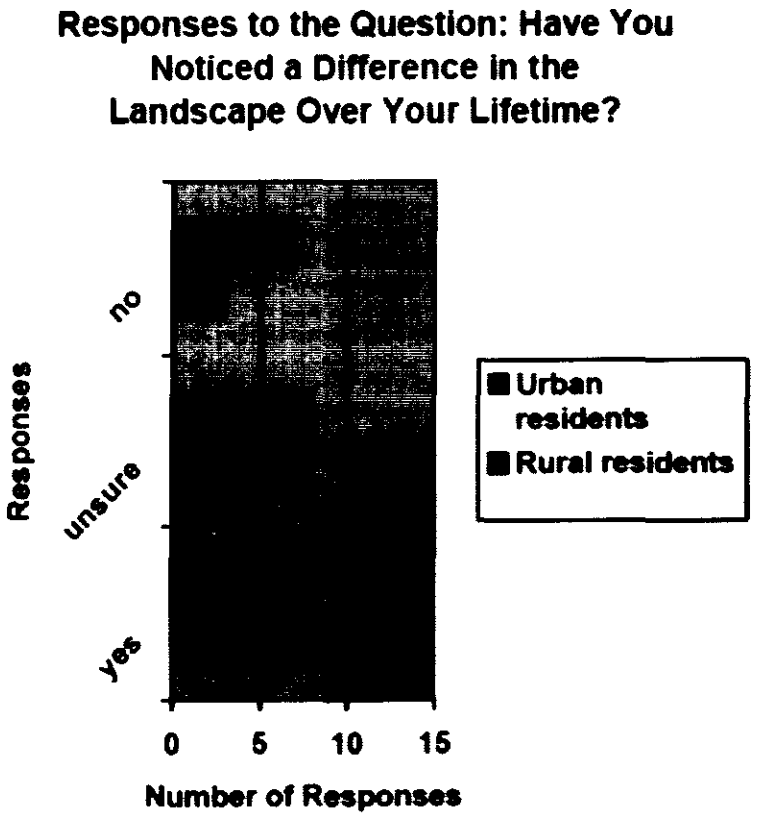
To quantify the results, students may determine the theme occurring most or least frequently. To determine this information, stu-

dents should start with the first theme listed. Have them reread the answers to Question #1. If the theme is represented in their response, record an X next to the theme. Students should do this for all themes and all questions. To determine the total score for a theme add all of the X's.

Discuss themes that occur with the most and least frequency, and compare the information found with the class hypothesis. Does the information support or disprove the hypothesis in any way? Students may find it interesting to determine if there are differences in responses to questions based on age or gender (i.e., for a particular question, more women than men referred to beauty and more men than women referred to economic concerns.

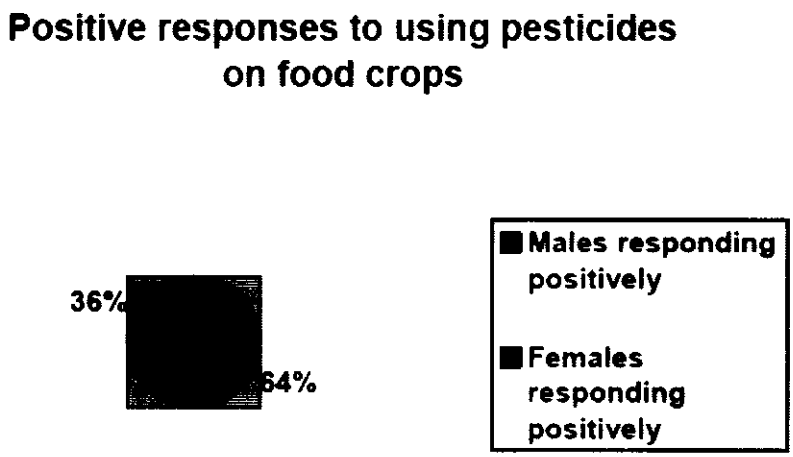
9. After completing data collection for the student tests, ask the students to revisit their hypotheses and think about how they can use their data to either accept or reject their hypothesis. Demonstrate some common graphs that can be used to compare data.

Line graphs or **bar graphs** can be used to compare measurements of the same information. These types of graphs may work well for comparing data on different themes, or comparing one theme across variables (i.e., place of residence).



Example Bar Graph

Pie graphs can be used to show the percentages of males versus females who found a particular theme in their story.



Example Pie Graph

After demonstrating graphs, break students into groups and have each group of students prepare a graph to describe something that they observed in the test. Students should present their graphs to the class.

10. Based on the information found, the class should decide if the original hypothesis should be accepted, rejected, or if there is not enough information to form a conclusion.

11. Discuss the results of the entire activity with the class. Ask students if they were satisfied with their results. Do they think that their results were accurate? What would they do differently next time? Did they come up with new questions as they were trying to answer the original question?

12. The class should work together to create a presentation of all lessons learned about values and how they affect decision-making about natural resource use. Arrange a time when students can present this information to a larger audience that may include parents and community members, or other students at the school. Students should present their information orally, as well as visually, using charts, graphs, and pictures.

Time/ Length of activity: Varies from 10-20 total hours

Assessment:
Students should be assessed based on their participation in the activities, their understanding of the scientific method and the information gathered during activities, and their overall understanding of the topics covered. Participation should be evaluated throughout the project. Assessment of student presentations and an exam that focuses on using a similar process to answer a different question can be used to evaluate their understanding of the scientific method and the information gathered during activities as well as their overall understanding of the top-

ics covered. The following guidelines can be used to assess student work (teachers should also determine how to assess curricular standards that were met through this activity):

	Needs improvement	Satisfactory	Excellent
Participation in the activities	Did not participate.	Participated.	Participated and asked relevant questions.
Understanding of the Scientific Method	Did not demonstrate understanding of the scientific method. Did not differentiate between questions that could be answered and could not be answered using this method. Did not demonstrate the formulation of a testable hypothesis. Lacked accuracy in collecting data. Did not display data relevantly. Had trouble following the same process to answer a new question.	Demonstrated an understanding of the scientific method. Differentiated between questions that could and could not be answered using this method. Formed a basic hypothesis for a variety of questions. Collected data accurately. Displayed data in a way that supported the acceptation or rejection of a hypothesis. Could relate most of the steps of the process to a new question.	Demonstrated a detailed understanding of the scientific method. Differentiated between questions that could and could not be answered using this method and transformed questions that could not be answered into those that could. Formed specific hypotheses for a variety of questions. Collected data accurately and suggested methods for improving accuracy. Displayed data in a variety of ways that supported the acceptation or rejection of a hypothesis. Could relate all of the steps of the scientific method to a new question.

Understanding of the Topic Studied	Recognized less than half of the factors that were tested by the class in this project. Did not recall the conclusions to the study. Could identify less than half of the methods used for data collection. Did not demonstrate recognition of the importance how values affect behaviors/decision-making.	Recognized the factors that were tested by the class in this project. Recalled the conclusions to the study. Could identify most of the methods used for data collection. Demonstrated recognition and understanding of the importance of how values affect behaviors/decision-making.	Gave a detailed explanation of the factors tested by the class and how they relate to each other. Recalled the conclusions of the study and how they were reached, including all of the methods used for data collection. Demonstrated recognition and understanding of the importance of how values affect behaviors/decision-making.

Appendix I
Basic Principles of Natural Resource Management

The term **'natural resources'** refers to all of the products that humans receive directly from the natural world. These products have traditionally included food products, wood products, useful plants, and wildlife. We are now beginning to recognize that the natural world, which is made up of a series of **ecosystems**, provides us with much more than just an income, food and shelter; in fact, the most essential resources that sustain *all living organisms* come from the natural world. Ecosystems can be defined as groups, or systems of organisms that interact with each other and with their physical environment on a continuous basis. Ecosystems are self-sustaining if the organisms that comprise them are able to maintain relationships that benefit one another and the physical environment. For instance, plants provide the oxygen that living organisms need for breathing as well as storage for excess carbon that might otherwise cause damage to the atmosphere. Layers of soil, wetlands environments, and the water cycle continually purify water that many organisms use for drinking. We are also discovering that the diversity of species on this planet, both plant and animal, hold important genetic information that can be used to fight disease and to improve agricultural methods and products. Clearly, the countless numbers of organisms that help build and also rely upon natural resources provide 'life support' for all organisms in Earth's ecosystems, including humans.

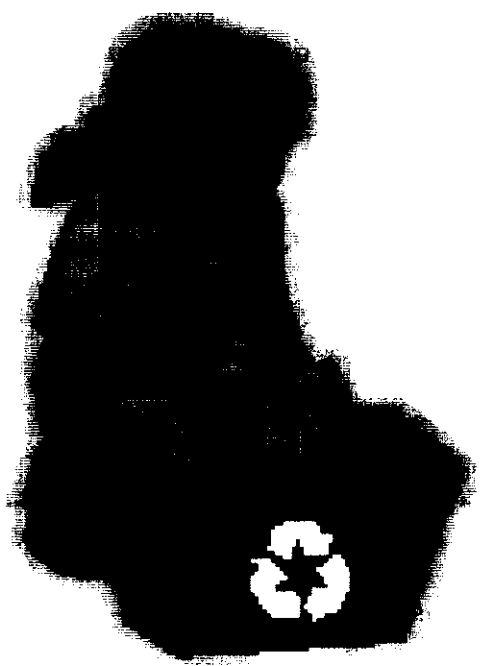
As our definition of natural resources has broadened, the task of natural resource management has moved from being the responsibility of farmers and foresters to the responsibility of every human. Ecosystems can provide resources for life, but these resources are not limitless. Ensuring continued life support and availability of resources depends on everyone and the daily decisions that we make. Human use, or *over*use, of natural resources often pushes an ecosystem's capacity to its threshold and can therefore cause it harm. This stress may cause the ecosystem to function less favorably for all organisms, including humans. Natural resource

management is therefore not about managing the resources of the planet but rather managing the people that use the resources. This task begins with managing our individual resource use.

Studying our ecosystems is a key step in understanding the impact of human decisions on natural resources. As we learn more about how ecosystems function we can begin to interact with them in ways that allow us to meet our needs while causing less stress to the systems.

Two obstacles to maintaining continuous availability of natural resources are 1) the persistent rise in Earth's human population and 2) the excessive consumption of these resources by those in developed countries. Overcoming these obstacles can only be accomplished if people are willing to adjust their needs and behavior for the benefit of others and for future generations. For example, learning to reduce the number of items that one uses and instead, reuse what one already has, will save a tremendous amount of natural resources as well as money needed to produce the materials. Another simple example of preserving natural resources would be to turn off running water when it is not being used or fixing leaky faucets.

It is important that students, the stewards of tomorrow's ecosystems, learn these basic principles of natural resource management. Through exploring the ecosystem and drawing their own conclusions through scientific inquiry, students can create and act upon their own understanding of these principles.



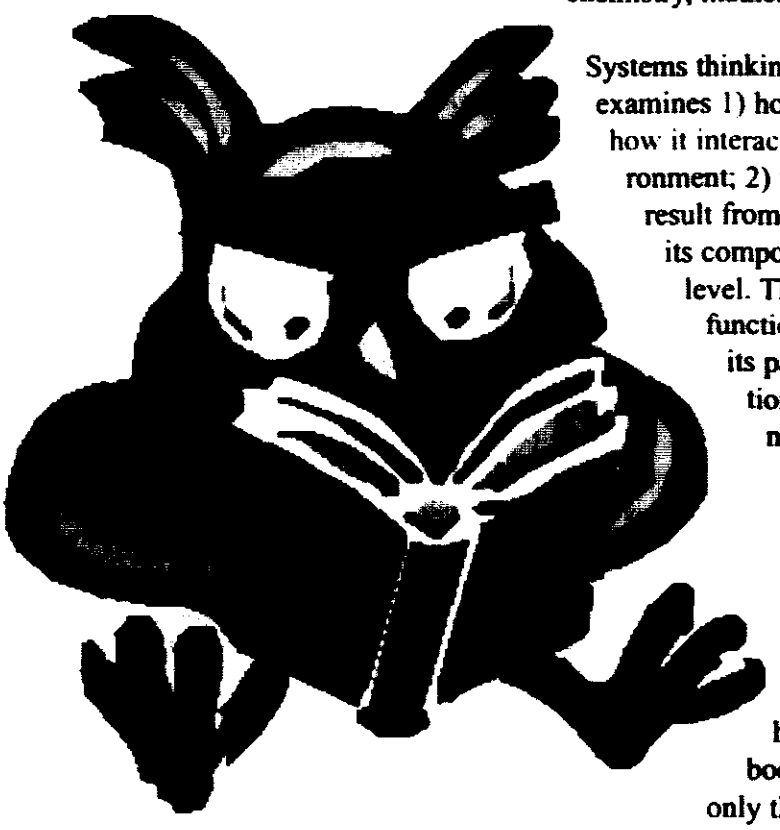
Appendix II
Supporting Materials

Appendix IIA: Systems Thinking, Adaptive Management and Constructivism

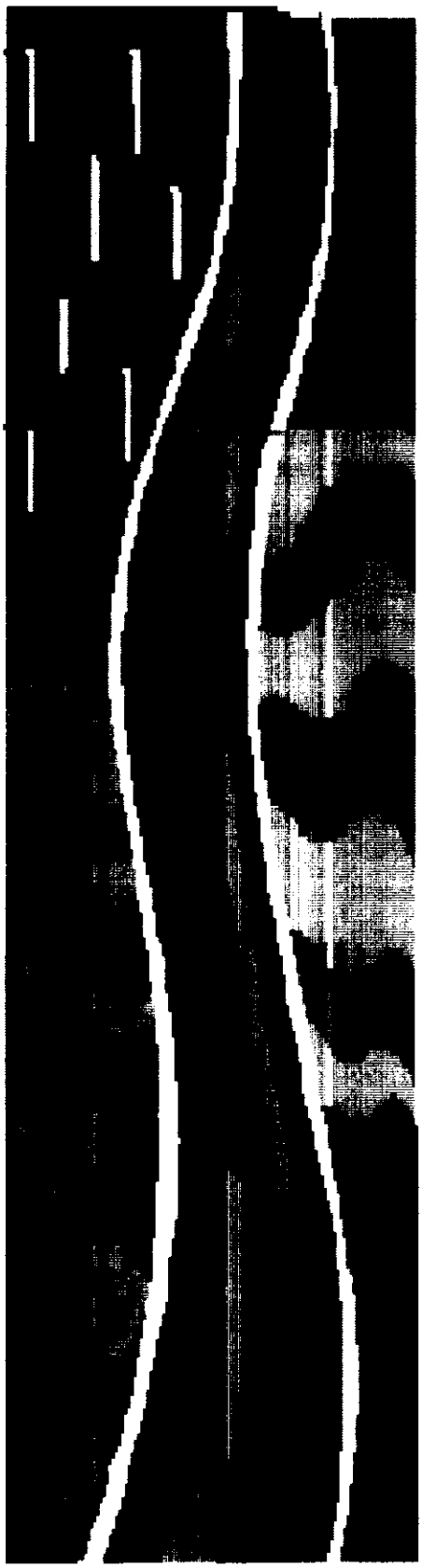
In creating the template and lesson plans included in this manual we drew on knowledge from a variety of scientific and educational fields as well as from examples of effective curricula. We felt that the following ideas and sources of information greatly inspired and influenced our work and may be of use to others.

Systems thinking and **adaptive management** are important tools that can be used together to better understand complex issues (in any subject area) and to create useful solutions to these problems.

Systems thinking, one method of analyzing information, assumes that when attempting to understand how something works, the *relationships between* the objects that comprise what is being studied, as well as the *relationships between* what is being studied and other factors in its environment, are as important as the objects themselves. This assumption is different than conventional techniques of analyzing information where what is being studied is broken into individual components and then those parts are studied in-depth (these conventional practices are commonly used today in academia, especially in 'hard' sciences such as physics, chemistry, mathematics and engineering).



Systems thinking takes what is being studied and examines 1) how its components interact *and* how it interacts with other factors in its environment; 2) the behavior or outcomes that result from these interactions; and 3) how its components function on an individual level. This approach of examining the functions of a *whole* system, as well as its parts, will often lead to assumptions that vary greatly from those normally created when *just* analyzing the pieces of the system, particularly when the system being studied is continually interacting and changing at multiple levels. Medicine is a field in which systems thinking is very important. In studying how a medicine functions in the body it is important to consider not only the chemical make-up of the medicine but also how it will react to the



millions of other chemicals in the body under varied circumstances. Systems thinking can be of great value when complex problems require seeing the 'big picture' as well as its smaller parts.

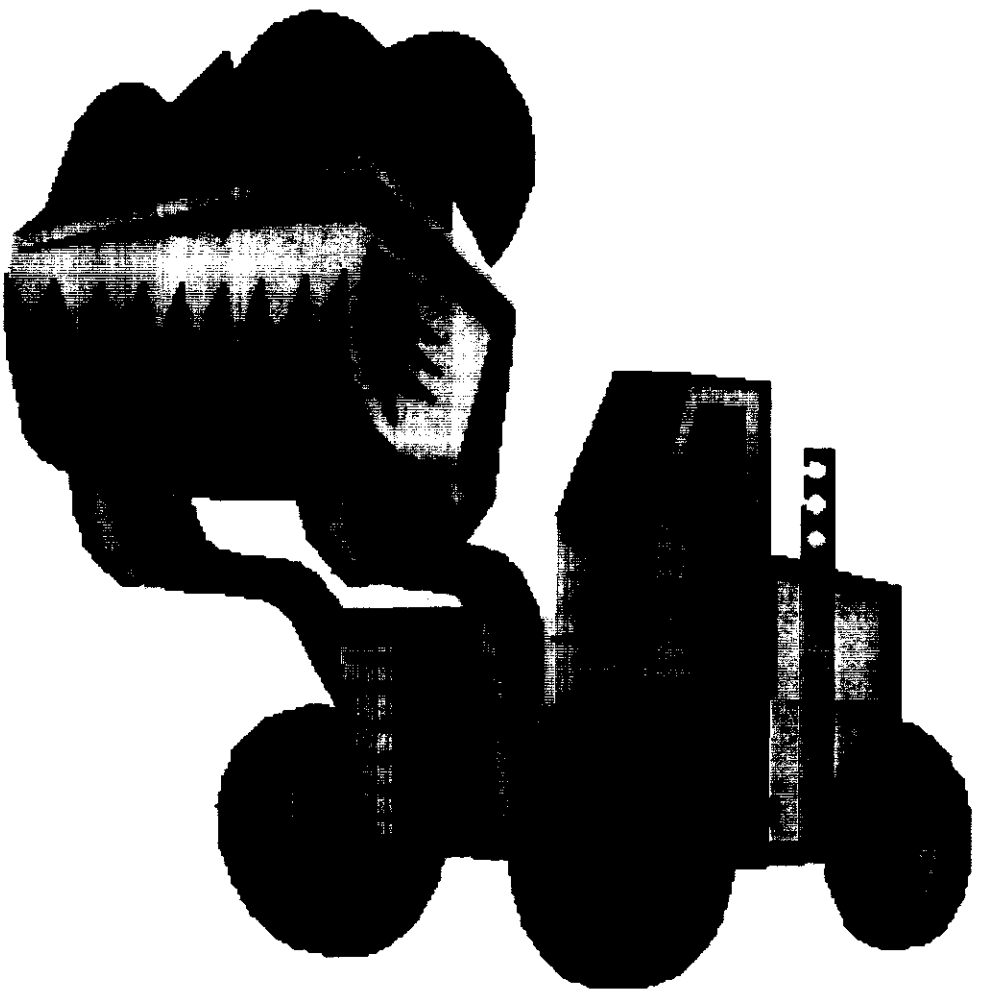
Adaptive management is a process by which one can continually improve a management policy or practice by systematically monitoring, evaluating, and modifying implemented solutions in order to learn from past attempts and adapt to new situations. Adaptive management recognizes that systems change over time. Therefore, a management practice or policy applied to a situation at one point in time may need to be modified at a later point in order to account for changes to the system that have occurred.

In determining natural resource management (NRM) practices and public policy (law) on how to use natural resources wisely, people have begun to rely on information that is complex and ever-changing: scientific information. However, science rarely provides definitive answers, especially when trying to consider how human actions will affect a complex and ever-changing ecosystem. Since science is not a black and white process, it is not translated clearly and easily into public policy, therefore making it difficult to confidently base policy on science alone. For instance, if water needs to be drawn from a river for irrigation, the river will be greatly impacted. Known and unknown organisms will be affected, and the effects that they feel may vary based on the season. There may even be situations in which drawing water harms one organism while encourages the growth of another. Policies must be created to allow for enough water to be drawn for irrigation but with the least impact on the river and the organisms that depend on it. Because ecosystems are complex and dynamic it is impossible to predict how any one policy will affect an entire ecosystem at any point in time. In this case, adaptive management would allow for systematic monitoring of the policies created. Rather than waiting the many years scientists would need to study every last organism in the river, a decision is made based on the information that is known at the time. The effects of the decision are monitored over time, and the value of the decision is reassessed and the decision modified regularly as conditions change or new informa-

tion is learned. This way people can use the natural resources while continually learning how the system works and adapting policy to work best over a long period of time. Adaptive management allows for mistakes. Because it integrates monitoring and reassessment of policy, mistakes are caught and learned from rather than allowed to cause excessive harm to the system.

Adaptive management is a **constructive process:** over time, as more is learned through experience and experimentation, a body of knowledge is constructed. **Constructivism** is the process of actively constructing knowledge by integrating new information into previous knowledge and understanding. This is how we learn when no one is teaching us. In this way, the lessons that we learn on our own are often the lessons that we remember and that shape our perceptions and values. In a formal educational setting this type of learning is often overshadowed as students are expected to learn what they are presented. Although many students retain this information it rarely has the impact that comes from learning through experience and constructing meaning for themselves. Teachers that encourage constructivism are more interested in the students uncovering meaning than covering prescribed material.

Appendix IIB highlights examples of existing teaching models, curricula, and lesson plans that integrate some of the above ideas.



Appendix IIB: The EIC™ Model, Learner-Centered Lesson Plans and Information About Service Learning

The EIC™ Model

One model that has been developed to train teachers to use a learner-centered, constructivist approach to education in the United States is the **EIC™ Model,** ***Using the Environment as an Integrating Context for Learning***. This program offers a well-packaged synopsis of how teachers can integrate pedagogies that enhance learning into their current standards based curriculum.

The elements included in the EIC™ Model are:

* Integrated – Interdisciplinary Instruction
* Community Based Investigations – Service Activities
* Collaborative Instruction
* Learner-centered, Constructivist Approaches
* Cooperative and Independent Learning, and
* Local and Natural Community Surroundings as the Context for Learning

The EIC™ Model is a comprehensive, highly structured program that requires an intensive, commitment from teachers, school committees, superintendents, and other higher school officials.

The phrases "EIC Model™" and "using the Environment as an Integrating Context for Learning (EIC Model™)" are copyrighted and trademarked by SEER (State Education and Environment Roundtable) and therefore cannot be reproduced. Information about the EIC™ Model can be accessed online at http://www.seer.org/pages/eic.html.

Two examples of lesson plans that use a learner-centered approach and integrate systems thinking, adaptive management, and constructivism are provided in the remaining pages of this Appendix. A summary explanation of service learning is also provided. World Wide Web links to download these lessons for free are given below:

* *Education for a Sustainable Future Unit: Are We Growing Like Weeds or Cultivating a Garden?* Education for a Sustainable Future Project, Center for a Sustainable Future, Cobb County Schools, Marietta, Georgia, U.S.A..
  http://csf.concord.org/esf/index.php?module=curriculum&type=unit&func=display&unitid=149

* *Education for a Sustainable Future Unit: Voices for the Lorax: Thinking About and Affecting the Future (Land Conservation).* Education for a Sustainable Future Project, Center for a Sustainable Future, Cobb County Schools, Marietta, Georgia, U.S.A.
  http://csf.concord.org/esf/index.php?module=curriculum&type=unit&func=display&unitid=22

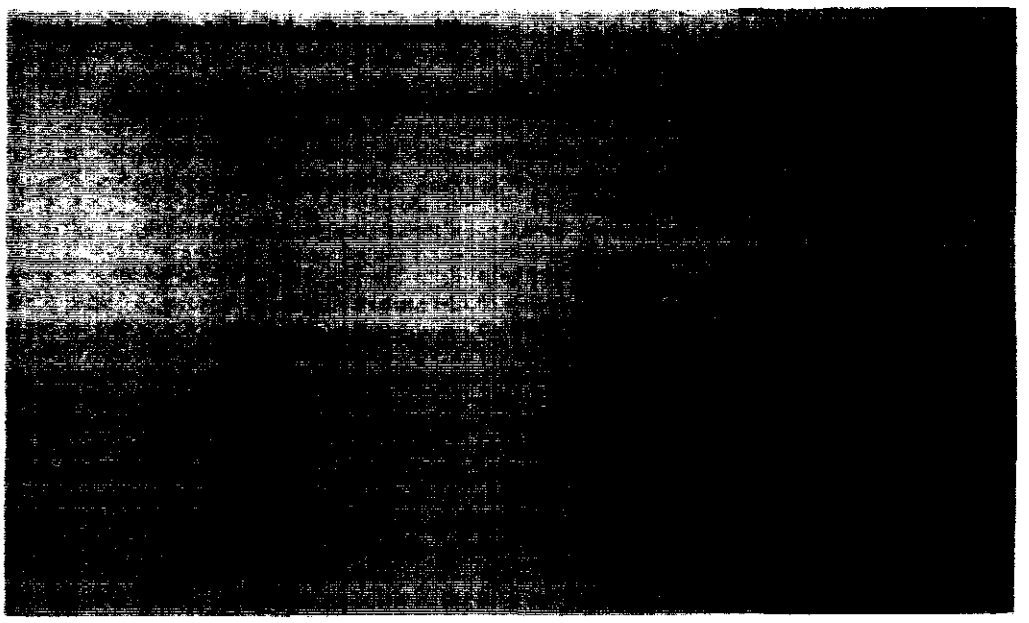
* Service-Learning, California State University: Module 1: Introducing Service Learnin. California State University Chico, Chico, California, U.S.A.
  http://www.csuchico.edu/psed/servicelearning/mod1/mod1_4-1.html

ESF ation for a Sustainable Future

Curriculum

Quote of the Moment

I am, after 24 years of teaching, more interested in a 'sane' answer than chasing the 'same' answer to the question of how to best provide an education for a community of learners. I believe that to assist a community as it moves into the future to become a part of the global village, we must begin with a community designed and implemented



educational experience. The promise of this project lies in the fact that it begins with a restricted local focus. The project's intent is to sustain a community through a future-not just drop it off at the future. Sustaining our own community does not mean isolating it from the world, It means inclusion in the sustained global village. I am energetic and enthusiastic about the problems and possibilities

-- Randall Crump, Harrison High School

ESF Topic

Designing Sustainable Communities

Unit Title

Are we growing like weeds or cultivating a garden?

Authors

Tracy Young

Unit Overview

This unit provides tasks for students in grades 3-5 in all subject areas to focus on "Are we growing like weeds or cultivating a garden?" as it relates to the Education for a Sustainable Future topic of Designing Sustainable Communities. The concept of design is very important in helping us get to a sustainable world. Good design needs to account for environmental and social attributes and is bound by economic reality. This unit will be a study of the components of a community and how they affect its sustainability. Students will explore and investigate the driving question, "Are We Growing Like Weeds or Cultivating a Garden?" by studying the changing patterns of land use in Kennesaw, Georgia through looking at the present, past and future. They will investigate what makes up the land in our surrounding area, how city limits are defined, categories of land use, and map types and map making. Artifacts produced by the students will include interviews of local citizens, maps of land use, a three-dimensional map of Kennesaw as well as a daily journal of thoughts and feelings regarding land use in their community.

Through activities such as map exploration, studying landforms, and having visits from a zoning official and a cartographer students will gain a better understanding of the way that their land has been used, is being used, and how they can make changes in how it is used in the future to maintain a sustainable community.

Essential Question

How can we make changes in our use of land to successfully affect the future of sustainable communities?

Guiding Sub-questions

-What are different types of maps?
-How are maps made?
-What is our land like?
-How do you know when you're in Kennesaw?
-What is our current land use pattern?
-What are the patterns of land use from 30 years ago?
-What do you think?
-Using current data, what are the projected patterns of land use 30 years from now?
-What are the changing patterns of land use in our city?

Desired Results

The students will:
-Make predictions about uses for the many types of maps presented
-Explore to find various landforms, landmarks, and places on a scavenger hunt
-Discover real-life uses for the maps they've explored
-Prepare questions to ask a cartographer about making maps
-Listen attentively during a speaker's visit
-Take notes about cartography
-Develop questions to be used by the teacher in test construction
-Write a note to thank a speaker for his/her visit
-Use observation skills to examine soil samples
-Learn the three major types of soil and their characteristics
-Hypothesize about how people might use the soil in our area
-Discuss landforms that can be found on maps
-Explore their area to discover various landforms
-Locate bodies of water in their area
-Locate sources of bodies of water
-Develop questions for inquiry
-Research for information using the questions they developed
-Create models of their homes
-Utilize mapping skills
-Identify the purpose of map scale
-Review characteristics of urban, rural, and suburban communities
-Identify at least four types of current land use (including but not limited to : residential, commercial, industrial, parks/recreation)
-Utilize a map grid to locate places/areas in the community
-Calculate the percentage of land currently utilized in each category
-Chart/compare/discuss results
-Create models of buildings in their area
-Explore land use in their community
-Utilize historical maps to identify the types of land use
-Calculate the percentage of land utilized in each category
-Construct a graph showing the percentages of land use from 30 years ago
-Utilize technology to demonstrate the status of land use
-Construct a survey
-Administer a survey
-Graph results of a survey using technology
-Analyze results of a survey.
-Determine action to be taken.

Grades

3-5

Curricula

Interdisciplinary

Time Frame

16-20 hours

Unit Preparation for Implementation

Students should have a basic understanding of the following map terms:
-Cardinal directions
-legend/key
-symbols
-scale
-political/physical
Students should also be familiar and comfortable with working in cooperative groups. There are wonderful resources available, which give information about how to best implement cooperative groups. A key is to make sure that each student takes an active, important role in the group. For example, you may assign jobs such as: materials, reader, researcher, recorder, reporter, timekeeper, encourager, and so on. A great resource for learning about helping students develop these skills, as well as using the body/mind connection is (http://www.kovalik.com). We call our cooperative groups learning teams (see appendix). Our classroom model encourages the use of Lifelong Guidelines and Lifeskills (see appendix).

Community Contacts:
Atlanta Regional Commission
City of Kennesaw Zoning Board
City of Kennesaw Mayor's Office

Technology:
Community Construction Kit
Neighborhood Map Machine
Sim Town
Geographical Information Systems
Inspiration
The Graph Club

Unit Resources

All resources available through Amazon.com (http://www.amazon.com) unless otherwise noted.

Professional Resources:
-Ten Minute Field Trips by Helen Ross Russell, National Science Teacher's Association
-ITI: The Model Integrated Thematic Instruction

Websites:
Discovery Gardens
http://www.mindspring.com/~discoverygardens/dgihome.html
Mainly specific to Georgia, this site gives information on maximizing the use of your school grounds as an outdoor classroom.

USGS (US Geological Survey)
http://www.usgs.gov/fact-sheets/finding-your-way/finding-your-way.html
This page gives information on topographic maps - what they are, and how to use them.

Map-It: Form-based Simple Map Generator
http://crusty.er.usgs.gov/mapit/
Enter the longitude and latitude for anywhere, and this site will generate a simple map for you!

Sustainable Communities - Student Activities
http://www.wri.org/wri/enved/suscom/scenrich.html
This site gives some activities which can be used to extend the activities in our unit.

Landscape Lesson Plans for Teachers
http://www2.cr.nps.gov/hli/landless.htm
This site provides tools to teach students how to be the historians as they study primary sources, using a variety of research tools that may include historic and contemporary maps, surveys, photographs, etc. Students could be taught how to "read" the landscape itself, and search for the history within the cultural landscape in their community.

Enviro-Source
http://www.enviro-source.com/us/us2.cfm
This lists a number of websites, which can provide background information for teachers. The sites include links to land-use planning resources, and information on professional planners. There are also links to sites about sprawl issues.

With the Grain
http://www.wtgrain.org/
Providing planning and zoning solutions geared toward natural resource conservation and

preservation, through public education, resource advocacy support, and documented alternatives for specific sites and local conditions.

Center of Excellence for Sustainable Development
http://www.sustainable.doe.gov/landuse/luintro.htm
This is a government site useful for teacher background. It outlines the issues involved in land use planning and provides information on how citizens can become involved.

Kagan Cooperative Learning
http://www.kagancooplearn.com/Newsletter/0898/index.html
This site contains newsletters with tips for cooperative learning and multiple intelligences as well as numerous resources for sale.

Susan Kovalik and Associates
http://www.kovalik.com/
The mission of Susan Kovalik and Associates is to teach educators about the biology of learning and its applications in classrooms, schools, and school districts to create dynamic learning communities and responsible citizens across the country and the world. The site contains links for many related areas in developing a body/brain compatible environment for learning.

Study Web
http://www.studyweb.com/
Has links for educators. A search for "soil" turned up great background information primarily for teachers, but which students could also understand.

Evaluation and Assessment

Standards Alignment (Top)

**Georgia (unstructured)

,GA

**

SS.3.4 Explains that rules and laws protect the rights of people.

SS.3.5 Explains the difference among making laws, carrying out laws, and determining if laws have been violated. Identifies the governmental bodies that perform these functions at the local, state, and national levels.

SS.3.6 Describes how violations of the law produce consequences.

SS.3.7 Distinguishes among city, county, and state governments.

SS3.8 Identifies the duties of local officials (e.g., mayor, county commissioner).

SS.3.12 Determines the purpose of a map by examining title and content

SS.3.13 Recognizes how human actions and physical environment affect one another.

SS.3.14 Determines the type of map needed for a specific purpose

SS.3.15 Explains the purpose of map scale.

SS.3.16 Describes physical characteristics of landforms and bodies of water including mountains, peninsulas, islands, plains, plateaus, valleys, gulfs, rivers, bays, and lakes.

SS.3.17 Identifies the features of a river.

SS.3.20 Describes and classifies the physical and human characteristics of urban, rural and suburban communities.

SS.3.23 Describes the local community in regard to origin, growth and change over time.

SS.4.7 Distinguishes between political and physical maps.

S 3.1 Asks questions, classifies objects and events, communicates with other, makes inferences and predictions, uses estimation and measurement, uses evidence to construct explanations, makes sketches and diagrams to explain ideas, and organizes data into tables and charts to interpret and formulate simple hypotheses.

S.3.4, 4.4, 5.4 Actively engages in the learning process via hands-on science activities and experiences. Uses appropriate tools to collect and analyze data and solve problems.

S.3.20 Compares various soils such as sandy soil and red clay.

S 4.1 Asks questions, makes inferences and predictions, uses estimation and measurement, uses evidence to construct explanations, makes sketches and diagrams to explain ideas, organizes data into tables and charts for interpretation, reads

and interprets various types of graphs, formulates simple hypotheses, identifies and controls a limited number of variables, and designs a simple experiment.

S 5.1 Asks questions, makes and keeps records of observations, classifies objects and events, communicates with others, makes inferences and predictions, uses estimation and measurement, uses evidence to construct explanations, makes sketches and diagrams to explain ideas, organizes data into tables and charts for interpretation, reads and interprets various types of graphs, formulates simple hypotheses, identifies and controls a limited number of variables, and designs a simple experiment.

SS.4.7 Distinguishes between political and physical maps.

M.3.38 Locates points on a map or grid.

M.3.39/4.26 Organizes data into charts and tables and constructs bar graphs using scales of one, two, five or ten units and pictographs using scales of one, two, three, four, five or ten units.

M.3.40 Collects, reads, interprets, and compares data in charts, tables, and graphs.

M.4.25 Collects, reads, interprets and compares data from charts, tables and graphs using a variety of scales and estimation.

M.5.33 Collects and organizes data into tallies, charts, and tables; determines appropriate scale and constructs bar graphs and pictographs.

LA 3.29 Draws conclusions, makes predictions, compares-contrasts, and makes generalizations.

Teaching Procedures (Top)

#1 120 min.

Are We Growing Like Weeds or Cultivating a Garden?

This lesson may need to be done over a 2-3 day period.

As a pretest, before the day of the first lesson, students will use Inspiration to design a web that has ÒLand UseÓ as the center. They will be asked to make the branches of the web into things that they think of when the term ÒLand UseÓ is used.

Now tell students they will be going outside during this lesson to observe, sketch and write about types of areas on the school grounds (garden, play, school building, parking lot, park/green space, etc.). Review the importance of observation as data collection Ð what you see, hear, feel etc. Go outside as a group, and give students about 15-20 minutes to sketch different areas.

Back inside, have students write about their impressions for 15 minutes independently. Have them think about and answer the following: What did you notice about each area? Which area appealed to you more? Why?

Have students complete a **Venn diagram** comparing two areas.

Share the results as a large group, creating a class **Venn diagram**. Draw analogies between gardening and land use.

Introduce the term/concept of sustainable communities. A sustainable community is one that meets its present needs in a way that will allow future members of that community to meet their needs. Discuss/introduce the terms environment, economy, quality of life and relate to sustainable communities.

Discuss the following questions, using the Think, Pair, Share

technique (see **Glossary of Terms**).

What kinds of things are being built in our community? Where are they being built? Does our community seem more like a cultivated garden, or a wild, weedy area? Why?

Explain that the focus for the next unit will be on land use in our community. Share the general areas of study: What is our land like? What is our history of land use Ð now, in the past? How does our community feel about this development? What can we do about it?

Students will decorate the covers of their daily journals and respond to todayÕs lesson.

Assessment: Use the **General Grading Rubric** to grade studentsÕ sketches and Venn Diagrams. Pretest will determine what students know so one can determine with a posttest if learning has occurred.

#2 *Exploring Maps*
60 min.

In today's lesson, refer to the pictures the students drew of the areas around the school. Ask students for other ways that we can show representations of land. (Make sure to get the idea of using maps from your children.)

Distribute maps to groups. Ask students to make predictions about why the maps are given their specific names (i.e. political, physical, relief).

Distribute **Geography Scavenger Hunt**.

In cooperative groups, students will find things on **Geography Scavenger Hunt**. They will label what they find as well as the type of map they used.

After completing the **Geography Scavenger Hunt**, students will individually find a real life use for each type of map. They will share these with their cooperative groups.

Using Inspiration as a whole group, create a web showing the types of maps as well as their real life uses. As closure, ask how these maps could help in cultivating a garden/ creating sustainable land use.

Students will respond to todayÕs lesson in their journals.

Assessment: The **Geography Scavenger Hunt** will be graded as an assessment and will be recorded on the **General Grading Rubric**.

#3 *Autobiographical Maps*
60 min.

This lesson will include an explanation of the homework assignment and a follow-up the day the assignment is due.

Connect to previous lesson by asking students: "How is knowing about your home ÒturfÓ important to understanding sustainable communities and your quality of life?"

Present the **Autobiographical Mapping** homework to the students using the transparency model. Explain that they will be responsible for presenting their Autobiographical Maps to their cooperative groups.

Distribute white paper and instructions.

Follow-up: As students share their Autobiographical Maps, they should remember to tell how their neighborhood and the area around their neighborhood has changed over the past few years. (They may not see many changes, as they are only between 8-10 years of age.)

Students will complete a brief assessment of their neighborhoods in their journals. Is my neighborhood sustainable? What was taken down to build my neighborhood? Do I like what is happening in and around my neighborhood?

Assessment:

Teacher will assess the quality of the Autobiographical Map using the **General Grading Rubric**.

#4 *A Visit from a Cartographer*
120 min.

This lesson can be done over a period of days: preparation for the visit, the visit itself, and follow-up.

Connect to Step 3's lesson: How were our autobiographical maps made? What about the ones we used for the scavenger hunt? Who does this? Why are these people important as we study how land is used in designing our cities?

Prior to the cartographerÕs visit, have the students prepare questions. They may wish to use some of the materials on map making that the teacher gathered.

During the cartographer's visit, the students may take notes as their questions are answered. Take some digital pictures during the visit, illustrating some of the major points.

Next, review the answers to the students' questions, and the major points that the cartographer made. Have students work with the digital pictures to explain what each one shows by writing captions. These may be bound into a book.

Students should then respond to this question in their journals: How can a cartographer help a community become more sustainable?

Finally, have students write thank you notes to the cartographer. This can be done for homework or during class.

Assessment: Review student journals to assess understanding of a cartographer's job and how it relates to designing sustainable communities.

#5 *Studying Soil*
60 min.

Explain that we have been looking at communities in 2 dimensions, and studying what is above the ground by using maps and drawings. Now, they will be going deeper, into 3 dimensions. They will look at the soil in our area. Ask students how they think this relates to where things are built. Begin a KWL chart about soil (What We Know, What We Want to Know, What We Have Learned), working as a whole group.

Divide students into cooperative groups of 3-4. Groups will find a digging spot, collect a few spoonfuls of soil, and seal it in the plastic bag.

Upon return to the classroom, they will complete the thinksheet, **Soil Observations**: What do You Observe?

As a class, discuss the results of your soil sample observations. Using a variety of books, the soil samples and water for experimenting, and seeds in the three soils, have students

complete the thinksheet, **Soil Observations**. Review the charted information as a group, so that the students can draw similar conclusions. Discuss the answers to the questions. Students may have a variety of ideas, and may propose some inquiry questions for further investigation. Summarize, on chart paper, their ideas about how the soil could be put to use and how this relates to designing sustainable communities. Relate to the environment, economy, and quality of life.

Students will respond to todayÕs lesson in their journals.

Assessment: Thinksheets completed by students

You could further assess their knowledge of soil types by presenting students with unlabeled soil samples, ask them to categorize the samples, and explain the reasons for their choices. Students can use the **Studying Soil** form to record information.

#6 120 min. *Do Landforms Affect Where we Live?*

Procedures: Connect to previous lessons. Expand into the study of bodies of water. Make sure to link this concept to sustainable communities. Read As the Crow Flies by Gail Hartman. Discuss the landforms observed in the book. Students will begin the lesson by exploring a map of their state. They will be asked to make connections between the landforms they see on a daily basis with their representations on a map. They will then look for bodies of water (lakes, rivers, streams, etc.) in the state. After listing these in teams, students will look to find the sources of these bodies of water (i.e. Is there a river that runs into the lake? Do we know if the lake is manmade?) Students will then look at a map of their county. They will explore the bodies of water in the county. After listing the bodies of water in our area, each group will pick one body of water to research. They will look at the GIS map to find out what is built around the body of water. Students will develop their own research questions for inquiry such as: Are there neighborhoods that are built around these bodies of water? Are there things that you think were built in a different place because the body of water is there? Are the bodies of water natural or man-made? After students research, they will share

their research with other cooperative groups in their classroom. Encourage students to locate other landforms in their state. After they have found some, make sure that they share them with other cooperative groups in the classroom.

Play **Georgia Geography Jeopardy**. You may modify the answers within the various categories to fit your location.

Students will take the studysheet home to use as a review tool. The studysheet has ÒgradedÓ questions so each grade level knows how much information theyÕre responsible for. Students will take a grade appropriate quiz covering the various landforms in Georgia (or your state). Students will respond to todayÕs lesson in their journals.

Assessment: Students will do a self-assessment of their research. They need to check to make sure that it is correct, complete and comprehensive. The **Georgia Geography Quiz** will also be graded.

#7
150
min.

Procedures: During your Social Studies time, give students a demonstration of Community Construction Kit. Making a model of your own house or the school is easiest. Make sure you show students the picture of your home and how you made each part of your home on the computer. Tell students that they will be making models of their own homes. They can make these models any time during the day that it suits your schedule. Review the types of communities there are and what type of community their school is in. Connect to previous lessons by recalling types of maps and soil youÕve learned about and also how and why maps are made. Make sure to tie these concepts into sustainable communities, the environment, the economy, and their quality of life. This ÒlessonÓ is only the first part of the community. Students will only be discovering the neighborhood portion of land use at this time. While homes are being completed, groups of students will utilize a map of their city to lay out streets on the wall space youÕve designated for the three dimensional map. They will label the neighborhoods around the school. As homes are completed, they will be placed in the correct neighborhoods on the map. This is a perfect time to discuss map scale. As the students will not make all homes in a neighborhood, they need to

decide how many homes their created house stands for (i.e. If 3 kids in your class live in a neighborhood of 75 homes, each house stands for 25 homes. As part of the Community Construction Kit, you can print houses of different sizes. You can decide that small houses represent 10 homes, medium represent 50, and large represent 100.) Extra Credit can be obtained by contacting builders of the neighborhoods and homes to find out why they built homes where they did. Students can also find out what was moved to put in the neighborhoods. Students will respond to todayÕs lesson in their journals.

Assessment: Students will be evaluated on whether or not they completed their home using Community Construction Kit.

#8
120
min.

Procedure: Recall the term sustainable land use as how we in our community choose to make use of the land. Relate this to the driving question, Are We Growing Like Weeds or Cultivating Gardens? Students brainstorm their ideas; teacher lists them. To connect to prior unit lessons: Students should analyze the partial three-dimensional map of Kennesaw (your town/city) which was constructed using the Community Construction Kit. Relate to the cartographerÕs visit and the tools that he/she uses. In the analysis, students should identify the types of land use evident on their map. Reflect upon soil types, sources of water, etcÉ Distribute maps of the community. Students locate, using the map grid, the school, their neighborhoods, and other significant places. Students attach the acetate grid to the map using small pieces of tape. Each group should divide up the map so that the entire community is covered (your community will probably cover a number of pages if the map is quite detailed). Each group decides on a key for land use. For example, residential areas could be red, parks could be green, and so on. This should be recorded on the **Land Use Chart** in the appropriate area. Students fill in the grid boxes on the acetate for their area, using the appropriate colors. Discussion should take place as the studentÕs work as questions arise. Land use categories can be added if needed. When all in a group are finished, students will record numbers on the chart for each land use category. Show students how to calculate percent; dividing the number of coded boxes by the total number of boxes. Students calculate the percent for each land use category, and record it on their chart.

Groups present their findings, summarized on a large group

chart. During this time, you may wish to discuss the following questions. Discuss one in a large group. Then do a carousel brainstorming activity (see **Glossary of Terms**) for the other questions. Why might groups have different results? How could we check our results? What surprised/interested you about the way we use land in our community? Why do you think we use the land this way in our community? How do you think this has changed over the past 30 years? How do you think it will change in the next 30 years? Are you satisfied with our community land use? Why/why not? If you are not satisfied, what could we do? Reinforce the concept of sustainable communities. Discuss things that are done that wonÕt hurt the future. Debrief as a large group. Have student/facilitator for each question (from the group that ended with the chart) report.

Focus on the last question, ÒAre you satisfied with our community land use? Why/Why not?Ó Students will respond to todayÕs lesson in their journals.

Assessment: Assessment for this activity includes studentsÕ ability to locate places on the map, code them according to land use, convert fractions to percents, record information accurately and neatly on the Land Use Chart. As a follow-up or homework assignment, you may wish to have students complete a similar activity independently.

#9
60 min.

Procedures: Connection to previous lesson: How were the maps made that we used in our last lesson? Who does this? Why are these people important as we study how land is used in designing our cities? Prior to the zoning officialÕs visit, students will complete the homework assignment **"Zoning Board Visit"** regarding questions that they have about their community today, zoning issues, and the future of their community. The students will read their questions from notecards during the zoning officialÕs visit. Students will respond to todayÕs lesson in their journals.

Assessment: After the zoning official leaves, we will have a 15 minute debriefing about the zoning issues of our city and how

they relate to sustainable communities. There will be no graded assessment.

#10 150 min. Procedures: On the first day of the lesson, students will break into four cooperative groups. The groups will be commercial, agricultural, industrial, and ÒotherÓ for other areas of land use. The students will develop questions for inquiry to guide their week long homework (i.e. The commercial will need to find out what the buildings look like as well as the names of them.) Give the students their jobs, and give them 3-4 nights to gather their information. The ideal would be to let them break into groups on Monday, work at home on Tuesday-Thursday, and complete the three-dimensional map in class on Friday. The commercial and industrial groups will need to use Community Construction Kit during the week to make their buildings. The groups will meet on the 5th day and compile their information, construct their buildings, farms, etc. and place them on the three-dimensional map. Present to other cooperative groups. Assess work on self-assessment checklist. Be sure students make the connection between what theyÕre doing and the driving question, Are We Growing Like Weeds or Cultivating a Garden? Students will respond to todayÕs lesson in their journals.

Assessment: Ongoing teacher observations of the process students go through to develop their buildings and other areas of land use as well as organization of the three-dimensional map will be the assessment. There will be no graded assessment.

#11 60 min. Procedures: Refer back to notes made in Step 6 "What is Our Current Land Use Pattern?" regarding studentsÕ speculations about what the land use was in our community 30 years ago. Make sure students see the connection between the mapping lessons, the current land use, the environment, the soil survey, and sustainable communities. Distribute the historical maps, and ask students to complete the Past **Land Use Chart**, using the same techniques as in prior lessons. They should also complete the questions at the bottom of the page. Discuss the questions on the **Land Use Chart**. Utilize Think, Pair, Share (see **Glossary of Terms**).

Have students figure out information using the **Land Use in Kennesaw - 1972** form. (Modify for your community). Then they'll use The Graph Club to create line graphs reflecting their data of past and present land use. They should also include the future, so the graph will show a projection 30 years into the future. They may use Center time, before school, free time, etc. Students will respond to todayÕs lesson on the **Land Use in Kennesaw-Graph**form.

Assessment: Past Land Use Chart Graphs constructed by students using the **General Grading Rubric**.

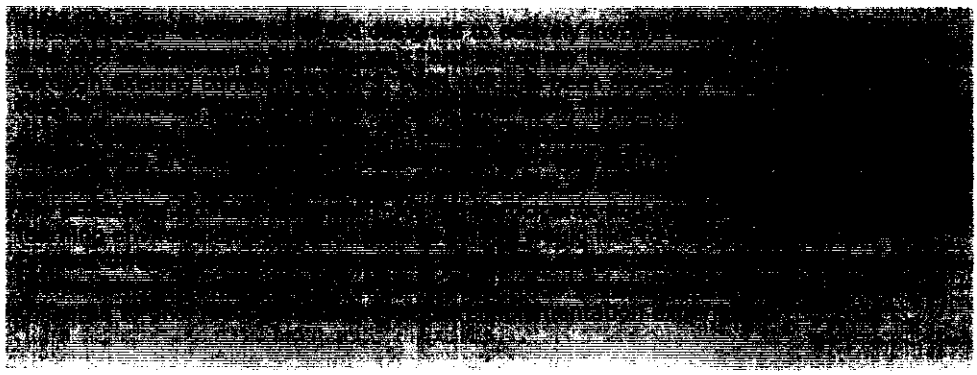
#12
45 min.

Procedures: Introduce students to the purpose of a survey: to gather information/opinions about a particular topic from a group of people. Share samples of surveys with students (U.S.A. Today is a good source of surveys Ð they include at least one daily). As a group, compile a list of what should be included in a survey. Make sure students include the idea of demographic information (necessary in order to graph results of different groups) as well as the questions themselves. Ask students to brainstorm questions they could ask residents regarding land use changes in our community. Finalize the questions to be included on the survey,. It is important that students understand how to approach the task of conducting a survey. Model it for them and have them practice in pairs or threes. Next, students conduct the survey of community residents. As a large group, chart the results. Total the studentsÕ findings, and calculate the averages. Using the results of the survey, students will construct graphs, using The Graph Club. This can be done during Center time, before school, during free time, etc.

Once all graphs are complete, discuss the results as a group. Ask students what they think should be done as a result of their survey. Is there a group, such as the city council, to whom it could be presented? Should they write a letter to the newspaper? Who would be interested in these results? Students will design a web that has ÒSustainable Land UseÓ as the center. They will be asked to make the branches of the web into things that they think of when the term ÒSustainable Land UseÓ is used. If your students donÕt know how to use Inspiration, they can illustrate the web by hand. Students will respond to todayÕs lesson in their journals. TAKE ACTION!!!

Assessment: Teacher evaluation of the survey: complete/not complete. Grade will be written on the grading checklist.

Comments (Top)



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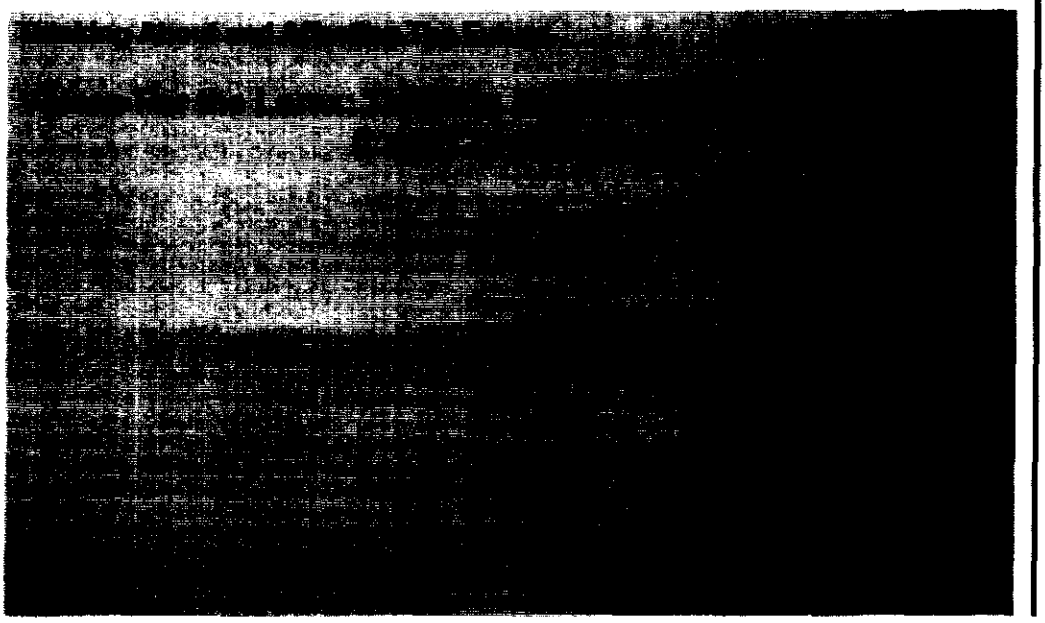
ESF ation for a Sustainable Future

Curriculum

Quote of the Moment

To seek to look ahead into the future is to seek to understand the momentum of the past and choices available to us in the present. We live in a world of options constrained by decisions already made and actions already taken - many before we were born.

-- Thomas Sowell, The Economics and Politics of Race: An International



Perspective

ESF Topic

Thinking About and Affecting The Future

Unit Title

Voices For the Lorax: Thinking About and Affecting the Future (Land Conservation)

Authors

Rebecca James

Unit Overview

This unit provides tasks for students in Kindergarten to second grade to focus on "how they can save our world from Once-ler Actions as described in the book The Lorax by Dr. Suess as it relates to the Education for a Sustainable Future topic of Thinking About and Affecting the Future. Sustainability is bound in the future. We are making choices today about how we live in order to affect the future for our children and grandchildren. Most students have a very short future view, ranging from days to weeks. Sustainability requires that we take a long view, often many generations into the future. So the challenge is to create learning opportunities for students to 1) look into the future and 2) understand the systems that affect the future through the use of system tools to plan for the future. Students should thus be empowered to affect the future both for themselves and for their communities. This future view needs to be seen through the lens of the environment, the economy and an equitable society.

Through activities such as reading children's literature, making observations, graphing, interviewing, creating causal loop diagrams and behavior over time graphs, using computer programs, drama, writing a class book and a field trip, students will begin to understand systems, cause and effect relationships, the terms past, present and future, the effects of choices made today on the future and the importance of caring for their environment now for the future.

Essential Question

How can we save our world from Once-ler actions?

Guiding Sub-questions

What problems occurred in the Lorax's world after the Once-ler arrived?
What similar problems do we have in our world?
How is the land in our coummunity being used?
How do trees benefit our environment?
How does the loss of trees affect animals?
How does population affect land use?
How do choices now about the use of land and population development affect future generations--what will the environment be like when your children start school?

Desired Results

Students will:
-begin to understand systems that affect the future
-begin to understand connections –the importance of the interconnectedness of these systems in a sustainable world
-introduce multiple perspectives – respect the diversity of points of view
-introduce systems thinking capabilities- understand cause and effect, change over time, "what-if analysis"
-be able to identify their families, their school class and their neighborhood as systems
-understand the term "future" as it relates to the present and the past
-understand how their choices today affect the future
-use System Dynamics tools such as, behavior over time graphs(BOTG), causal loops (CL), and computer models and scenario building

Grades

K-2

Curricula

Interdisciplinary

Time Frame

10-15 hours

Unit Preparation for Implementation

-Computers with Internet access
-Students should know how to use the computer to access specific websites for information.
-Students should have an understanding of how to make observations. Opportunities to practice making observations and recording information would be helpful prior to the field trip described in this unit.
-Students need to understand the interview process. Young learners often have difficulty realizing that someone is asking questions and recording 'another' persons answers--they often try to answer their own questions. There is an interview form attached in this unit, however it may be helpful to design one with the students.
-Students need to know how to tally.
-Multiple copies of The Lorax would be helpful for reading instruction for students who are reading at that level.
-This unit involves cooperative group work and whole group discussions. Students should be familiar with working in a group and how to be a contributing member. In the

attachments for the Student Activity is a form for cooperative group self-evaluation that would be helpful in teaching students how to work in cooperative groups.
-The teacher may need to make arrangements for the field trip at the beginning of the unit as this is a part of step 5.

Unit Resources

Books: These are available through Amazon.com
-The Lorax
Dr. Suess
-Yonder
Tony Johnston
-The Little House
Virginia Burton

Videos
-The Lorax
Dr. Suess

Bookmark
Kids Explore at-http://www.epa.gov/kids/chipmunk.htm
Friends of Trees-http://www.teleport.com/~fot/
Welcome to the Wonderful World of Trees-http://www.domtar.com/arbre/english/index.htm
Education for Sustainable Futures-http://csf.concord.org/esf/index.cfm

Computer Programs
-"**Inspiration**" by Inspiration Software,Inc.
-"**Choices, Choices Kids and the Environment**" by Tom Snyder
-"**Model-It**" by Cogito
-"**What-If Builder**" software by ESF
-Photo Studio(or software to edit digital camera photos)

Evaluation and Assessment

Standards Alignment (Top)

Georgia (unstructured) QCC

Language Arts K-2

-Listens to a variety of literary forms including stories and poems.

-Responds to questions on orally presented material.

-Increases vocabulary to reflect a growing range of interests and knowledge.

-Draws conclusions, makes predictions, and comparisons

Social Studies

-Identifies events as past, present and future.

-Makes decisions and identifies the consequence(s) of choices.

-Participates in a group as a follower and /or leader.

-Uses pictorial and semi-pictorial symbols on maps as needed, such as symbols for house, school, church, and road.

Science

-Asks questions, classifies objects based on similarities and differences, communicates with others, makes inferences and predictions, uses estimation and measurement, uses evidence to construct explanations, and makes sketches and

diagrams to explain ideas.

Math

-Constructs simple graphs using concrete objects such as blocks and squares.

-Constructs and interprets simple bar graphs and pictographs with up to five columns, using whole unit data.

Teaching Procedures (Top)

#1 45 min. Prior to introducing this unit administer the **Pre/Post Test Voices For The Lorax**. Introduce this unit by reading The Lorax by Dr. Suess. Discuss the story and create a story map. Use "**Inspiration**" to brainstorm Once-ler actions (those behaviors that harm the environment with no regard for the future). Begin brainstorming activity with those actions found in the story then include the students' own actions. See attached examples of this activity-- **once-ler actions**

and **our once-ler actions.**

#2 45 min. Show the video The Lorax. Compare and contrast the environment in The Lorax after the Once-ler arrived with our environment using a Venn diagram. (See **Venn Diagram**, picture of students at work on this activity). It would be helpful to use hula-hoops in creating the Venn diagram as a concrete learning tool for the primary child. Copy on a chart to refer to later in the unit.

REMEDIATION: Provide opportunities for students to practice using a Venn Diagram.

#3 45 min. Refer to the story map from step #1 to predict the future of the Lorax's world. This discussion should lead the students to develop an understanding of the future as it relates to the past and the present. Use "Inspiration" template "character web" to map the **past-present-future** in the story of The Lorax. Each student will create a **Poster** to illustrate his or her past, present and future. Then let them share their posters with the class. Continue to reinforce the concept of past, present and future using the daily calendar.

#4 45 min. The Lorax illustrates numerous systems. Discuss these examples, such as, the pond and the Humming-fish, with the students to help them understand systems. Discuss the fact that when something happens to one part it affects the whole system. Identify with the children the fact that their body is a system and discuss the effects to the whole system (the body) when they are sick. In order to show that the family is a system read the book_ Yonder by Tony Johnston. Discuss the farmer's family and explain how it is a system. Create a family tree based on Yonder with the students to exemplify systems. Here is a sample of a Family Tree created by the students, **systems**.

Continue to develop the concept of systems by using the framework of the classroom and the neighborhood.

A good follow up activity is to have the students chart their own family tree. This , **Family Tree**, could be used as the homework assignment.

REMEDIATION: Discuss the class as a system or their sport team as a system.

ENRICHMENT: Students could draw and explain other systems they find.

#5 120 min. Review the Venn diagram from step 2. Students will take a field trip to observe what is happening in their community. They will tally their observations using the recording sheet " **My Community Observation**." Students will transfer this information into a bar graph (see picture, **graph**, of students) and discuss the results that represent a factual picture of what is happening in their community. You may create a class graph using "**The Graph Club**" by Tom Snyder (or other graphing software) after sharing observations.

REMEDIATION: Provide students the opportunity to tally

observations of animal movements while watching a video, for example, tally how many times an animal jumps, runs, or climbs.

#6
90 min.

Use the observation sheet from step 5 to discuss how many items they observed that involved the use of land. Then lead the discussion to the recognition that as the land is used there is a loss of trees. Create a class "T" graph to record each student's response to the question "Should we cut down our trees to build?" Save this to compare with a follow-up "T" graph. Students will then use the following internet site to investigate the ways in which trees help us: **Welcome to the World of Trees**. Afterwards do another class "T" graph like the one above to assess understanding. Using a model of a tree as a chart, create a class list of the ways in which trees help us, posting the ways on the branches. Save this model to use in the last step.

ENRICHMENT: Allow students the opportunity to create a model of what happens to the community as the trees are cut for building. Community Planner-ESF software (can be found at the website) is an excellent program for students to do this.

REMEDIATION: Use Community Planner-ESF software (can be found at the website) to help students create a picture of what they observed.

#7
45 min.

Use the story of The Lorax to develop **behavior over time graphs (BOTG)** illustrating what happened over time to the Truffula trees, the Bar-ba-loots, Thneeds and the people. These should be created in a whole group setting with student participation. Using teacher observation, be sure that students understand BOTGs. Lead the discussion of the graphs to help students realize that Truffula trees affected the Bar-ba-loots, the Thneeds and the people. Use "Community Planner" (http://csf.concord.org/esf) as a whole class activity to demonstrate these cause and effect relationships.

Tip: Demonstrating cause and effect relationships using unifex cubes to represent the Truffula trees, etc. in The Lorax, helps

some students to have a better understanding of this concept prior to introducing Community Planner (see picture of students, **cause and effect**).

#8 165 min. Review the BOTGs from step 7 to introduce the **Student Interview Activity**. During this activity students will interview family members or neighbors that have lived in their area using the **Interview Form**. These interviews will help students to collect data so that they can create a BOTG graph illustrating what has happened over time to the trees, animals, houses and population in their area. A **Group Self-evaluation Form**and a **BOTG Design Checklist Form** will be used to assess performance.

#9 45 min. Using the graphs shared by the students from their interview activity, create **causal loop diagrams** to illustrate the cause and effect relationships between (1) land use and the trees; (2) trees and the animals; and (3) people and houses (from the interview data in Student Interview Activity). Discuss the fact that all three of these loops are interrelated to the use of land and that what happened to the land affected the animals, the people and the houses (Refer to step 4). This would be a good time to point out that all these parts make up an ecosystem. Save these causal loops to help build scenarios in the last step.

ENRICHMENT: Students create their own causal loops using other concepts from the environment that they observed.

#10 45 min. Review the causal loop diagrams from Step 9 emphasizing the cause effect relationships of each one. Demonstrate the "**Choices, Choices Kids and the Environment**" computer program by Tom Snyder (this is a great technology tool that demonstrates the effects of choices). Allow students the opportunity to explore this software to prepare them for using the "**What-If Builder**" and to demonstrate the effects of choices. "Choices, Choices Kids and the Environment" could be a center activity or whole class activity.

#11 45 min. Review some of the outcomes from the choices students made using "Choices, Choices". Demonstrate how to use the "**What-If Builder**" (ESF computer program). Students will use the "**What-If Builder**" in groups, to create what-if stories based upon the three causal loops from step 9. Each group will share their stories. (It might be helpful to have the groups work with What-If Builder with the teacher, depending on their age and ability, while other students are working in centers.)

#12 60 min. Begin building scenarios for the future with the class. A scenario is a story about the future based on current trends. Have students focus on the concepts of land use and population when building their scenario (future story). Students in groups will develop stories to act out their predictions of the future. The **Scenarios Rubric** will be used to guide and assess their performance. A rubric is included, however, it is a more effective teaching tool when it is created with the students before they begin their plays. Share these plays of the future with the class. (These can also be shared with other classes or parents.) Use the digital camera to take a picture of each group. (See picture of one group, **plays**). Afterwards each group could write about their scenario using Microsoft Word and create a class book. Or the class could use "**What-If Builder**" software beginning with a common stem and then each group could use their scenario to branch. Then discuss possible futures versus preferred futures by asking the students which scenario they would like to live in for the future.

#13 45 min. Introduce the book The Little House by Virginia Burton explaining that this story portrays the future of a house and what happened to its environment over the years. Afterwards discuss what happened to the house in the story. Be sure to include a discussion about what caused the changes in the environment of the Little House. Chart with the students what the voice of the Lorax would say they should do now to create the scenario of the future that they most want to exist when their children start school. This chart should be included in the class book. It could be scanned or typed in Microsoft Word to be printed for the book. Students could take turns sharing the class book with their parents.

#14 Administer the post test **PrePosttest Voices For The Lorax.**
15 min.

Comments (Top)

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Module 1 - Introducing Service-Learning

Lesson 4: Student Demonstrations of Service-Learning in K-12 Education

Activity 1: Design Examples of Student Work for California Draft Interim Service-Learning Standards

What should students know and be able to do as a result of their participation in a service-learning activity or project? This lesson presents five key elements that should be addressed in every service-learning activity. These "key elements" or areas for student learning provide guidance for the design of effective service-learning experiences. ("Student Demonstrations of the Key Elements of Service-Learning," CalServe Program, California State Department of Education, 2000).

This lesson presents examples of student learning within the five key elements of service-learning as recommended by the California State Department of Education.

NOTE: The five elements discussed here were originally described as "content and performance standards" in a 1995 document, Draft Interim Content and Performance Standards for California Schools. Because service-learning can be incorporated into all disciplines and is defined as an "instructional strategy," it is a method of integrating curriculum across content areas, and not actually a "content" area as are the disciplines of mathematics, reading, writing, science, and history/social science. Service-learning allows the student to make meaning of these curriculum content areas through participation in the design and implementation of a service-learning project.

Step One: Study the Student Demonstrations of the Key Elements of Service-Learning presented here.

Element 1: Meeting a Real Community Need
Students will understand how the needs of the community are identified or, when appropriate, will identify the needs of the community. Based on demonstrated understanding of these needs, students will actively participate in thoughtfully organized service that addresses the needs of the community as identified by the needs assessment. (Note: The school may be defined as the community.)
For example, students with help from their teacher have determined that a school beautification project is needed to build a sense of community pride and improve the physical surroundings of the neighborhood. A third grade class designs and distributes an opinion survey to their peers and the other teachers. They are responsible for tabulating the results of the survey. Based on survey information, the class designs, plans, establishes, and maintains a garden at the school. Flowers grown in the garden are used to beautify the school.

Element 2: Integrated into and Enhances the Curriculum
Students will demonstrate their mastery of curriculum content standards

1.1 Definitions of Service-Learning Terms
1.2 Two Principles of Service-Learning
1.3 The Standards of Quality for Service-Learning
1.4 Student Demonstrations of Service-Learning in K-12 Education
Activity 1
1.5 The Elements of Service-Learning
1.6 The Benefits of Service-Learning
1.7 Assessing Student Learning
1.8 Addressing the Learning Needs of Special Education Students
1.9 Summary of Module 1

through participation in a service-learning activity that is integrated into the curriculum.
For example, a seventh grade science class works with their teachers and staff members from local conservation organizations to design, create, and maintain a garden in a deserted lot in the back of the school. This becomes an on-campus community garden that consists of native California plants and ecosystems and is used as a focal point for the study of geology, ecology, and agriculture. Staff members from the conservation agency provide valuable scientific expertise, and assist the class with resources by donating garden supplies and educational materials. Based upon their service experience, students learn lessons in local environmental science, geology, agriculture, and ecology and participate in discussions about environmental issues that effect them and their community.

Element 3: Coordinated with a Community Agency, Another School, or the Community at Large
Students will understand the relationship betweeb school and community and the value of school-community partnerships. Students and teachers collaborate with individuals and organizations in the community to develop and implement meaningful service activities that meet the needs of the school and the community.
For example, in conjunction with the school's project-based curriculum, students participate in a six-week project on city planning. Students survey neighborhood needs, visit utility sites around the city, and invite city officials to speak in their classes. As a service project, the students decide to improve services and safety in their school community by designing wheelchair accessable ramps. Studnets learn geomentry as they design the ramps and are assisted by professional architects and city planners to be certain the ramps will meet all specifications. Parents and community assist the students with the building of a ramp at the school. Students write essays to refect on their understanding the issues of accessability in their own school and community.

Element 4: Helps Foster Civic Responsibility
Students will understand and demonstrate civic responsibility through participation in a service-learning activity which meets a real community need and improves the quality of life in the community.
For example, in an urban high school, science classes for English language learners study geology, including lessons on earthquakes and plate techtonic theory. The classes visit an office for emergency disaster management to understand the scale of natural disasters. The students decide to work with agency staff to raise awareness in their community, which has historically not been prepared for natural disasters. In English class, the students work with their teacher and community members to compile information and instructions about earthquake preparedness in the various languages reflected in their community. This provides an excellent opportunity for students to utilize computer knowledge and publication production skills while they reinforce their literacy in English-language arts, science, and business technology. Students gather materials for earthquake preparedness kits and then travel in teams with representatives from the natural disaster relief office to distribute kits to residents in thir neighborhoods. Students prepare and make presentation to the faculty, school board, and local civic organizations that reflect their knowledge about earthquakes, the importance of preparedness, and how their service benefits the community.

Element 5: Provides Structured Time for Reflection

Students will understand and reflect upon the significance of their service-learning experience, and how applying skills and knowledge affects them as individuals, their own learning, and the community.
For example, a high school American Democracy class selects the theme of poverty for the semester-long course. After brainstorming issues related to the theme, students identify community agencies at which they could volunteer throughout the semester. The teacher and staff from the local volunteer center help students identify service placements that match course expectations and community needs with each students' interests. Students volunteer at after-school tutoring programs, child-care centers, soup kitchens, and food banks in nearby low-income neighborhoods. Throughout the semester, the teacher assigns readings related to poverty. Each student maintains a journal with reflections on his/her volunteer experience and how it relates to the study of poverty, American Democracy, and the people that have been served.

Entry #8:

In your Journal, provide 2 examples of service-learning for each of the five key elements discussed above. Provide one example that is appropriate for the elementary grades of K-6 and one example that is appropriate for the secondary level, grades 7-12.

Step Two: E-mail this journal entry to your instructor as an attachment.

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Appendix III
SANREM CRSP Research Briefs

This appendix contains the three SANREM CRSP Research Briefs on which the example units of lesson plans in this manual are based. Additional SANREM CRSP Research Briefs can be viewed and downloaded for free from the SANREM CRSP web site: http://www.sanrem.uga.edu.

WATER SPIRITS AND CITIZENS' ACTION: COMMUNITY-BASED WATER QUALITY MONITORING IN THE PHILIPPINES

Can local people participate in monitoring the quality of natural resources in their communities? Can they produce information that is reliable and consistent enough to serve for environmental assessments and policy recommendations?

Global environmental policy is promoting decentralization and devolution to the local level as a key to sustainable natural resource management. Yet rates of natural resource loss exceed the capacity of local government structures to remedy the situation without the active involvement of civil society and private sector. How to generate awareness and motivation among citizens and facilitate understanding of ecosystem linkages among decision-makers remains a challenge.

This brief describes a unique initiative in which members of a rural Philippine community parti_cipated in collecting data about water conditions that was used by local government in making decisions about water management. The initiative is part of the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) and is directed by Auburn University scientist William Deutsch in collaboration with local communities and other international, national, and provincial institutions.

Despite the Philippines' rich water resources, the country is currently facing a crisis regarding the dwindling supply of high quality water. Water quality is threatened by high rates of soil erosion, sedimentation, nutrient runoff, and bacterial contamination. This kind of pollution (non-point pollution), which is generated from broad areas of the landscape, is far more difficult to control than pollution that results from a specific source.

The problem is particularly acute in the Manupali watershed, which in the last 30 years has experienced a high rate of conversion of forest cover to corn and vegetable cultivation at medium and higher elevations. These crops receive heavy doses of chemical inputs and offer insufficient soil protection, especially during heavy rainfall events. They are often planted against the contour to facilitate farm work and drainage, but this also encourages soil erosion and nutrient runoff, leading to downstream sedimentation and contamination of water courses.

Animals like carabao (water buffalo) may become ill from pesticide runoff.

Farmers complain that local stream flows have become more irregular, going through cycles of flood and drought, which causes further soil erosion, crop and animal losses, and, occasionally human casualties.

Siltation has reduced the efficiency of lowland irrigation networks to 25% of normal capacity. An important hydroelectric power generation reservoir in the watershed is half-filled with sediments and siltation occurs at nearly one meter per year at the dam. Suspended solids contribute to wear-out of turbines and frequent power outages.

Pesticide and pathogen contamination of water resources affects animal and human health. Public health records show higher than average infant mortality and morbidity, with many ailments caused by waterborne pathogens.

Defining a set of water quality indicators

The project adapted training methods and sampling techniques from the EPA-sponsored Alabama Water Watch, a volunteer water quality monitoring program operating in the United States. The approach centers on a minimum set of indicators that are:

a) scientifically valid to ensure credibility;
b) relevant to the community for their endorsement and participation;
c) practical and inexpensive for sustainable use.

The monitoring activities began in 1994, with a baseline description of water quality conditions throughout the watershed. This initial assessment incorporated the qualitative indicators of community perception, memory and experience.

Selecting sites and sampling techniques

The monitoring sites were chosen for accessibility and ability to represent diverse portions of the landscape, including forest and farmland. Monitors used imported simple test kits and locally available materials (ropes, sticks, floats) to take measurements once or twice per month at four sites in daytime, base flow conditions. During selected intense rainfall events, samples were taken on an hourly basis. At certain sites, soil loss increased up to 1,000-fold within a two-hour period of heavy rain. To better convey this to farmers, the weight of soil lost was likened to the weight of a sack of corn approximately the size of a small desk.

Addressing stakeholders' interests

As agriculture is the primary source of livelihood for most residents, measurements of soil loss, such as TSS (Total Suspended Solids), generated much interest among farmers. Stream velocity and discharge were also measured. Concurrent TSS and stream discharge resulted in valuable estimates of sediment yield and identification of hot spots of soil erosion throughout the landscape.

Women's groups were very involved in the monitoring and showed particular interest in biological indicators, such as *E.coli* and other bacteria, that may contaminate drinking water and affect children's health.

Integrating cultural and ritual dimensions

Particular attention was paid to reconciling scientific methods with indigenous spirituality concerning water and nature. Researchers and volunteers received permission to enter streams and sample water by the leadership of the Talaandig, the tribal group that holds ancestral claims to the area. A Ritual of Understanding was also held to ceremonially sanction the research activities. This ritual included a recognition for the Talaandig beliefs in water spirits, which need to be respected.

Building local institutional capacity

Monitors, which included teachers, students, and local government officials, became involved in other aspects of environmental activism and education. After several months of operation, they formed a group called *Tighantay Wahig* (Water Watcher) that was incorporated and officially recognized as an NGO. Volunteers received training in water quality monitoring as well as in leadership, management, outreach, aquaculture, agro-forestry, and livestock production.

Population and land use as key factors influencing water quality

The data showed a progressive decrease in water quality along an east to west gradient. This variability is due to a combination of cropping patterns and rainfall frequency and intensity. While more severe erosion might have been expected to occur in the western sub-watersheds, which have steeper slopes, higher TSS levels were recorded in the eastern part, where more houses, roads, and farms are found.

Farmers involved in vegetable production plow and expose large areas of bare soil for planting just prior to heavy spring (May-June) rains. Not surprisingly, measurements of sediment yield were highest during the wetter months and where forest cover was least. In eastern sub-watersheds, soil loss exceeded the maximum measured in western sub-watersheds by 10-25 times, achieving levels of 3,400 kg/h with intense rains that fell in July 1999.

Unstable stream flows threatens community well-being

Stream discharge indicators, which provide a useful early alert to watershed disruption, followed the same west-to-east pattern as TSS. The coefficient of variation in monthly flows varied from 32 to 140% among sub-watersheds. Flood and drought cycles were exacerbated by the effects of El Nino events. This instability in stream flows was becoming a serious problem for the municipality and for local people who depended upon rivers for bathing, washing clothes, and watering livestock.

A group of local water monitors gather to collect and analyze samples.

Bacterial contamination exceeds World Health Organization (WHO) standards

Bacterial contamination also increased from the western sub-watersheds to the eastern sub-watersheds, where 75% of the municipality population lives. In some eastern streams, concentration of potentially harmful bacteria reached rates that exceeded the WHO standard by 10-50 fold. Several community faucets showed presence of *E.coli* bacteria, which seeped into ruptured pipes from contaminated soils and water.

30% forest cover identified as sustainability threshold

By correlating the water degradation data with demographic and land use cover patterns from government census and remote sensing data, researchers identified a threshold of unsustainable soil erosion. Abrupt increases in TSS occurred when sub-watershed forest cover dropped below 30% and agricultural land made up more than 50%. These findings coincide with those by the International Center for Research in Agroforestry (ICRAF), which also determine a threshold of 30% minimum forest cover before severe environmental degradation affects upland tropical forests.

Important research results often go underutilized because they fail to enter the political arena. A favorable political conjuncture enabled the integration of project findings into local level processes of planning and policy making.

Findings inform local government policies

The 1986 "People Power" revolution had laid the foundations for greater involvement of civil society in decentralized governance. The 1991 Local Government Code mandates the participation of citizens' groups and accredited NGOs in Local Government Unit (LGU) deliberations. It also devolved to municipalities the responsibility to develop natural resource management plans, which include water issues.

Municipal leaders were generally receptive to initiatives that helped inform and mobilize the community and offered cost-effective ways to obtain information to guide decisions. Research findings from water quality monitoring activities were provided to the LGU, with recommendations for priority areas and feasible interventions.

Project impacts extended beyond the municipality. The Provincial Planning and Development Office organized a forum to present the project and key indicators to policy makers and planners in the 15 other municipalities that constitute the province.

Indicators used in making community decisions

Indicators of soil loss and water contamination have proved to be key decision support tools. For instance:

- stream discharge measures indicated that a eastern sub-watershed was particularly prone to seasonal flooding. This finding coincided with the occurrence of destructive floods and the decision by the municipality to build new culverts to prevent washout and blockage of access roads.
- a village leader requested the services of water monitors to test bacterial levels in a spring that was to be used for drinking water. The analysis showed that the water was contaminated, so that an alternative source was chosen.

Monitoring promotes environmental awareness

Community-based indicators were effective in helping people to understand the consequences of land use decisions on a landscape scale. The variance among sub-watersheds was used in the course of community presentations to simulate "a walk through time". A watershed resident could look west and see how their environment was in the past, and look east and see how it would be in the future if land use changes were not made.

Involvement in water quality monitoring by teachers also ensured a greater emphasis on water quality and environmental conservation issues in the curriculum. Children were able to learn which rivers were clean and which were polluted. Schools also started restoration activities, such as tree planting on riverbanks to prevent erosion.

Application of partly understood conservation practices with full community involvement may be better than waiting for a thorough scientific analysis to be completed, especially in the case of rapidly degrading watersheds.

Community indicators are effective tools for:

a) *Priority setting*: to identify "hot spots" of soil erosion and water pollutions or weak links in the public water system in need of repair;

b) *Environmental assessment*: to quantify baseline conditions, to evaluate impacts of development, and track progress of restoration activities;

c) *Awareness raising*: to illustrate ecosystem linkages and landscape effects of farmers' resource management decisions:

d) *Advocacy and resource mobilization*: to document need and make stronger cases in grant proposals for federal or foreign aid;

Hands-on activities stimulate awareness and action

Citizens were directly involved in producing information and knew that their efforts mattered because the data was used in improving land and water conditions. The community's receptivity was due to the fact that the project responded to a widely perceived need and sense of urgency, which was shared by local govern-

Policy making calls for "good-enough" research

Information needed by policy makers must be science-based but need not necessarily meet the most stringent scientific standards with regard to methodology. Community monitoring may forego some precision and accept possible bias for the sake of cost-effectiveness, feasibility, and relevance. Application of partly understood conservation practices with full community involvement may be better than waiting for a thorough scientific analysis to be completed, especially in the case of rapidly degrading watersheds.

Political turnover

Effective environmental monitoring needs continuity to capitalize on capacity building and regular data collection activities. Yet administrative shifts and political instability at the national level may induce changes in local government leadership and resource management agendas. An informed, organized, and active community can play a key role in sustaining monitoring efforts throughout LGU changes.

Development priorities

The devolution of responsibilities for public services to the local level may result in pressures on local government to generate revenues. Economic development, such as building new roads and attracting agribusiness, may take precedence over conservation goals. But the development of a municipal natural resource management plan, informed by SANREM research findings, is a positive step toward reaching a balance between economic growth and environmental sustainability.

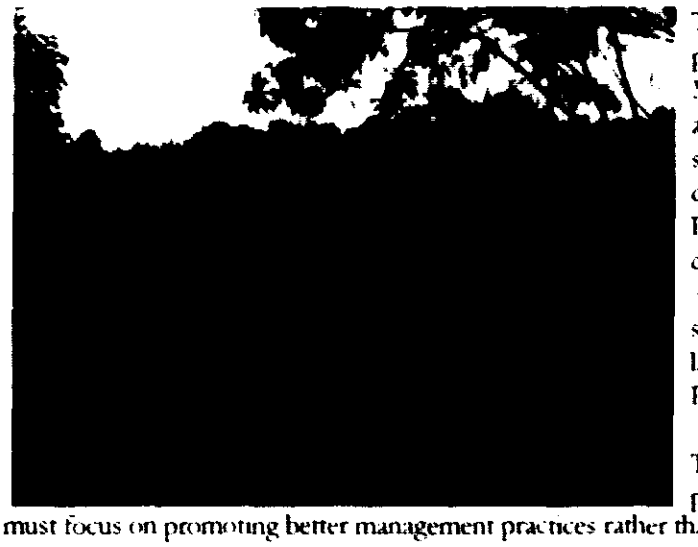
Transaction costs

The startup of a collaborative process that involves community members and diverse stakeholders is relatively slow and costly, but results indicate that the benefits and potential for sustainability are much higher than if implemented in isolation.

This brief draws from articles by William Deutsch et al. in: *Seeking Sustainability: challenges of agricultural development and environmental management in a Philippine watershed.* Edited by I. Coxhead and G. Buenavista. PCARRD, Los Banos, Laguna, 2001. PDF versions of individual articles can be downloaded from: http://www.aae.wisc.edu/sanrem-sea

SAVING SOIL: INTEGRATING EROSION CONTROL IN UPLAND AGRICULTURAL SYSTEMS (MINDANAO ISLAND, PHILIPPINES)

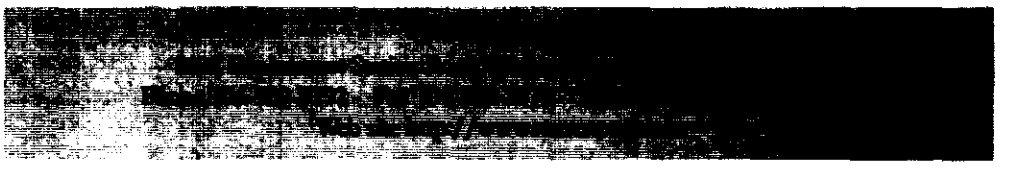
Can smallholders in developing countries afford sustainability? Can soil erosion be prevented at relatively low cost to producers? What conservation practices are most acceptable to farmers that live off the land in fragile upland environments?



These questions were explored by researchers David Midmore, Durga Poudel, and Todd Nissen through a series of on-farm trials conducted in collaboration with Philippines farmers in the context of the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP).

They stress that efforts to prevent land degradation must focus on promoting better management practices rather than on restricting access and resource use. In their view, this approach is more likely to succeed in the long run than the top-down conversion of upland tropical areas into nature reserve and national parks that do not account for the livelihood needs of local people.

The researchers also point to the need to situate natural resource management and long-term development planning in a landscape perspective, based on an understanding of ecological and economic linkages between lowlands and highlands.



As is the case with many upland ecosystems of the humid tropics, the Manupali river watershed in the Philippine island of Mindanao is plagued by population pressure and environmental stress. Mean annual rainfall is 2,470 mm and has a bimodal distribution with dry spells in July and November. Heavy rains fall at the onset of the rainy season in May and in August, while November is the driest month. Most of the soil erosion occurs due to steep slopes where forest is being cleared to grow temperate climate vegetables. Over the last 20 years, the permanent forest cover has diminished from half to one fourth of the total area, while land under corn and vegetables has grown from 20% to 40%. But average farm size is small, half of the farms are less than 3 ha, and three fourths are less than 5 ha.

Agriculture is the main source of income for at least two thirds of the population. Trade and price policies promote annual crops, such as corn and vegetables (whose management practices are highly erosive and require heavy doses of chemical inputs) compared to tree crops. In half of the farms, crops are planted up and down the slope to facilitate farm work and drainage, but this also causes greater erosion and runoff of chemicals.

Many farmers are aware of the soil depleting effect of these crops and practices, but few fallow land, rotate crops, or invest in conservation technologies.

Corn is planted after tomatoes or potatoes and then the land is fallowed for three or four years. But fallowing is not always motivated by the desire to restore fertility. In some cases, farmers are forced to leave land uncultivated because they lack labor or capital.

Solutions that ensure financial returns, such as planting high value crops or fast-growing timber, are clearly more acceptable to farmers than taking land out of cultivation.

Measures on total suspended solids (TSS) across the watershed were significantly higher in more intensively cultivated areas and when land preparation activities are under way. Siltation, due to rainy season runoff in denuded upland areas, hampers the functioning of irrigation systems and of an important hydroelectric power generating reservoir, which only a decade after construction is half-filled with sediments.

The SANREM scientists carried out field trials for two and a half years (seven cropping seasons) in collaboration with 12 participating farmers as well as on managed experimental plots.

Soil erosion varies with slope

The estimated rates of soil erosion under different management options by using two models (Erosion Productivity Impact Calculator and Modified Universal Soil Loss Equation) calibrated to the watershed conditions. Soil loss was found to be more severe on steeper slopes (being 4-6 times greater on 44% slopes than on 20% slopes). Loss of organic matter was greater in the upper portions of each plot, which usually produced lower yields.

Tomato associated with highest degree of erosion

Among vegetables, tomato was found to be associated with the highest degree of erosion because required tillage leaves the soil exposed and its foliage provides little protection during erosive rainfall events. For instance, soil erosion in tomato-cabbage-tomato was three times as

severe as in cabbage-tomato-cabbage. Corn provided better soil protection.

Farmer-endorsed soil conservation practices halve soil erosion rates

Implementation of conservation technologies will also be needed in conjunction with crop rotations. To identify effective and acceptable ways of preventing soil loss, a set of technologies, endorsed by 30 of about 100 surveyed farmers, were compared to planting up and down the slope. They included: planting on the contour; planting vegetables with strips of bean crosscutting the slope; and planting up and down the slope but with strips of high value hedgerow crops on the contour.

These practices were found to reduce soil erosion by half without negative impacts on crop yields. Vegetable and corn yields were highest where contour and strip treatments were used. Contour hedgerows were more effective in controlling erosion after three seasons as they became more established.

Trees and annual crops prove to be compatible

Trees can be planted in fallow land or intercropped with annual crops to provide canopy cover and retain nutrients that would otherwise be leached out. A shift from intensive vegetable production to tree crops, which are less demanding of labor and inputs, would also enable farmers to devote time and resources to other income generating activities.

The research evaluated benefits and drawbacks of intercropping trees with vegetables, particularly comparing the degree of above and below-ground competition. The performance of tree species alone was compared to mixed agro-forestry plots. The tree species intercropped with vegetables were analyzed for the effects of various planting densities, pruning practices, and supplementary fertilization treatments on trees.

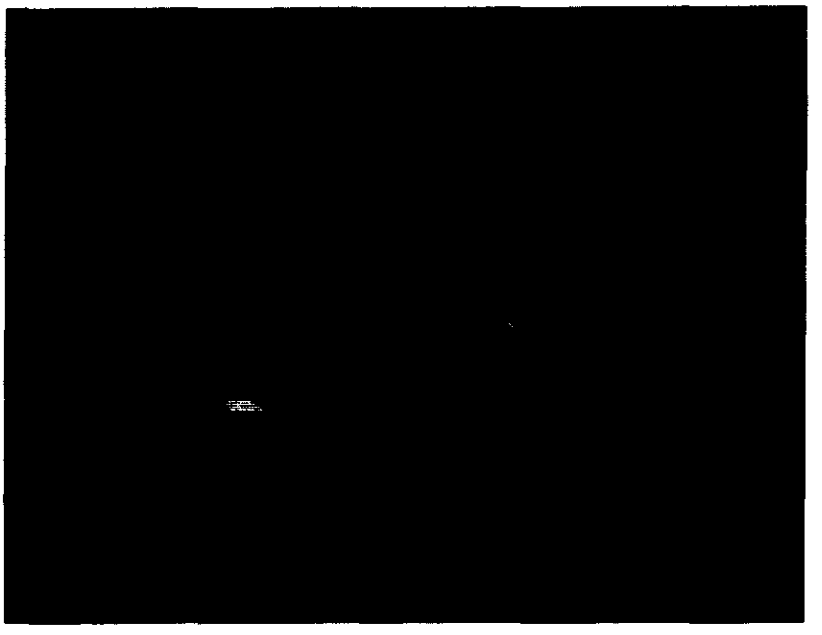
Below-ground competition was minimal. In fact, intercropped trees grew twice as fast since they benefited from excess nutrients applied to vegetables. Above-ground competition for light affected crops planted in the vicinity of tree species with denser canopy cover (i.e. *Eucalyptus torreliana*), and as the trees grew. The shading effect can be managed by planting trees with sparser crowns (i.e. *Paraserianthes falcataria*), by adjusting intercrop density and geometry and by periodic pruning.

Indirect advantages of agro-forestry

While timber may not appear as profitable as vegetables on a per area basis, this is only true if one assumes that vegetable production does not decline with continuous cropping. But data from the field trials shows that productivity does decline overtime. Soil conservation and crop diversification may also offset the decline in vegetable prices if price supports are removed. As rural labor is increasingly absorbed by non-farm employment, less management-intensive agro-forestry systems appear more advantageous.

Targeting steeper slopes and upper field portions

Efforts must be directed to minimizing erosion and replenishing nutrients on steep slopes and upper field portions. Crop choices and planting time and applications of organic nutrient sources must be calibrated to this purpose.



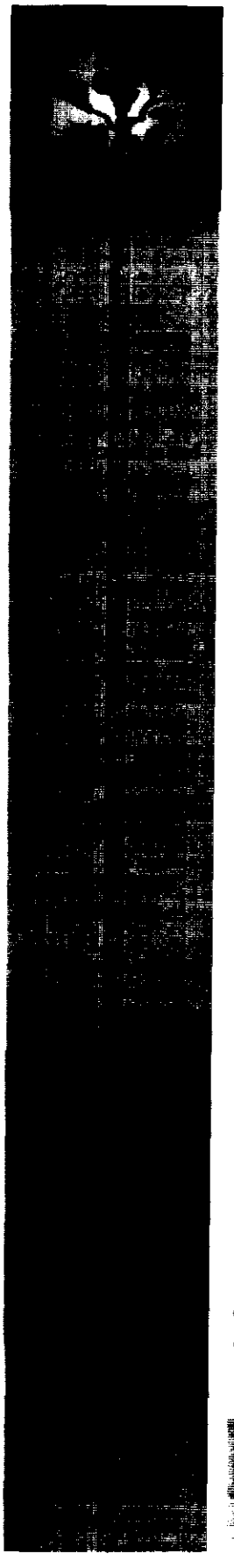
Farmers identify feasible conservation practices for on-farm testing

Testing efficacy of conservation technologies during heavy rainfall events
Conservation practices can reduce soil erosion by about half, but during highly erosive rain events the level of soil conservation effect was less than hoped for. In particular, research must explore ways of preventing scouring effects (digging into the slope) behind contour hedgerows.

Working with farmers to improve feasibility and profitability of agro-forestry
Multi-season trials show that trees and annual crops are compatible and, to some extent, mutually advantageous. Planting practices and periodic pruning can minimize competition for light between trees and vegetables. But, since pruning slows tree growth and moving vegetable rows away from trees reduces land area available to vegetables and limits nutrient access by trees, these options are likely to be less acceptable to farmers. Light competition management should rather be treated as a component of long-term farm planning rather than as a problem in need of short-term solutions.

Analyzing economic returns for different conservation technologies and intercrop mixes
Solutions that ensure financial returns, such as planting high value crops or fast-growing timber, are clearly more acceptable to farmers than taking land out of cultivation. This is particularly true if these techniques call for additional inputs of labor, as in the case of hedgerows. The effectiveness of different techniques and profitability of different crops and trees must be assessed overtime, to account for changes in growing conditions and in market demand.

This brief draws from articles by David Midmore et al. in: *Seeking Sustainability: challenges of agricultural development and environmental management in a Philippine watershed.* Edited by I. Coxhead and G. Buenavista. PCARRD, Los Banos, Laguna, 2001. PDF versions of individual articles can be downloaded from: http://www.aae.wisc.edu/sanrem-sea

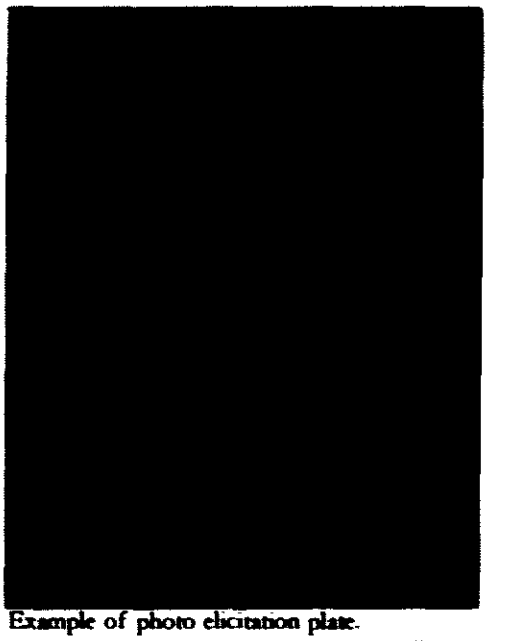


LOOKING AT THE LANDSCAPE THROUGH LOCAL LENSES: INTEGRATING COMMUNITY VALUES AND VARIATION IN INDICATORS OF SUSTAINABILITY

Are there tools that enable us to identify culturally relevant indicators of sustainability and quality of life? Can we quantify local people's assessments of environmental change, which are qualitative in nature? How can we ensure adequate representation of the diversity of local perspectives?

Increasingly, donors and decision makers require hard evidence of the effectiveness of research and development programs. Scientific research can substantially improve environmental planning and policies by providing operational measures that signal when ecological or socioeconomic conditions are reaching critical thresholds.

Conventional approaches to environmental monitoring hinge on externally-imposed standards, such as crop yields or income levels, which are assumed to be universally applicable and equally relevant for all sectors of the population. But such parameters fail to adequately represent local people's holistic understanding of the environment, being biased in favor of monetary or material valuation over aesthetic, emotional, moral, and spiritual considerations.



Example of photo elicitation plate. Respondents were asked, " Could you tell us a story about this photograph?.

This brief illustrates an innovative tool that enables researchers to elicit culturally relevant indicators, many of which are non-monetary and non-material. But it also shows how qualitative parameters can be quantified for evaluative and comparative purposes. The analysis of quantified data makes it possible to unveil and reflect underlying patterns of intra-cultural diversity in environmental assessments.

[redacted]
Phone [redacted] Fax [redacted]
Web site http://[redacted]

This approach, based on applied ethnoecology and modified projective techniques, was pioneered by University of Georgia anthropologists Virginia Nazarea and Robert Rhoades, in the context of the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP). First tested in the Philippines SANREM CRSP site, the methodology was replicated successfully in different ecological and cultural contexts.

The case study focuses on the Manupali watershed, in northern Mindanao. The watershed encompasses the Mt Kitanglad National Park, one of the most important biodiversity reserves in the country. In recent decades, the buffer zone surrounding the Park has undergone massive deforestation. Immigrants from other parts of the country, attracted by land availability and favorable agricultural conditions, moved in and converted forest to farmland.

As a result of this influx, the current population is characterized by multiple layers of ethnicity – native Talaandigs, Dumagats or Lumads from the Visaysan Islands, and Igorots and Ilocanos from Luzon. The agricultural landscape is an equally composite patchwork of production strategies, including irrigated rice, corn, sugarcane in the lowlands, and corn, coffee, and temperate climate vegetables in the uplands. Agricultural intensification, coupled with heavy application of chemical inputs has resulted in high rates of soil erosion and water quality degradation.

Sampling design

- Respondents were selected from *three villages* along an elevational gradient and among people above 40 years of age (likely to have more extensive ecological knowledge).
- The sample was *stratified* to represent significant social differentiation variables: *ethnicity, gender* and *age* as follows:
- Equal numbers of participants (n=18) were *randomly* selected from the 3 main ethnic groups: Igorots/Iloganos, Dumagats/Lumads, and native Talaandigs.
- For each ethnic group respectively 3 men and 3 women were *randomly* selected from 3 age cohorts: 40s, 50s, and 60+ (for a total of 9 men and 9 women).

Recommended Sampling framework (original sample n=54)

	Men	Women	Men	Women	Men	Women
Igorots Iloganos	3	3	3	3	3	3
Dumagats/ Lumads	3	3	3	3	3	3
native Talaandigs	3	3	3	3	3	3

- Because the method requires that participants engage in a relatively tedious and time-consuming process, individuals who were unwilling to do so were eliminated from the list.
- The small size of the remaining sample (n=51) limits the validity of statistical tests, but it does allow for a more contextualized understanding of perceptual data and emerging patterns.

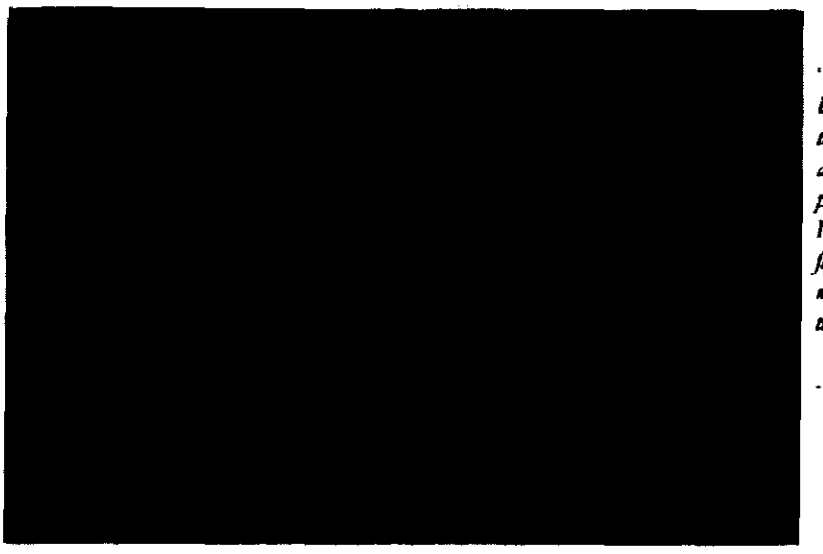
While this brief focuses on the application of TAT interviews and scores, this technique was used in combination with other tools, including:

- *Oral histories* describing patterns of resource use as 'lived experience';
- *Human activity grids* based on observation of informant intensity and frequency of resource use (conditional upon his/her consent);
- *Cognitive mapping* depicting the relative salience of environmental features from the informants' point of view.

Methodological tools

Researchers adopted and modified a commonly used projective technique for psychological assessment known as Thematic Apperception Tests (TATs), consisting of a set of cards each showing an ambiguous representation, generally drawn, of one or more human figures. The respondent is asked to tell a story about each card. The theory is that respondents reveal their concepts and wishes in the process of making sense of the figures.

This study used 20 photographs of scenes from the watershed, illustrating aspects of the landscape, sustainable and unsustainable agricultural strategies, and humans in relations to plants and to each other. Respondents were asked, "Could you tell us a story about this photograph?"



"...This mountain needs to be taken care of because there are trees, there are woods. These trees are used to preserve the water, this will also give fresh air here; the woods are used as places to live for the animals in the mountain. I can see the flowers in the mountain, these flowers can make the mountain beautiful and make it more beautiful to look at if there are trees that grow flowers."

- Dumagat male in his 50s

Pretesting of the materials and methods is essential since the structure and significance of storytelling varies across cultures. The visual tools were developed by drawing from materials and insights generated by their previous and concomitant research, pre-tested with respondents of both genders and different ethnic groups

Data analysis

Local enumerators interviewed respondents in their native language. The elicited stories were tape-recorded, transcribed verbatim, and translated into English by two assistants who constantly cross-checked each other. The transcribed stories were analyzed and a total of 32 themes were identified.

The themes were clustered in four major categories:

1) intrinsic value (i.e. beauty, harmony, diversity, sense of place, interconnectedness of natural elements, etc.) :

What I can say is that the trees in the environment are all very beautiful... this can make us feel cool and we get fresh air...

When there are a lot of fruits, there are also a lot of birds that feed on it and their voices or humming are good too.

2) care for and use of environment (i.e. usefulness of resources, but also concern for using them sustainably, etc.):

The trunks can also be used as posts for houses and are more comfortable than bamboo... The leaves can be used as roof for the nursery ....

3) production orientation (i.e. commercialization, use of inputs, economic success, etc.)

The sugar cane here is nearing harvest, they are healthy... I think they will get plenty of money.

The corn kernels are very big. I am not sure if they added fertilizer or not?

4) social, political, economic relations (i.e. family health, livelihood strategies, social stratification, government control, life difficulties, etc.)

This house indicates that the owner is poor. Because sometimes owners of houses like these are being oppressed by the rich.

These children here, they are healthy because their mother took good care of them even if they only have a common life because they are farmers...The children who live in the mountains are better taken care of than children from the towns.

The stories were scored based on dominant themes pertaining to locally relevant concepts of sustainability and quality of life. The scoring was done by three graduate students from different disciplines and countries. Eventually the project intends to take the TAT categories back to local people to see how closely the scoring system corresponds to their way of classifying themes.

A score of 1 or 0 was given depending on whether a particular theme was present or absent in a TAT story (TAT stories contained more than one theme). The total score for a theme was the number of times it was mentioned by all the informants (the maximum score being 20 x 51 = 1,020 points).

Total sample

The data shows that local people give priority to values that are not often reflected in conventional measures and indicators. For instance, direct uses of natural resources were stressed more than their commercial worth. Also salient for watershed residents were intrinsic, non-utilitarian values, such as beauty of the landscape, diversity of plants, and interconnectedness of natural elements.

Themes related to family and community relations, social hierarchy, and government authority, were also prominent. While generally predisposed to accept the status quo and the downsides of development, the informants nonetheless questioned the necessity of changes that threatened quality of life and environmental health.

Environmental perceptions and priorities differ according to the individual's positioning in the local social structure. That is, his or her 'vantage point'.

By disaggregating the data by significant social differentiation variables, the researchers found that environmental perceptions and priorities differed according to the informant's positioning in the local social structure (that is, her/his *vantage point*) which is determined by gender, ethnicity, and age.

Gender

Discourse analysis of stories shows women dominating in managing internal relations and ensuring social stability, and men prevailing in control of resources and contacts with markets and the state. Women showed greater appreciation of indigenous knowledge, while responsibility for natural resources received more attention by men. Commercialization was more emphasized by men. Social hierarchy and government control were also more salient for men, while family relations and human health scored higher in women's stories.

Ethnicity

Usefulness of resources was a primary concern for all ethnic groups. But commercial and production issues were mentioned more frequently by Dumagat settlers, who have greater access to capital and resources than other groups. On the other hand, social inequality and state power were more salient for indigenous Talaandig, who have suffer greater marginalization.

Age group

Informants in their 50's were less focused on the inherent beauty and direct use of resources, more attuned to their commercial value, and more willing to use external inputs. The hypothesis is that farmers who are now in their 50's, might have been more deeply influenced by Green Revolution ideas, promoted during the 1970's. During that time period, these farmers were in their 20s, a more impressionable age. Younger people, on the other hand, may be more aware of the failures of the Green Revolution and more committed to restoring the environment.

Quantitative, operational indicators of sustainability and quality of life do not always coincide with what matters to local people. This case study indicates that modified TATs, complemented by other ethnographic methods, can be used to integrate local perspectives and concerns into environmental monitoring.

Moreover, it points to the importance of an analytical approach that encompasses the diverse angles from which the landscape is perceived by people belonging to different ethnic, gender, and age groups. The method has great potential not only for cross-cultural comparison but for investigating finely-patterned intra-cultural variations as well.

This brief draws from an article by Virginia Nazarea, Robert Rhoades, Erla Bontoyan, and Gabriela Flora entitled *"Defining Indicators Which Make Sense to Local People: Intra-Cultural Variation in Perceptions of Natural Resources,"* published in: *Human Organization*, Vol. 57, No. 2 1998, pp. 159-170.

Appendix IV
Acknowledgement of Feedback

Prior to the printing of this manual, all lessons were reviewed by a panel of eleven experts in science education, environmental education, sustainable agriculture, and natural resource management. Six were from the United States and five were from developing countries. A great deal of the feedback from these individuals has been incorporated within the current version of the lesson plans, either directly within the text of the lessons, as "side bar" suggestions, or within introductory or supporting material. Some comments, however, were country specific and therefore could not be incorporated into these lessons without completely restructuring them to meet specific country curriculum standards and requirements. Additionally, some reviewers noted that lessons presented in this manual might be too complex for some teachers and students who do not have a strong science background or who are unfamiliar with the scientific method of inquiry. The authors readily acknowledge this concern and would like to re-emphasize that we do not wish to replace indigenous knowledge or traditional ways of inquiry and investigation. We hope that that educators will use this manual as a means to compliment these methodologies and provide new perspectives for teachers and students. Additionally, as a result of reviewer comments, scientific and technical language has been simplified and ways to modify parts of (or entire) lessons are provided.

The authors are most grateful to the eleven reviewers who volunteered their time and thoughts in the lesson plan review as well as the overall project:

Kim Bailey, Environmental Outreach Coordinator, Georgia Department of Natural Resources, Environmental Protection Division, Land Protection Branch, Atlanta, Georgia, U.S.A.,
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* Education for a Sustainable Future Project, Center for a Sustainable Future, Cobb County Schools, Marietta, Georgia, U.S.A. http://csf.concord.org/esf/

* California State University, Chico, Chico, California, U.S.A., Service Learning Online Course. http://www.csuchico.edu/psed/servicelearning/

* The National Geographic Society. http://www.nationalgeographic.com

* AAAS (American Association for the Advancement of Science). http://www.eureklert.org/kidsnews

* Science News for Kids. http://www.sciencenewsforkids.org

Thank you to the United States Agency for International Development (USAID) for the support of this project.

Appendix V
Scientific Documents for Children

This appendix contains four scientific documents written for children. These documents can be used to develop units of lessons that introduce science and natural resource management concepts and are multi-disciplinary, learner-centered, and fun for students.

The following article was reprinted with permission from AAAS. "A Forest's Appetite for Carbon," *Science* for kids: http://www.eurekalert.org/kidsnews/index.php?page=matamala-kids. Copyright 2003 AAAS. Individuals using this manual may use AAAS material for non-commercial, classroom purposes only. Any other use requires permission of the copyright holder.

While you're outside diving into piles of fallen leaves, imagine piles of dead roots underground. A group of scientists did more that just picture it. They dug into the dirt in search of dead roots with a specific question in mind:

Do the tiny roots from different kinds of trees live for the same length of time?

These root-searching scientists say no. Instead, they report that tiny pine-tree roots live longer than the itsy-bitsy roots from sweetgum trees. Roser Matamala of the Argonne National Laboratory in Argonne, IL, and her colleagues describe this discovery in the 21 November issue of the journal *Science*.

In the past, other scientists have predicted a different answer—suggesting that most of the smallest tree roots from all kinds of trees die and get replaced by a new set every year.

The length of root life is important. It helps determine the amount of carbon that the forests pull out of the atmosphere (through photosynthesis) and deposit into long-term storage. The level of carbon in the air, especially in the form of carbon dioxide, impacts the process of global warming.

If long-lived roots are found in other forests, then the world's trees might not be storing carbon in the soil as quickly as scientists have estimated.

Realizing that some forests may not be soaking up carbon as fast as we thought highlights the small things that kids can do to reduce the amount of carbon dioxide in the atmosphere. Turning off lights, recycling paper, and walking instead of driving are simple ways to limit the carbon you add to the atmosphere, says Matamala.

As a kid, she said that she didn't think about protecting the environment. Now she is more careful.

"It's easier for us to reduce the amount of carbon dioxide that we add to the air than it is for forests to pull extra carbon out," says Matamala, who will be teaching these same lessons to her four month old baby when she is old enough to understand.

Science is published by AAAS, the non-profit science society.

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Cocoa May Help Fight Cancer, Study Says

By Sarah Ives
National Geographic News
December 19, 2003

Scientists at Cornell University found that hot cocoa may help fight cancer.

Photograph courtesy Corbis

Could hot chocolate actually be good for you? According to a new study, the answer may be yes!

Scientists at Cornell University in New York State found that hot cocoa may help fight cancer.

Chang Lee, a professor of food chemistry, led a team of scientists that did the first ever study comparing hot chocolate with other drinks known to help fight cancer (a harmful disease).

Lee and his team compared hot cocoa with green tea, black tea, and red wine.

The results give hope to chocolate lovers everywhere.

"Cocoa came out on top," said Lee.

Sound too good to be true? Lee explained that cocoa is high in antioxidants (an-tee-OX-uh-dints).

Antioxidants are chemicals in the body that fight cancer-causing substances called free radicals. Free radicals naturally occur in the body, but if there are too many of them, they can damage the body and cause cancer. Getting a lot of antioxidants from fruits, vegetables—and cocoa—may help your body stay cancer free!

Just because cocoa may help fight cancer, you shouldn't necessarily drink hot cocoa for breakfast, lunch, and dinner. Experts still recommend eating fruits and vegetables as a way of making sure you get plenty of antioxidants.

The study appeared in the December 3 issue of the *Journal of Agricultural and Food Chemistry.*

NATIONALGEOGRAPHIC

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The Cuddly Side of Rattlesnakes?

Reported by James Owen and written by Sarah Ives
National Geographic Kids News
March 04, 2004

According to some researchers, an adult rattlesnake can recognize its brothers and sisters that were born in the same litter—even if they were separated at birth.
Image courtesy Rulon W. Clark, Department of Neurobiology and Behavior, Cornell University

Danger—that's what most people think when they see rattlesnakes. But some scientists are starting to think that these deadly snakes may have a more caring side.

Researchers, led by Rulon Clark of Cornell University in New York, have been studying timber rattlesnakes in the eastern United States. And what they found may surprise you.

As adults, researchers say, rattlesnakes can recognize their brothers and sisters that were born in the same litter—even if they were separated at birth.

Sister snakes that were born together spend more time close to each other than other snakes, says scientist Rulon Clark.
Image courtesy Rulon W. Clark, Department of

Snakes can tell a lot with their senses. "With a single flick of his tongue, a male garter snake can not only tell the species of another snake, but also its sex, its body

size ... and whether or not it has mated recently," said Rick Shire, a snake expert at the University of Sydney in Australia.

Neurobiology and Behavior, Cornell University

"Clark's work lets us know that—like lizards—these animals can also tell whether or not the other animal is a close relative," Shire added.

Clark studied 24 timber rattlesnakes in a laboratory. He kept the snakes apart from each other for two and a half years. Clark then brought the snakes back together in pairs. Clark found that sister snakes that were born together spent more time close to each other than other snakes. Sister snakes spent almost half the time with their bodies wrapped together!

Male snakes did not spend time close together whether or not they were related. Clark believes that the males' lack of closeness was a result of lab conditions that made male snakes more aggressive than normal.

Clark says that related snakes probably stick together for protection from their enemies. Rattlesnakes can be food for badgers, coyotes, eagles, foxes, opossums, raccoons, skunks, and wild pigs. "I even had an adult female [snake] I was radio-tracking last year killed by a red-tailed hawk," Clark added.

Timber rattlesnakes need all the protection they can get. The animals are listed as endangered or threatened by 15 U.S. states.

NATIONAL GEOGRAPHIC

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Sounds and Silence

Emily Sohn

Shhhhh

You already have to deal with your teachers telling you to sit down, your parents asking you to be quiet, and your big brothers and sisters shooing you away.

Now some scientists are trying to get all of us to shut up—at least once in a while. We may be surprised by what we hear. They say, when we stop and listen. Paying attention to natural sounds could also help us do a better job of keeping our planet healthy.

"Natural sounds are an important resource," says Chris Shaver of the National Park Service in Denver, Colo.

A seashore soundscape may include the roar of surf and the cries of birds.
Peterson

People often visit parks to find a sense of peace and solitude they can't get at home. Animals use sounds to communicate with one another. And just as cutting down trees threatens the wilderness, so also does interrupting the normal symphony of sounds in our surroundings, Shaver says.

"There ought to be somewhere in every park where people can go and know they are hearing natural sounds," she says. "Just like there are 'no smoking' zones, there should be 'no noise' zones."

Protecting the sounds of nature is a big part of what Shaver does. As chief of the Air Resources Division of the National Park Service, she is leading a major effort to study and preserve natural soundscapes in a variety of parks around the United States. A soundscape is the sum of the noises that make up a particular environment: chirping birds, screeching crickets, buzzing bees, rustling leaves, or whatever else the location and season present.

Animal noises

Even if tourists don't notice the noises of nature, lots of animals do, Shaver says. "Animals use sounds to communicate with each other in ways we don't even hear or understand," she says.

From birds to bison and crickets to cuckoos, all sorts of creatures use sound to find mates, hunt prey, hide from predators, or track down their babies, among other important tasks.

If you've ever played quietly outside in the woods, you've probably noticed a hum of activity happening around you. As soon as an airplane flies overhead, a car drives by, or a snowmobile zooms past, though, the chirps and squawks can suddenly disappear. There's just an uncomfortable, unnatural silence.

It can sometimes take more than half an hour before the normal sounds come back completely, Shaver says.

Such a delay can spell the difference between life and death for some animals, suggests Bernie Krause. Krause is a musician and a bioacoustician who studies animal sounds.

Bird sounds, like those of the rare white headed woodpecker, enliven a wooded soundscape.
U.S. Fish & Wildlife Service

When all the animals are speaking together, he theorizes, they are safe because it's hard for predators to figure out who is where. The first one to open its mouth after a disturbance, though, is as good as gone.

At the same time, some animals get used to noise. They already put up with the rumble and crack of thunder. Some birds live at airports and pay no attention to planes taking off or landing. There's even a bird sanctuary within range of the roar of occasional space shuttle launches at Cape Canaveral in Florida.

Plane disturbances

Airplanes are the biggest concern for Shaver and her colleagues. So many of the loud, hulking machines fly back and forth across the country every day, it's nearly impossible to go anywhere without hearing one go by at some point.

"We have a map in the office showing flights over parks," she says. "There are very few places you could stick a finger where there isn't a flight path."

The National Park Service can't do anything about commercial flights. Instead, the staff is focusing on easing the impact of tourist flights in small airplanes or helicopters. Air tours are popular at Grand Canyon National Park and Hawai'i Volcanoes National Park, where tens of thousands of people pay to see the views from above every year.

To understand the impact of air tours and other human disturbances on park ecosystems, the Park Service is racing to record sounds from natural lands in a number of states, including Utah, Alaska, and Hawaii.

"We're trying to get to parks as quickly as we can to get baseline data before air tours arrive," says bioacoustician Skip Ambrose, who works for the National Park Service in Fort Collins, Colo.

Ambrose spends much of his time in the field, recording sounds. Since the soundscape projects are fairly new, the researchers first need to figure out what is out there and how loud it all is. So, after collecting sounds, the information goes into a computer to make a sort of library of natural and manmade sounds.

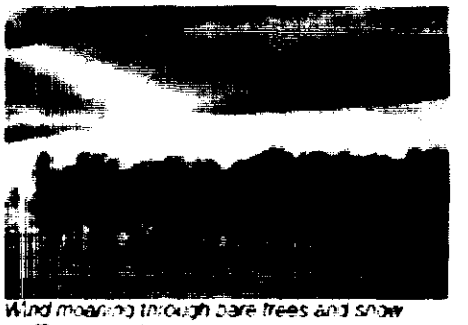
Ambrose is also working to put natural soundscapes on the Internet. Some parks have web-cams that show live pictures of certain places. Ambrose is helping design a sound cam for the Smoky Mountains National Park that would be regularly updated with new sounds from a given setting. Net surfers anywhere in the world would be able to visit the site to find out what they would hear if they were in the mountains at that very moment.

Recording soundscapes, Ambrose hopes, will help people recognize and appreciate what we are losing, before it's too late. "Some people think National Parks are so quiet," he says. "It's not true. If you go to a park, sit down, and listen, you'll hear man-made noises way more than you think you will. It's happened so gradually, people don't realize what we've lost."

Time to listen

Animals aren't the only reason to care about sounds, says radio producer Jim Metzner. A resident of Ulster County, New York, Metzner has been listening to, studying, and recording sounds for almost 30 years.

"There are sounds that really enrich our lives, almost like a kind of food," he says. Among his favorites, he lists a babbling stream near his home, the hum of the city from a rooftop on a summer night, and the voices of his dearest friends, including some who have passed away.



Wind moaning through bare trees and snow muffling natural sounds gives a winter soundscape its own distinctive qualities.

Taking the time to listen, Metzner says, can teach us to make sense of the constant bombardment of noises around us. Every time you listen, he adds, there's something new to learn. "The whole paradox of listening is the last admission that you don't know something," he says. "If you knew, why would you listen?"

Even if you've already heard something 100 times, you'll probably hear something new on the 101st, Metzner says, if you pay attention.

Metzner recommends that kids use a little tape recorder to start a sound diary of their own. "One of the great sounds are sounds of parents and grandparents telling their stories," he says. Recordings are one way to keep a time capsule of those memories—one that you can come back to for the rest of your life.

You might even want to start your own wilderness sound diary to see how the world around you changes through the years. You might be surprised at what you find. "I have a daughter who complains that the crickets are too loud," Shaver says. "I tell her it used to be the freeway, honey. We need to have children understand that crickets are good."

Next time you go outside, give it a shot. Close your eyes. And shut up. You might just find a whole other world out there—if you're willing to listen.

The Nature Sounds Society (www.naturesounds.org) suggests 16 simple ways in which to enjoy natural sound. Here are some of these activities:

- Stop. Listen to what's around you. Now close your eyes. Do you hear other sounds? Do you hear more with your eyes closed?
- Walk and listen. Do you hear your footsteps? Do you hear your clothes rustle? Can you walk without making any sound?
- Try to hear the wind's sound blowing through different plants.
- Find a stream or waterfall and listen carefully with your eyes shut until the sound separates into single notes.
- How does the shape of the land affect the way sound travels to your ears? Where is the source of each sound? Are there any echoes? What's the closest sound you hear?

http://www.sciencenewsforkids.org/articles/20040107/Feature1.asp
From *Science News for Kids*, Jan. 7, 2004

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Appendix VI
Additional Information

Over the past year, this project has taken numerous forms. As this project took shape a variety of additional products were created. Two of these efforts follow:

1. **Appendix VIA:** This appendix includes a sample two-day teacher training agenda that was written as a collaborative effort between the authors of this manual, SANREM South East Asia (SEA) team members, and a Filipino teacher/graduate student (the objectives of this proposed agenda are listed on pages 2-4 of this manual). While the authors of this manual did not travel to the Philippines to take part in this suggested training, the agenda was reviewed, modified and approved by our Filipino partners as being a worthwhile endeavor for Filipino teachers. At least some, if not all, of the training agenda was to be used as a resource for Mrs. Sumbalan's doctoral dissertation.

This agenda was designed to serve as an outline of a proposed teacher training workshop and therefore does not contain a significant amount of detail per scheduled activity. This workshop outline can be modified to focus on any type of research (not just SANREM) and involve faculty from nearby colleges or researchers from agricultural stations. It can also be used to improve language skills (e.g., English language skills).

2. **Appendix VIB:** This appendix provides a brief annotated list of sustainable agriculture and environmental education resources (i.e., lesson plans and curricular material) as well as information about service learning, all of which can be accessed via the World Wide Web.

Appendix VIA: Integrating Natural Resource Management in the Classroom: Philippines Teacher Training

Objectives:
* To give teachers background information on Natural Resource Management (NRM) Principles, SANREM-SEA research and results, to improve language skills through NRM lessons, and to create learner-centered lessons that use the local environment to engage learning.

* To develop a Unit Development Plan that will guide teachers in creating NRM lessons that enhance English language skills, are learner-centered, and use the local environment to engage learning.

* To introduce the people working on this project to one another and to solidify the intent of this collaborative project to the teachers developing the lesson plans.

Example Agenda:

Day 1
8:00
Introduction
* Introduce project and project collaborators.
* Ice breaker activity (i.e., a game to introduce everyone).

8:30
Introduction to Natural Resource Management Principles and Systems Thinking
* Teachers define a *system* and identify different systems.
* Introduce and discuss rules of how all systems function.
* Discuss the *Natural System (e.g., river ecosystem)* – how it functions (general relationships)

(15 minute break)

* Discuss the *Social System (e.g., human health care system)* and the interactions between social and natural systems. What demands do we put on natural systems?

* Issues (problems) that arise from these interactions.
    * Diagram an issue and look at the interactions of the systems involved.
    * Consider solutions to the problems based on the interactions of the systems.

* Introduce the idea of *sustainability*. Have teachers define sustainability. Discuss the importance of understanding the relationships between systems in order to make sustainable decisions about our resources.

11:30
Why integrate natural resource management in the classroom; how/why is this a good way to enhance English language skills?

12:00 - Lunch

1:00
How can we integrate natural resource management information into our current curriculum?
* Effective methods for teaching NRM concepts: An introduction to different teaching methods (one of these methods will be *"learner-centered"* teaching).

* Presentation of two different teaching methods for the same material and objectives. Comparison of the methods. Discussion of variations.

* How to use the local environment to engage learning and create lessons that are learner-centered.

2:00
Begin developing a Unit Plan

Linking Curriculum
* Teachers will create an interdisciplinary *curriculum standards map*. This map will link curriculum standards so that standards for different subjects can be taught in an interdisciplinary fashion. Enhancement/improvement of English language skills can be incorporated in all parts of this map.

* Teachers will determine the best places in the curriculum for teaching NRM-based lessons.

3:00
Teachers will develop an essential question based on standards that they must teach and the interactions of systems in their local environment.
* *Essential questions* are the main questions that are addressed in a lesson. They are general questions that focus on the interactions between systems in the local environment (e.g. How does an increase in the number of banana plantations affect the water quality in our village?).

4:00
Creating a Resource Map
* Teachers will determine what resources they have in their community/ environment that can help them teach a lesson.

5:00
Adjourn for the Day

Day 2

8:00
Presentation of SANREM-SEA research and results and how they can be used in a classroom

11:30
Teachers determine how the resources available to them can be used to teach the standards that they have chosen to address
* This process would ideally be a collaborative one; small groups of teachers and SANREM SEA presenters could work together.

12:00 – Lunch

1:00
Teachers determine *student generated questions*
* These are questions that students will likely formulate after observing relationships between systems in their local environment. These questions will drive learner-centered investigations.

* Discuss the steps between formulating a question and formulating a hypothesis.

1:30
Teachers describe possible activities to address student questions
* Lesson plan ideas will be created for these activities. In subsequent months, these ideas will be further developed in the form of full lesson plans. Because the students generated the questions that are driving the lessons, students will feel a greater ownership of the lessons and the learning process.

2:00 – Break

2:15
***Discuss what to do with results**
* How can results be used?
    * Creating causal loop diagrams to describe system behavior (causal loop diagrams are a way to illustrate how a system works; they consist of arrows connecting the system variables in a manner that shows how one variable affect another variable)
    * Graphing system behavior
    * Organizing data for comparison
    * Integrating SANREM data as a comparison for results

2:45
***Assessment**
*Determining methods for measuring students' understanding of the subject matter and mastery of the standards

3:15
Preparation of materials for teacher presentations

3:30
Teachers present their Unit Plans and two potential NRM lessons

4:45
Describe the rest of the project and the timeline

5:00 – Adjourn

Appendix VIB: Sustainable Agriculture (SA) and Environmental Education (EE) Resources

Website URL	Website Title	Annotation/Comment
http://www.nal.usda.gov/afsic/AFSIC_pubs/k-12.htm	Sustainable Agriculture Resources for Teachers K-12 (United States Based)	This web site gives an extensive list of 'SA' resources/curricula/websites. However, many of the curricula listed are broad-based EE curricula and do not specifically address SA. Grade level: K-12; primary through secondary.
http://www.gatewest.net/~green/from/index.html	Green and Growing (Canada Based)	This web site provides lessons that focus on SA. They are quite detailed in information and have a heavy science content. Grade level: high school; upper secondary.
http://www.acsu.k12.vt.us/ROOTSNet.html/sisters.html	Food Works – In the Three Sisters Garden (United States Based)	Of the publications from Food Works, In the Three Sisters Garden is the book most related to SA (rather than just EE). This book focuses on the link between culture (especially those of Native Americans) and agriculture. Web site provides a detailed description of the book, but example lessons from the book are not available. Grade level: grades 1 and 2; primary.
http://www.tilburyhouse.com/Children%27s%20Frames/child_health_fr.html	Healthy Foods from Healthy Soils (United States Based)	This web site provides a detailed description of the book Healthy Foods from Healthy Soils. This book focuses on the connection between human health and the health of the land and food that we eat. Example lessons from the book are not available. Grade level: K-6; early and upper primary, early secondary.
http://www.umich.edu/~nppcpub/resources/ResLists/agri.html	Sustainable Agriculture Resource List (United States Based)	This resource list provides articles, books, videos, online resources, faculty, and organizations to help incorporate pollution prevention into agriculture classes. It does not include specific curricula/lessons but does provide resources for curriculum development. Geared for advanced levels (i.e., college students, researchers, practitioners, professors).

Website URL	Website Title	Annotation/Comment
http://www.nrm.qld.gov.au/education/modules/junior_secondary/sustainable_agriculture/	Sustainable Agriculture Practices – DNR Queensland (Australia Based)	As stated from the website: "This module provides a selection of activities as a basis for teachers to develop their own individualized units of work. These units could combine activities from a range of modules and other sources...The key concept developed in this module is that decisions about the ways in which science is applied have short-term and long-term implications for the environment, for communities and for individuals. Other key concepts to which this module relates are: that living things use the resources of the earth, solar system and the universe to meet their needs; and that environments are dynamic and have living and non-living components, which interact. Activities are designed to help students understand that the applications of science have immediate and long-term consequences for society, and consider the implications of using renewable and non-renewable resources on habitat modification and species diversity." Lessons have a strong focus on meeting standards, particularly areas of science. Lessons are not very interdisciplinary. Lesson content is thorough. Good lessons/curriculum. Grade level: middle school level; junior secondary level.
http://faitc.netc.net.au/resources/books/fieldwork_kit.htm	Agriculture and Land Management Fieldwork Kit (Australia Based)	This site promotes learning materials that have been developed on a collaborative basis by farmers, students, teachers, Department of Natural Resources and Environment staff, and other organizations. The few lessons that can be reviewed have themes that relate to SA, but the lessons lack in detail and assessment. Grade level: middle/upper elementary; middle/upper primary.

Website URL	Website Title	Annotation/Comment
http://foodlandpeople.org	Project Food, Land and People (United States Based)	Web site provides brief descriptions of lessons that comprise the book Project Food, Land and People. These lessons cover a diverse array of topics associated with agriculture and the environment (e.g., grazing practices, role of aviation in agriculture, tillage techniques). Example lessons can be viewed and are designed in a general framework so that states (of the United States) can "easily" match them to state curricular standards. These lessons are not learner-centered, vary in detail, and are for a wide range of age/school levels. Grade level: elementary and middle school; primary and secondary.
http://www.wisc.edu/cias/pubs/curricul.html	Center for Integrated Agricultural Systems (United States Based)	Description of sustainable agriculture curriculum, a teacher's guide, and resources for teaching sustainable agriculture given. No example lessons given. Inexpensive to order. Grade level: high school, upper secondary.
http://www.csuchico.edu/psed/servicelearning/mod1/mod1_4-1.html	Service-Learning, California State University: Module 1: Introducing Service Learning (United States Based)	Description of the basic terms and concepts associated with service learning.

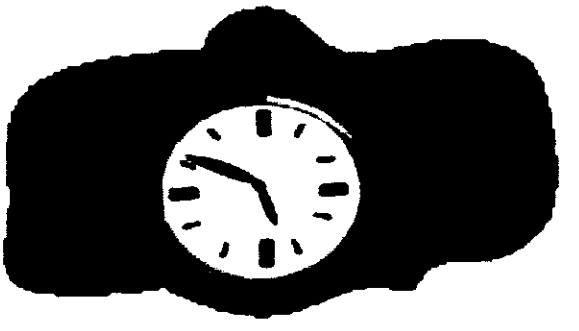
Appendix VII
Addtional Tests for *A Water Watch* and *A Soil Study*

Appendix VIIA. Addtional Tests for *A Water Watch*

I. Determining Stream Flow (including volume [how much of something is present] and velocity [how fast something travels]).

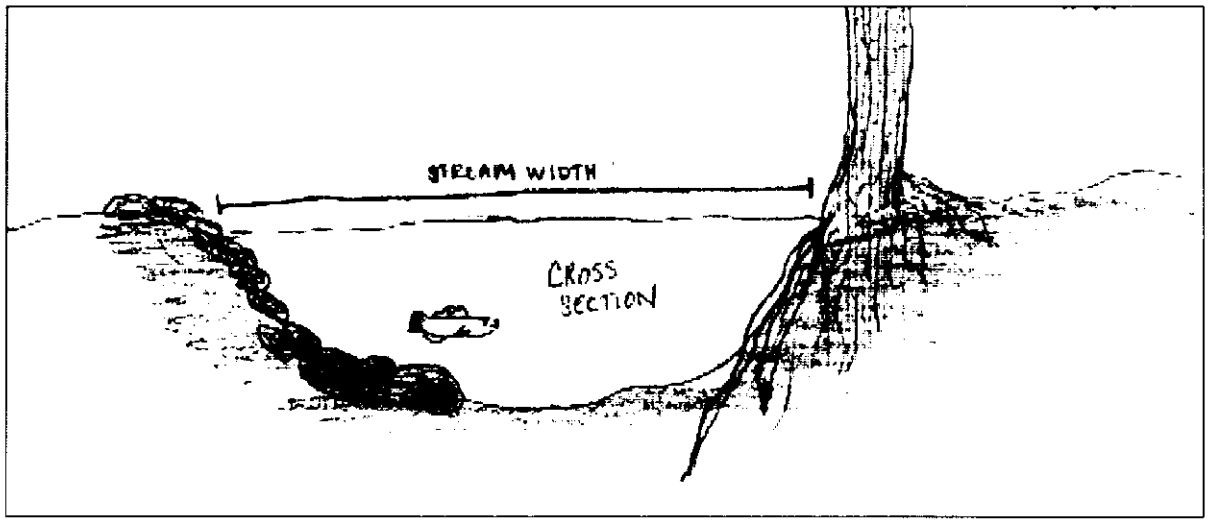
Stream flow is defined as the volume of water moving past a certain point during a specific period of time. In order to determine stream flow, one must measure the stream velocity and the average volume of water in a given area. Stream flow is useful in determining the effects of weather events or seasons such as flooding or drought . One can calculate the stream flow in a specific season and compare it to another season or a season average. During storm events one can also determine the increase in stream flow based on the amount of rain that has fallen in a period of time. This data can be used to predict when rain may cause severe flooding. Stream flow measurements are also used to determine the how well a stream can turn a turbine (motor) or for diluting pollution.

Stream flow is influenced by the amount of vegetation present in a watershed. The more vegetation present, the slower water will move across the land and into stream or other body of water. The vegetation slows runoff by acting as a barrier and by taking up water through its roots.



Materials:
* a **watch** or a **timer**
* an **orange** or **other floating object**
* a **measuring tape** or **length of string** that is marked to measure 10 meters
* **extra string**
* **dry sticks** or **measuring sticks** for determining stream depth
* optional: a **calculator**

Mark ten meters along the bank of the stream. This will be the area that you will sample. The first measurement that students will collect is the average area of the **cross section** of the stream. Explain that a cross section is what one would see if they could cut a stream in half (width-wise) and look at it from the end. It may be helpful to draw a picture of a cross section of a stream.

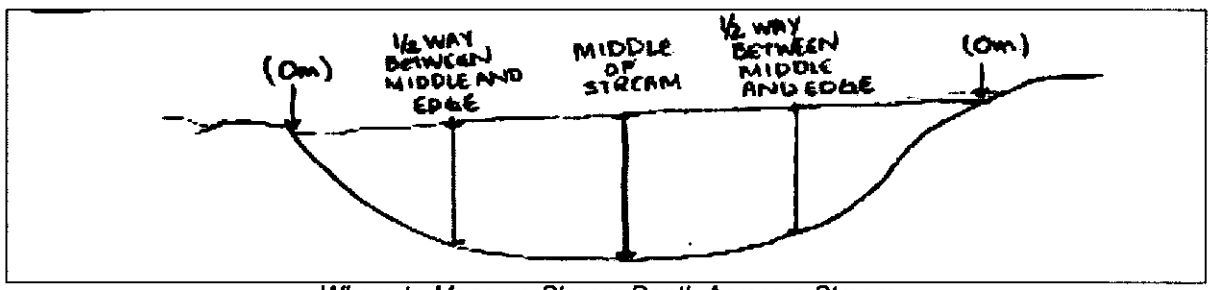


Cross Section of a Stream

To determine stream volume, students will first need to know the width of the stream. This information can be gathered by using a measuring tape or string to measure from one side of the stream to the other.

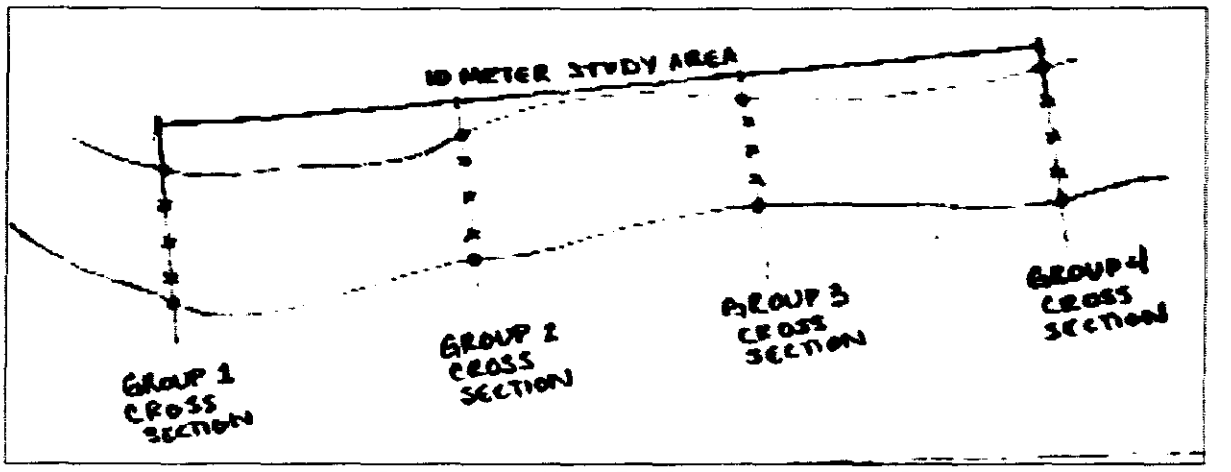
Width of the stream = _____ m

Next students will need to measure the depth of the stream. Explain that the depth of the stream varies from the sides to the middle, so students will measure the stream in three regularly spaced areas and then use an average of those three numbers and the number zero (which is the depth of the stream at the very edge).



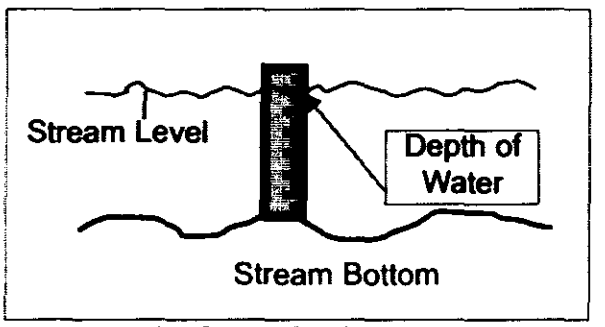
Where to Measure Stream Depth Across a Stream

Break the class into four groups and choose four areas along the 10 meters (regularly spaced) for groups to take measurements. If possible, tie pieces of string so that they stretch across the stream and mark the four cross section areas. Students should measure stream depth once in the middle of the stream and once between the middle and the edge of the stream on each side.

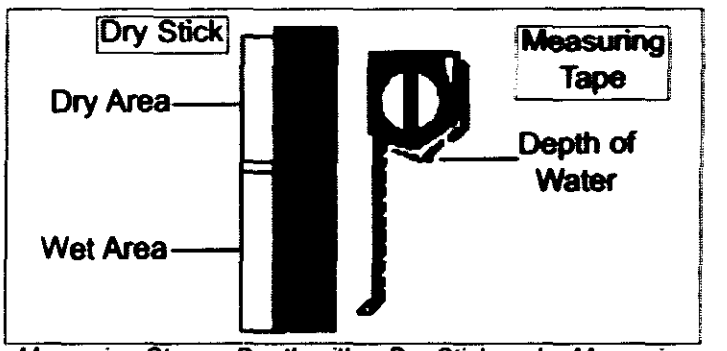


Measuring Stream Depth Using Dry Sticks or Measuring Sticks

Measure stream depth using a measuring stick or dry stick and a measuring tape (if using a dry stick measure shallow areas first). Place the measuring stick or the dry stick in the water. Record where the water reaches on the measuring stick (or remove the dry stick from the water and measure the distance from the bottom of the stick to the top of the area where the water left a mark).



Measuring Stream Depth with a Measuring Stick



Measuring Stream Depth with a Dry Stick and a Measuring Tape

Record the three measurements on a piece of paper and also include the number zero. Add the four numbers (including zero) together and divide by four. That is the average depth across the line in the stream.

_____ m +	_____ m +	_____ m + 0m =	_____m / 4=	_____m
measurement 1	measurement 2	measurement 3		average depth at cross section

Multiply the average depth at the cross section by the width of the stream at the cross section to determine the area at the cross section of the stream.

_____m	x _____m	=	_____ m^2
width of the stream at cross section	average depth of the stream at cross section		area at cross section

Determine the average area at the cross section by adding each group's area at the cross section value and dividing by 4.

_____m^2 +	_____m^2 +	_____m^2 +	_____m^2 =	_____m^2 / 4 =	_____m^2
group 1 area	group 2 area	group 3 area	group 4 area		average area

The average of all of the measurements along the ten meters can then be multiplied by the length of the area (10 m) to determine the volume of water. Volume is expressed in cubic meters (m^3). Explain that the volume measurement represents all of the water in the ten-meter area.

_____ m^2 x	10 m =	_____ m^3
average area	length	volume

The next task is to measure how fast the water in the stream is moving (**velocity**). Explain that velocity is measured by determining how far the water moves in a specific amount of time. An object that floats will move at the same speed as the water (note: objects that float slightly below the surface of the water, such as an orange, are more accurate measures of stream velocity than objects that float high in the water because they have less contact with the air above the stream and therefore produce less friction).

One student should be in charge of watching the watch or timer. Another student should toss the orange into the middle of the current upstream from the ten-meter boundary marker. The student with the watch should begin counting time as the orange passes by or under the beginning mark of the ten meters. Once the object passes the person at the downstream end of the ten meters that person should yell "stop" to the person with the watch. The time should be recorded and the activity should be repeated three times. Calculate an average time.

_____s +	_____s +	_____s =	_____s / 3 =	_____ s
trial 1 time	trial 2 time	trial 3 time		average time

At the very bottom of the stream the moving water comes in contact with the earth. Because the

earth at the bottom of the stream is more or less stationary (does not move), this creates a small amount of friction (or drag) that slows the water. To compensate for this slower water at the bottom of the stream, multiply the average time by a coefficient of 0.8 (s) for streams with rocky bottoms or 0.9 (s) for streams with smooth bottoms.

_____ s	x	0.8 or	0.9	=	_____ s
average time for drag		rocky bottom	smooth bottom		average time with compensation

The length of the stream section (10 meters) can then be divided by the average time with compensation for drag to determine the velocity of the stream (students may wish to convert the example units of measurement into more common ones such as inches or feet).

10 m	/	_____s	=	_____ m/s
length of stream section		average time with compensation for drag		stream velocity

To determine stream flow multiply the volume of water in cubic meters by the velocity that the water is moving in number of meters/ second. This will give you the stream flow in cubic meters per second.

_____ m^3	x	_____ m/s	=	_____m3/s
volume		stream velocity		stream flow

II. Sampling for specific plant or animal species: Students may wish to know if the body of water that they are studying contains a certain species of plant or animal. Sampling an area for a specific species requires research on the specific species to determine the best methods for sampling. For example, a student interested in salamanders may find that the best place to look for them is on the streamside near vegetation. Another method may be searching for a specific species in a variety of areas in the body of water. The species presence or absence may indicate changes in the stream habitat and it might lead to hypotheses about what the particular species requires in a habitat. Salamander presence upstream and absence downstream may indicate a change in habitat that excludes salamanders in downstream areas. Students should test a variety of areas multiple times for accuracy.

III. Measuring Total Suspended Solids (TSS): Total suspended solids is the amount of particulate matter (sand, silt, clay, and other particles) that are present in a stream. A measure of TSS can show where there are problems with erosion and siltation (the presence of large amounts of silt or sand) in the stream. TSS is measured by the weight of solids per volume of water sampled. This is usually expressed in milligrams per liter (mg/L). TSS will generally fluctuate with the stream flow. In order to compare TSS over time, stream flow must also be considered.

Materials:

*A liter (or other known volume amount) vessel for carrying water from each site sampled to the classroom

* **2 micron filter paper** (If this is not available a coffee filter or regular paper can be used. Test

the filter paper to determine if TSS particles will flow through the paper. Ideally water will filter through the paper very slowly and TSS particles will remain on the filter paper. Regardless of the paper used, be sure to use the same paper for each sample so that they can be compared.)

* A **bowl or jar** for catching filtered water
* A **funnel** (this can be made by cutting the top off of a plastic soda bottle)
* A **scale or balance** (the more sensitive the better)*

Weigh the clean, dry filter paper using the balance or scale.

Weight of filter paper = _____mg

At each area to be sampled, a liter of water should be drawn in a clean vessel. This sample should be taken before any other sampling that may increase the amount of sediment in the water. Carry the water back to the classroom for further study.

In the classroom place the filter paper inside the funnel (it may need to be folded into a cone shape to fit well in the funnel). Slowly pour the water through the filter paper into the empty bowl or jar. Once all of the water has been poured through the paper, remove the paper and place it in a warm area to dry. Once the paper is completely dry weigh it again.

Weight of filter paper and sediment = _____mg

Subtract the weight of just the filter paper from the weight of the paper and the suspended solids. The difference is the TSS in mg/L.

_____ mg	-	_____mg	=	_____ mg/L
weight of filter paper		weight of filter paper and sediment		weight of sediment

*Note: if a senstive scale is not available, fill a plastic liter bottle (e.g., soda bottle) with water from a local stream and observe it for two to three days. Take note if any sediment forms on the bottom. If so, measure the sediment with a ruler. This will give you an apprimation of how much sediment, or TSS, can be found in your water site.

Appendix VIIB: Addtional Tests for *A Soil Study*

I. Determining physical characteristics of soil: depth and texture. A soil's **texture** and depth are important indicators of how well plants will grow in a given area.

In an area that is not eroded, the soil is often deeper than in an area that is eroded. The top layers of soil, including the organic matter and rich topsoil, are the first to wash away into air or water when erosion takes place. The remaining subsoil is generally less favorable for plant growth. (see *Plants, Animals, and Soil: A Natural Connection* for more information on soil horizons.) The soil particles that wash away do not remain in the water or air forever. Eventually the water or air will slow and the soil particles will fall out and deposit themselves somewhere. This process is called **deposition**. In areas of deposition the soil depth is generally quite deep. By measuring soil depth students can compare areas of erosion and deposition and can begin to understand how soils have moved through the area.

Soil texture is the size and shape of the particles that make up the soil. Soil is made of sand, silt, and clay particles, as well as bits of organic matter. Particles that make up soil come from the weathered bedrock of the area. The best agricultural soils are made up of a variety of different particles, but plants grow differently depending on the soil in which they are found. For example, some plants grow best in soils with a lot of silt while other prefer a more even mixture of sand and silt.

Sand is the largest soil particle and it is generally circular in shape. A very sandy soil will absorb water well, but also dry out or drain very quickly. It is also not able to hold important nutrients for plants.

Clay is the smallest soil particle. Clay particles have a flat shape and they are very sticky. Soils that have a lot of clay can hold a lot of water and they drain very slowly. Clay holds onto water and nutrients so tightly that plants cannot absorb them.

Silt is in-between sand and clay in size and other characteristics. Most agricultural crops do well in soils with high silt content.

Soils of different textures erode and are deposited differently. In comparing soils from eroded and non-eroded sites students may discover differences in soil texture that make sites more or less suitable to growing agricultural crops.

Materials:
* A **shovel** or a **soil auger (soil corer)**
* **Containers** for collecting soil samples (one per site)
* **Water**
* **Clear jars** with straight sides and a lid (one per site)
* Teaspoon of **laundry detergent** (one per site)
* A **ruler**
* **Paper and pencils** for recording data

Explain the above information about soil depth and texture to students.

With students, choose two or more sites to compare.

At each site, students should dig with a shovel or soil auger to measure soil depth. The depth of each **soil horizon** (see soil activity *Plants, Animals, and Soil: A Natural Connection)* can be measured as can depth to the **water table** (point at which the ground is saturated with water) and the depth to **bedrock**. Students should record these measurements.

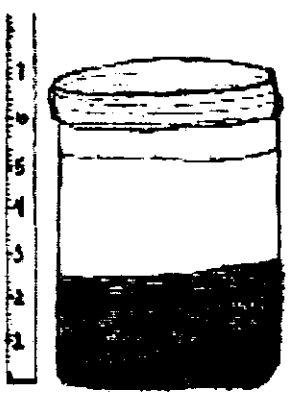
Collect soil at each site and bring it to the classroom to determine the soil texture. Be sure to label the containers with the name of the site from where the soil was collected.

Students should practice feeling the soil as it is collected. Once they become familiar with the different soil textures they can determine texture based on the way the soil feels.

To feel for soil texture students should place a small clump of soil in the palm of their hands. Students should moisten the soil with a small amount of water and then rub the soil between their fingers. They will be able to feel the texture of the soil and with practice will be able to determine a soil's suitability for growing crops. If soil feels gritty it has a high sand content; if it feels smooth and can be molded into a thin rope it has high clay content. Soils that are in-between sand and clay in texture may have high silt content.

In the classroom, place the collected soil samples on a table. To separate the soil particles and determine actual soil texture, students will place a clump of each soil sample in a separate glass jar. Fill the jar with water and add a small amount of laundry detergent (this will help the particles to separate).

Shake the jar until the soil is thoroughly mixed with the water and soap. Allow the jar to sit and the soil to settle to the bottom of the jar. If soil has high clay content the jar may need to sit overnight in order for the soil to settle. The soil will form layers as it settles with the heavier particles on the bottom and lighter particles on the top. Any rocks or gravel will sink to the bottom followed by a layer of sand, silt, and then clay on as the top layer. Non-decomposed organic matter will often float to the top.

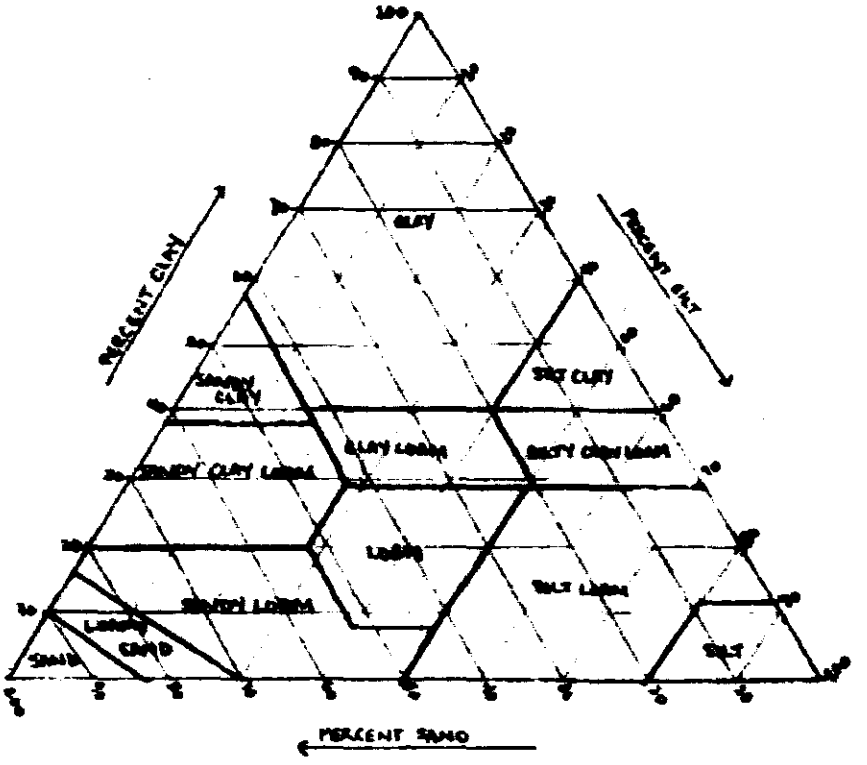


Jar of Settled Soil

Measure the different layers with a ruler. Use the equation below to determine the percentage of each layer:

_____cm	/	_____cm	x 100 =	_____
Height of specific layer		Total height of soil in the jar		percent of specific layer

Determine the percentage for the sand, silt, and clay layers. Soils of different sand, silt, and clay percentages have different names and different physical characteristics. Use the following chart to determine your soil's type:



There are two lines that extend from each percentage number on the figure above. It is important to remember than when drawing lines from a percentage number, follow the same direction in which the number is written.

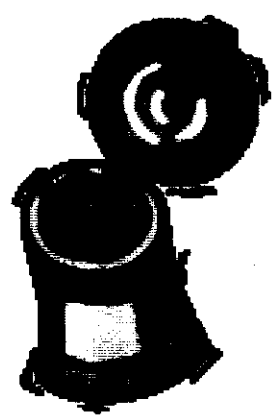
To determine your soil texture, begin on the bottom axis with the percentage of sand. Mark your soil's percentage of sand with an 'x' on the percentage number and then draw a line from the x toward the clay axis. The line should be parallel with or directly on the given percentage lines. Extend the line through the clay axis. Next, mark your percentage of clay on the clay axis and draw a line toward the silt axis, keeping the line parallel or on the given lines. Extend the line through the silt axis. Finally, draw a line from the silt axis to the sand axis and extend it through the sand axis. Find where the three lines intersect at one point. The closest label tells the name of your soil type. For agricultural crops, the most desirable soils are loams and are located near the center of the triangle. As one moves toward the corners of the triangle the soil becomes less desirable for growing agricultural crops.

Record the soil names and discuss the differences with the students. Which soils were found in areas that had been eroded? Which soils were found in areas of deposition? Did students find some soils to be more likely to erode than others? Which areas were best suited to growing crops?

II. Measuring water infiltration rate. As rain falls on soil it will either soak into the ground or move across the ground. Water that moves across the ground can cause erosion. There are many reasons that water will not soak into the soil. Excessive amounts of rain, a steep slope, soil compaction, small soil particle size, or a lack of organic matter can cause this.

> * **Compaction**: When heavy objects (such as rain drops) repeatedly pass over soil, soil particles get squeezed together more tightly. The air spaces between the soil particles get smaller or may disappear. The presence of large air spaces helps soil absorb water easily; therefore compacted soils cannot absorb much water. Rain that falls on these areas is more likely to run off the soil surface before being absorbed.
>
> * **Soil particle size**: Remember that soils are composed of different materials, such as sand, clay, and organic material. Sand particles are relatively large and large air spaces are found between them. Clay particles are much smaller and have smaller spaces between them. Organic matter has an irregular shape and can absorb water between particles. The composition of the soil (the relative amounts of sand, clay, and organic material) will influence the infiltration (or absorption) rate of water. Sandy soil will absorb water relatively quickly while clay absorbs water slowly (clay, however, will hold the water longer than sandy soil). The presence of organic matter will slow down the water infiltration rate of sandy soil and will speed the uptake of water in clay soils.

Plants' roots often use water that is absorbed into soil. On a steep slope where vegetation has been removed, heavy rain can cause soil to erode quickly. Students can easily measure the rate at which water is absorbed into the soil and, by doing so, can determine if a soil site is vulnerable to erosion.



Materials:
* A **tin can** with both ends removed
* A **vessel** for carrying water
* A **stop watch** or a watch with a second hand

Visit an outdoor area with vegetation growing in soil. The site must be large enough to conduct water absorption tests in three different areas of the site. Students should remove any vegetation from the soil surface but leave the roots in place.

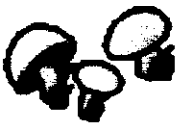
Push the tin can into the soil to a depth of about 2cm (0.787 inches). (If the soil is very dry and you cannot push the can in, wet the soil with a small amount of water before pushing the can into the ground.)

Fill the can with water until water reaches the rim of the can.

Using a stopwatch or a watch with a second hand, record the amount of time it takes for all the water to be absorbed by the soil. Perform this test multiple (at least three) times in different

areas at each site tested. Average the results for each site (for each area, take the three recorded times, add them together, and divide the sum by three; the answer is your average duration for soil to be absorbed).

Discuss the data that was collected: How do the rates of infiltration compare in the sample sites chosen? Can you think of reasons why these rates might differ? What could you do that would change the soil infiltration rates?



III. Soil organism diversity study. Many organisms live in the soil and in the **surface litter** (vegetation that lies on top of soil, such as leaves and sticks). Some play an important role in breaking down dead organic material and recycling the nutrients for plants to use. Soils that are rich in organic material often contain large populations of soil animals and insects. They may be **shredders** that break apart large pieces of organic material (like leaves) or **detritivores**, organisms that feed on the small bits of organic material produced by the shredders. **Fungi** (such as mushrooms) are also important decomposers. All perform important roles in breaking down organic materials and recycling the nutrients they contain. One indicator of healthy soils is the presence of these organisms in the soil and surface litter. Students can assess soil health and the amount of decomposition taking place by counting the numbers of decomposers found at different sites. Students should use the same sites that they used for the previous tests.

Materials:

* String four **stakes** to mark off a square meter on the ground
* A **measuring tape**
* **Paper and pencils** for recording data

Mark off a square meter (or multiple square meters) using the tape measure, string and stakes.

Break students into groups to count the number of decomposers in the soil at the different sites. Students should look on the surface of the soil and also beneath any plant material. In a forested area students can remove the leaves and replace them when they are finished counting. In a grassy area students should dig into the soil as needed without disturbing too many living plants.

Students should record the number of mushrooms and other decomposers that they find. If there are fungi available remind students that these are also decomposers. Record the number of soil animals as well as the number of types of fungi found.

Compare the data from the different sites. Which sites had the largest and smallest numbers of insects and fungi? Were there any surprising results? Students should enter the data from the different sites into a bar graph to compare.

IV. Determining soil pH. pH scales measure the acidity of a substance. "pH" stands for potential hydrogen. The pH scale ranges from 1 to 14 with 1 representing a highly **acidic** substance and 14 representing a highly **basic** or **alkaline** substance. A pH vale of 7 means that the substance being measured is neutral, neither acidic nor basic.

Although pure rainwater has a pH of about 5.6, the pH of water, once it enters soil, will change based on the chemical characteristics of the soil. Alkaline soils have a pH greater than 7 and acidic soils have a pH less than 7. Many nutrients found in soil, such as calcium and phosphorus, are better able to dissolve under slightly acidic conditions. That means that plants are better able to use those nutrients in slightly acid conditions. If a heavy rain occurs, these nutrients will dissolve in the water and can **leach** (sink) into lower soil layers where many plant roots do not occur. If soils are too acidic or too alkaline, certain nutrients may be unavailable to plants.

Materials:
* Three **plastic cups or glass jars**
* **pH paper** (also called litmus paper)
* A **spoon** for stirring soil (a stick or other object will work)
* **Distilled water** (Tap water will also work but may not be neutral and should therefore be tested for pH ahead of time; if you know the pH of the water ahead of time then you can compensate for it later. Distilled water can be found in most grocery stores.)

Test soil pH at the same sites where students tested other soil characteristics.

Collect a core of soil at each site and try to include a representative amount of each of the soil horizons.

Stir each soil sample so that all of the horizons are mixed.

In the classroom, place soil from each site into three separate cups.

Add 100 ml of distilled water to each cup.

Use the spoon to break apart the soil and mix the water with the soil.

Leave the cups on a shelf for about three hours or until the water has become fairly clear (soils with heavy clay content may need to sit overnight).

Tear off a small strip of pH paper (about 5 cm).

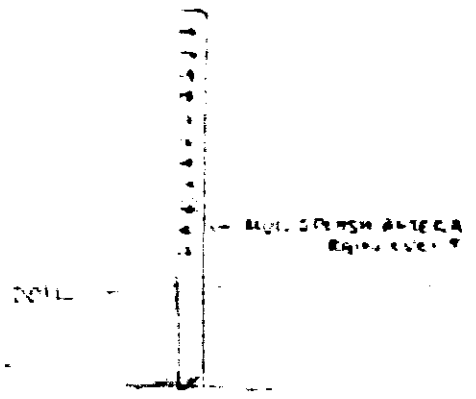
Touch the water with the paper. Do not touch any soil.

Match the color of the wet paper to the colors found on the pH package. Record the pH number of the matching color. This is the pH of your soil.

Discuss any the differences between the sites tested. What might have caused these differences? Add the pH results to a graph of soil characteristics at different sites.

V. Measuring the effects of rain on soil. When it rains, bare soil (soil without any vegetation growing in it) is likely to erode. **Ground cover** can help to protect the soil and prevent erosion. Ground covers may include **mulches** (protective coverings, usually of organic matter such as leaves or straw, placed around plants to prevent the moisture evaporation, root freezing, and weed growth or living plants. The following test can be used to determine the rate at which different ground covers protect the soil.

Materials:
* White or light colored wooden stakes
* A **measuring tape or ruler**
* A **marker** with ink that will not disappear if it gets wet



Place the white wooden stakes in the ground; do this in areas that have different plant covers. Make sure that the stakes are secure in the ground and that they are perpendicular to the ground.

Using the measuring tape and the marker, mark centimeter increments (one- or five-cm increments will work) up the length of the stakes. Start with the mark of zero centimeters at the point where stake comes out of the ground.

Visit the stakes after each rain event and record the height of where mud has splashed on the stakes. Wipe the stake clean after recording so that you may continue to take measurements after additional rain events.

Compare the results from different sites. Stakes that show small mud splashes will indicate that the ground cover present offers the soil good protection from rain; therefore, the soil is less likely to erode. Which ground covers provided the most/least protection from rain?