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Community-Based Natural Resource Activities for Biology

Northwest Center for Sustainable Resources (NCSR)
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necessarily those of the foundation

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Introduction to Community-Based Natural Resource Activities for Biology report

INTRODUCTION

Many educators are looking for more contextual and meaningful ways to make connections between the content they are required to teach, the natural world and communities they live in. This manual begins by taking you through some of our philosophy and processes of community-based education. These ideas are included and more fully developed in An Educator's Guide to Program Development in Natural Resources, a previous publication by The Northwest Center for Sustainable Resources (NCSR). The last part of this manual provides teachers, particularly those teaching in required biology classes or natural resource courses, with specific ideas and lessons to engage their students as community participants while covering the major topics and concepts of biology.

Our hope is that the activities in this manual will be used within an overall program that emphasizes community-based education. Background into community-based education, program processes, and program development are included in this manual to help educators place the activities within such a program. If the activities included in this manual take place within a community-based program, fill a community need, cover important biological processes, and raise the awareness and decision-making capacity of the community, then our goal has been achieved.

There is no particular sequence that needs to be followed with these lessons. Indeed the sequence should ultimately be determined by the needs of the community and the priorities that have been set through community surveys and mapping. Although there is always concern by teachers regarding their course's scope, sequence and state and national assessments, there has been research to show that using the community and environment as a learning context can, in fact, improve student learning

Teachers may want to select a single activity as a starting point to help them and their students begin that journey from teaching in the classroom to learning within the community. The activities will require teachers and students to reach out to resources in the community. Working with a variety of city, county, state, and federal agencies and organizations can provide needed expertise and equipment. Students will see the role of the professional and the groups they represent in the community. Students can themselves become a valuable resource for the community with the work they do and the products they produce.

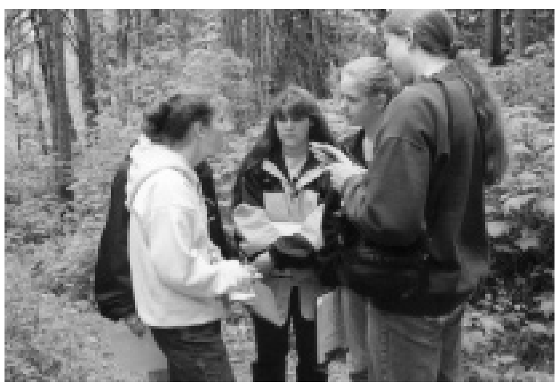
Each lesson follows a familiar format to most instructors. Science standards are included from the National Science Education Standards developed by the National Research Council. In the teacher background portion of the lesson there are ideas for community connections along with content information or hints on carrying out the lesson successfully. The activity also contains extensions, which allow teachers to add on to or expand the lesson. Perhaps a student may want to use these for extra credit or independent project ideas as well. The lessons end with the name of the teacher responsible for development of that activity. Feel free to contact them if you have any questions or feedback regarding the lesson.
The activities and lessons have resulted from a collaborative effort from a variety of teachers across the country. These teachers' hard work and efforts on their particular lessons are a testament to all the great work that they do with their students in their communities. Please feel free to contact them with any questions you may have regarding a particular lesson. In addition, a special thanks goes to Wynn Cudmore the co-PI for NCSR (the manual's sponsoring organization), for his editing skills and his support for these efforts.

Jon Yoder
Secondary Education Coordinator

Community-Based Education

The need for educational reform is on the agenda of nearly every group that is in any way connected to public welfare in America.

Although education historically has been called upon to lead the way in dealing with change in our society, clearly the pressures on our communities from international competition, current economic issues, lack of skilled workers, need for highly skilled and technology literate citizens, and the incidence of serious social and environmental issues cannot be denied. Increasing day-to-day needs for citizens to be scientifically, technologically, ecologically, and socially literate underscores that there is reason to be concerned about the educational preparation of our student-citizen.



THE CHALLENGE

This background of concerns clearly illustrates that the task for reforming education is more than simply rearranging what is currently being offered in most schools throughout America. Changes cannot be achieved by attempts to simply revise, restructure, reorganize, or update the current school curricula. These courses and how they are currently taught are the very reasons for the demands for educational reform. The task, instead, is one of separating us from the past and developing new ways of thinking about a citizen's education. As educators, our responsibility is to provide leadership in creating programs that represent a system for student-citizens to engage in change that protects and enhances our natural and social worlds. Programs need to be more than single courses offered at the end of a students' high school experience, and instead should be comprehensive, coordinated series of experiences grades K-12.

Neal Maine, NCSR's Secondary Education Consultant, uses a baseball analogy where the young player-citizen's community-based educational program may need some participation tees, the bases may be set closer, and more attention given to safety. However, when young player-citizens see major league baseball played, it includes a bat and ball much like theirs, the rules are generally the same, and the concept of the game is understood. They have actually participated in and played the game. Schools need to provide a setting where our student-citizens have authentic opportunities to participate in the "games" played out in their communities so upon leaving the educational institution their entrance into the community is a known and practiced experience. These authentic opportunities are requested by the community and are therefore the same experiences that are currently taking place there. An example would be a city agency asking students to assist them in completing their mission, which could be anything from conducting a tree inventory to educating community members about water quality.

It is to the communities' advantage to assure that young citizens have played the game for years and not start when they graduate from high school. To have students become productive and participating members of the community, is the mission of education. Without years of experiences actually doing this would seem to lower the capacity for reaching or maintaining sustainable and vibrant communities. The current approach of sitting in a classroom "learning" about math, English, science, and social studies, reading out of textbooks, and doing worksheets allows for little opportunity for the community engagement necessary for citizen participation. Connecting students to their own interests and lives is an important factor to consider in the education of the student-citizen.

THE NCSR APPROACH

The Northwest Center for Sustainable Resources (NCSR) has developed a process for educators to use as they develop community-based programs. Although focused around natural resource program development, it is a process that can be used in many other arenas. This approach encourages teachers to develop programs that engage students in surveying, exploring, and studying how their communities are involved in using and managing natural resources.

Step One

Examine documents that guide agencies and citizens in the use and management of resources to select a developmentally appropriate entry point for participation.

Step Two

Students learn the skills and knowledge necessary to monitor, inventory, and research areas that the community has said are important and needed. Students form partnerships with agencies and members of the community to help them complete their work.

Step Three

Student-citizens provide feedback to the agencies and general public on what they have found and learned from the participation. This then, raises the capacity of the community to be involved in policy and decision-making by becoming aware of and understanding the use and management of the natural resources around them.

In this way, our students have numerous opportunities to experience and participate in the processes and workings of our community. They not only acquire the necessary skills and knowledge that the public is concerned about, but through meaningful and authentic ways act as a participating citizen of their community.

It is time for communities and educators to expand their current efforts and develop community-based programs that will build civic engagement in our community. A more concerted effort is needed to involve student-citizens of our community in whose hands we leave the future of our world.

THE NCSR GOALS

A graphic representation of the possible relationship between school programs and community may help highlight the NCSR program goals.

Figure 1

Figure 1 represents the typical relationship that exists between schools and communities. Students take a set of discrete courses in what often looks very little like the experiences taking place or needed in the community. Upon graduation students are assumed to know how to be a participating, contributing member of the community without knowing what that means or having had previous experiences or opportunities within the community.

Figure 2

Figure 2 shows school activities taking place out in the community, but not interacting with the community processes. An example would be stream studies at a local site where there is no additional purpose other than to do stream studies. The school has not been asked to serve as a resource or participate by the community. In addition, guest speakers come in to school to talk about what may go on out in the community, but again students do not experience it first hand.

Figure 3

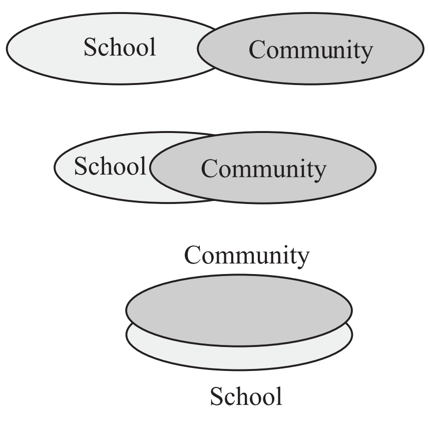


Figure 3 represents the relationship between schools and community that NCSR advocates for your natural resource program. In this model, schools are involved in serving as a resource for the community. The skills, knowledge, and attitudes are developed within the authentic experiences of the community. Student-citizens are involved in the community processes and are considered a valuable resource by the community. From the diagrams above you see that the amount may vary as you move from K-12. Developmentally appropriate experiences in the community would likely occur less frequently in the primary years than as a 12th grader who may be in the community arena nearly full time. Elementary school students should have frequent exposure to ecosystem studies and can be powerful spokespeople when given the chance to be community participants.

It is important to note that this relationship between schools and communities is almost always mandated. An example is the mission statement from the Salem-Keizer school district which reads:

> *In partnership with the community, we ensure that each student will have the essential knowledge, skills and attitudes to be a life-long learner, a contributing citizen and a productive worker in a changing and increasingly diverse world.*

If we are to take this seriously, we need to design our programs in partnership with the community so the learning that takes place is within the context of the community. Most schools and districts across the country have similar mission statements, yet most learning that takes place is not within the community context but in isolated classrooms. Establishing a community-based program is the fulfillment of the mission we have been given. Important knowledge, skills, and attitudes are still taught and content standards are addressed, but now it is within the context of "in partnership with the community."

We realize that this is a major paradigm shift and cannot be achieved by a single individual in a short period of time. What we are proposing will be a long and somewhat difficult task to accomplish. However, this approach will be rewarding enough for students, teachers and community members that it will be difficult to go back to a more traditional mode of education. Discussions with colleagues, administrators, and community members are good places to start the change process. We hope this manual will provide ideas, a process and framework that will aid you in initiating change in your school and community.

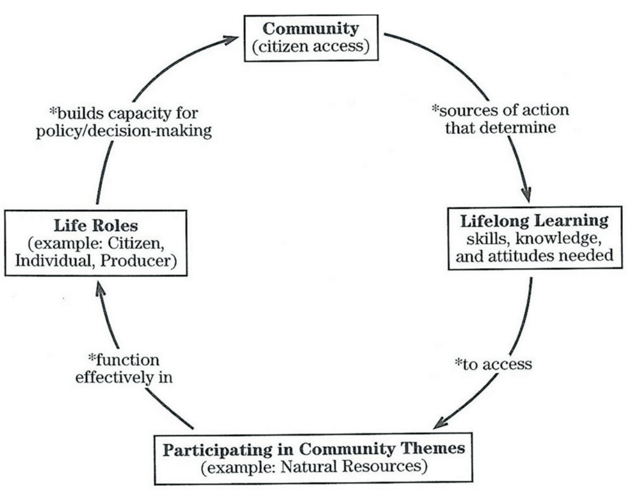
Community as a Context for Learning

Understanding the community around you is essential in the development of a community-based program. There are three areas that will be used to describe a community: lifelong learning, community themes, and community life roles of community members.The three areas that describe a community are all connected. All of these further support the notion that schools need to more closely interface with the community.

This section of the manual may also be used to justify the appropriateness or need for the community-based approach in natural resource programs. An example of the community process is shown below.

In the next section of this manual, we will revise this process to one you can use in developing your natural resource program. It is important to note that although we are focusing on natural resources, this process can be used for all community themes.

Figure 1



In Figure 1, citizens access and participate within a community in a variety of ways. Often this involvement serves as a source of action where life-long learning (skills, knowledge, and attitudes) is needed. This participation occurs within community organizations that can be categorized into broad themes such as natural resources. The interaction of community members within these themes allows for functioning in a number of life roles such as citizen, producer, and consumer. The result in this community process is to build a capacity for policy and decision-making among all members of the community.

LIFE-LONG LEARNING

The first area of community deals with life-long learning and the skills, knowledge, and attitudes necessary to function effectively in a community.

In this rapidly changing world, new skills are needed by broad segments of the public to maintain pace with community development, careers and jobs. Keeping up with these constant changes can often exceed the capacity of the average citizen. A community-based educational program could help bridge the gap between citizens and active participation in their communities.

Each member of the community brings a wide range of personal skills and knowledge to the public process: educational experience, their own personal life experience, diverse attitudes, and their own unique personality. The question for full participation is not so much how old the citizens are, but what is their personal entry-level skill for participation in the public arena? Although somewhat unclear for some, it is clear to the educational reform effort that students are and must be considered full participating citizens in our communities. The proposed framework insures that developmentally appropriate access would be provided for the young citizens of our communities.

In order for citizens to be successful participants in the public process, they must be able to acquire the basic public skills, such as being an effective communicator and team player. They must have an opportunity to develop additional specialized skills and knowledge, such as application of specific technologies, if they are to contribute to the more specialized "themes" of the community.

If citizen skills and knowledge are not developed in the formal process during their schooling, then this opportunity should be available for development at any time. Although some will seek additional formal educational opportunities, most will go with what they have, often limiting their participation to "crisis" community issues where the motivation exceeds the concern about personal skills and knowledge; or that concern motivates the individuals to personally develop the skills and knowledge necessary to get through the crisis.

Skills (Examples)

- Effective communications – oral and written
- Use of electronic communications, e-mail, web access, etc.
- Problem-solving approaches for community actions
- Techniques in being a "team player"
- Organizational skills

Knowledge (Examples)

- Knowledge of community processes
- Opportunity to build a sense of place
- Access to the community and regional history
- Relationship of community in state, national and global context
- Interactions of economic, social, and ecological elements of community
- Local geography

Attitudes (Examples)

- — A spirit of cooperation
- — Support for linkage between rights and responsibilities
- — Building a sense of ownership of community
- — Feeling for linkage between services and service
- — Confidence in actions to identify, analyze, and select
- — Actions to resolve issues

COMMUNITY THEMES

The actions of the community can be organized around community themes. The themes being proposed are useful organizers for our communities and can also be used to plan and focus asset inventories. These are the valued social, economic and ecological components of a community. The inventories would serve as the "common" resources of community members and be useful in planning and developing community action plans. None of these themes operates in isolation in the "real world"; thus, the community themes are only for the purpose of planning. The following is a list of proposed community organizing themes. Academic disciplines should be used to advance these themes.

Human Resources: A fundamental area of community study and participation that includes political and social systems. These may include, but need not be limited to, education, law and legal studies, law enforcement, public administration, child and family services, religion, and social services.

Health & Safety Services: A theme that is critical to groups and individuals in communities and fosters the promotion of health as well as the treatment of injuries, conditions, and disease. These may include, but need not be limited to, medicine, dentistry, nursing, therapy and rehabilitation, nutrition, fitness and hygiene.

Business and Management: The economic base of communities must be understood to ensure participation, and includes areas of study related to the business environment. These may include, but need not be limited to, entrepreneurship, sales, marketing, hospitality and tourism, computer/information systems, finance accounting, personnel, economy and management.

Arts & Communications: Often the base of community culture and community pride, this includes areas of study related to the humanities and to the performing, visual, literary and media arts. These may include, but need not be limited to, architecture, creative writing, film and cinema studies, fine arts, graphic design and production, journalism, foreign languages, radio and television broadcasting, advertising and public relations.

Infrastructure and Engineering Systems: Fundamental to current community infrastructure, this area of study is related to the necessity to design, develop, install, or maintain physical systems. These may include, but need not be limited to, engineering and related technologies, mechanics and repair, manufacturing technology, precision production and construction.

Natural Resource Systems: Often one of the limiting factors in community economics and development, this area of study is related to environment and natural resources systems. These may include, but need not be limited to, agriculture, earth sciences, environmental sciences, fisheries management, forestry, horticulture, and wildlife management. Ecosystem management is the standard for many public agencies and must include citizen participation. This theme also relates to citizens' stewardship and land use planning for communities and resource land.

These community themes are drawn from the Oregon's Certificate of Advanced Mastery (CAM) program and support the development of a program that includes natural resources as an organizing theme and connections to the community.

COMMUNITY LIFE ROLES

A third area of community description is community life roles. These life roles of the community are the front line of action and play a significant role in determining the breadth and depth of capacity being added to the community. Linking actions to the life roles can help focus the work, both within the formal educational community and the broader community institutions. All citizens, including young citizens-students, should have the opportunity to function effectively in the following life roles of the community:

"Citizen": to learn to act in a responsible manner; to learn of the rights and responsibilities of citizens of the community, state, nation, and world, and to learn to understand, respect, and interact with people of different cultures, generations, and races.

"Family Member": to learn of the rights and responsibilities of family members and to acquire the skills and knowledge to strengthen and enjoy family life.

"Individual": to develop the skills necessary for achieving fulfillment as a self-directed person; to acquire the knowledge necessary for achieving and maintaining physical and mental health and to develop the capacity for coping with change through an understanding of the arts, humanities, scientific processes, and the principles involved in making moral and ethical choices.

"Life-long Learner": to develop the skills of reading, writing, mathematics, spelling, speaking, listening, and reasoning and apply them in a context that creates a positive attitude toward learning.

"Consumer": to acquire knowledge and develop skills in the management of personal resources necessary for meeting obligations to self, family, and society.

"Producer": to learn of the variety of occupations; to learn to appreciate the dignity and value of work and the mutual responsibilities of employees and employers; and to learn to identify personal talents and interests, to make appropriate career choices, and develop career skills.

These life roles were taken from the Oregon State Education Goals whose goal is to assure that every student citizen shall have the opportunity to learn to "function" effectively in six life roles. Public school should provide developmentally appropriate participation during the school experience to accomplish this.

Educational Processes

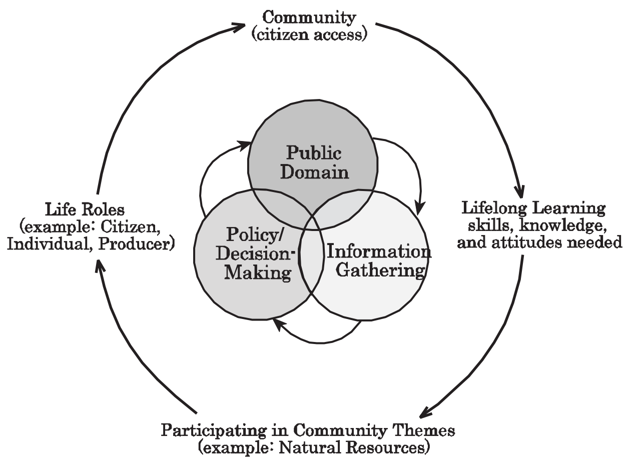


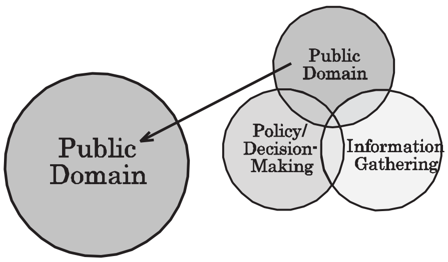
Figure 1 shows the community process on the outside of the diagram while the center circles are the instructional strategies used by educators that allow for student participation in those community processes.

Figure 1

This section of the manual will describe a process that can be used in selection of student experiences for your natural resources program. The focus is once again on the authentic participation of the student-citizen in the community processes. The graphic above provides an overview of this program/community process. Each circle or arena will be explained and an example will be used to clarify and showcase what the program processes look like.

The exchange of productive communication across each of the arenas in this model is the most critical element in building and maintaining a viable program. For effective program design, this model must support the development of skills and knowledge to ensure access for participation by young citizens in each arena.

Accessing the Community



In this arena, the community uses and manages natural resources in a variety of ways. Numerous agencies—city, county, state and federal—are responsible to carry out mandates and laws regarding the use and management of natural resources. Businesses, industry, and other community groups are also interested and involved in the use and management of natural resources.

POSSIBLE RESOURCES WITHIN YOUR COMMUNITY

Activities in the community that use natural resources are:

— Land Conversion
— Water Diversion or Use
— Agriculture
— Mineral Extraction
— Forestry
— Fuel Consumption
— Fisheries
— Industrialization
— Urbanization
— Recreation

The management or uses of natural resources in these activities is guided by laws and regulations, found in a variety of documents and agency mandates. Some public agencies that are involved in managing the use of our natural resources are:

— City Planning, Public Works, and Parks and Recreation Depts.
— County Planning Dept.

— U.S. and State Dept. of Fish and Wildlife
— Soil and Water Conservation
— Natural Resources Conservation Service
— Bureau of Land Management
— U.S. and State Forest Service
— Environmental Protection Agency
— Water Resources Dept.

Examples of documents that guide the use of our natural resources are:
— City and County Comprehensive Plans
— Forest Practices Regulations
— State Planning Goals
— Water Resources Planning
— Public Agency Plans
— Land Use Goals
— EPA Standards
— Business and Industry Regulations
— Land Trusts

The goal is to maintain healthy, sustainable ecosystems that provide both "goods" and "services" to the community.

—Ecosystem "goods" include:
—Food
—Medicinal plants
—Wild genes for domestic plants and animals

—Ecosystem "services" include:
—Regulating climate
—Generating and maintaining soils
—Maintaining hydrological cycles
—Providing sites for recreation and research
—Storing and cycling essential nutrients

CLASSROOM APPLICATION

For the educator, this is the entry point for most people in developing experiences and opportunities for students. The goal is to find a task or project the students have been invited to participate in by the community. There are a number of ways to have students enter this arena.

One way to start is by having the students do an inventory of their community to discover how natural resources are being used, who is in charge of managing the resources, and what documents determine how the resources are used and managed. From these documents there are always "invitations" to the community to become involved in some way. This is an open invitation to the student citizen to participate. In addition there is usually an education component to the plan and this is again another opportunity for student involvement.

There are several examples of public domain documents that can be showcased. These include state, county and city goals and plans. The state of Oregon has a document entitled *Oregon's Statewide Planning Goals and Guidelines*. Goal one is titled "Citizen Involvement," and states this priority: "to develop a citizen involvement program that ensures the opportunity for citizens to be involved in all phases of the planning process." The document goes on to specify citizen involvement and influence. Citizens are often called to be involved in data collection, inventorying, and mapping as specific tasks.

Polk County includes citizen involvement as one of its primary goals in its comprehensive plan. The plan states that "a strong citizen involvement program is felt to be essential to the success of the Polk County planning process." This includes "the formation and development of plans, maps, surveys, inventories, or other elements of the planning process." This provides the perfect entry point for authentic and contextual learning experiences for the student-citizen.

The City of Salem has numerous documents requesting citizen involvement. The Public Works Department is an example of this with operating documents that call for public education and participation. Schools are involved in collecting data and providing education on behalf of the city through the Stormwater Permit requirements and as part of the city's obligations for the Endangered Species Act.

These examples of state, county, and city documents can be found in every community throughout the United States. These are invitations for you and your school to become a resource for the community and will encourage the development of educational experiences that will involve students as citizens.

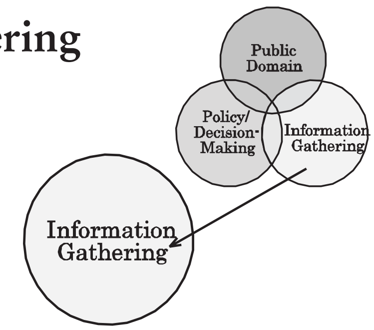
Educators themselves may want to conduct the community inventory beforehand and can themselves, or with student input, decide where an appropriate participation point may be. There are numerous ways by which you and your students can carry out an effective community inventory or assessment. One way is to create a community resource map. Through resource mapping you can identify community processes, needs, problems, and issues in your area. This process can help you identify possible project ideas and most importantly will help you make sure that you are doing what is actually needed by your community. Below are a series of questions that may help you start the community inventory or mapping. Ask these questions after you or your students have described in detail the area or site you are assessing. You may want to add or delete questions as you begin to discover more about your community.

- What natural resources exist at this site or in this area?
- Who lives, uses, or is affected by the area?
- Who manages the resources and by what laws, regulations, and rules?
- In what ways can citizens participate in the management of this site?

Often a survey or inventory of the community will reveal numerous opportunities for participation. A key feature in selection of an access point is that it is done in partnership with a group or agency that has invited your assistance in carrying out their mission. This "invitation" may come from the public documents that you have accessed or be a direct request from the agency or group. As your program becomes more established and well known in the community, numerous opportunities will be presented to you, and your school will become a valuable resource. Your class can be involved in helping those who use and manage natural resources reach their goals.

Contacting the resource users and managers involved and finding developmentally appropriate experiences that meet your program framework will engage students in the community process of natural resource use and management.

Information Gathering



INVENTORY/MONITOR/RESEARCH

The next step in the program process, after arranging authentic, developmentally appropriate student experiences in the community, is to conduct the research, survey or inventory, monitoring, or other tasks necessary to complete their work.

It is within this arena that the educator is most comfortable and familiar. This is where the necessary skills, knowledge, and attitudes are developed within the context of community participation. It is within this arena that the district, state, and national content standards are addressed. If these standards are important to our community, then schools should be able to find experiences in the community where these standards are needed or used. The selection of student experiences from the public domain needs to take these content standards into consideration. The content standards should be viewed as a means to an end and not the ends in themselves. Educators will need to use, modify, or create educational materials, activities, and labs that provide the information necessary to accomplish the task that has been selected. Traditional materials, texts, and labs may still be appropriate, but now are used in the context of solving a problem or completing a task in the community.

In addition, educators will need to access community resources and expertise. This often means that the educator is truly a facilitator—lining up and arranging resources, materials, and experiences from a variety of sources. Forming partnerships with the experts in the community will help both the educator and the students develop the necessary skills and knowledge.

In this arena, students may still study a chapter in a text on ecosystems or populations and do classroom activities and labs, but learning activities take place in the context of a real problem or project which they are working on in the public domain. In addition, content standards can be addressed in the selection of an appropriate project in the community. Lieberman and Hoody (1998) have shown that students actually perform better when the environment is used as the integrating context.

Examples of experiences that could fall within this arena are:

— Wetland inventories
— City and state park surveys
— Stream monitoring
— Estuary and beach monitoring
— Agricultural surveys
— Private land development monitoring
— Species diversity studies

Remember that these student opportunities are selected after the following has been done:

— Surveying natural resource use and management in the community
— Examining documents regarding the use and management of natural resources for an invitation to participate
— Forming partnerships with agencies, businesses, and industries associated with natural resources
— Considering what is developmentally appropriate and meets content standards for programs
— Involving students in decisions

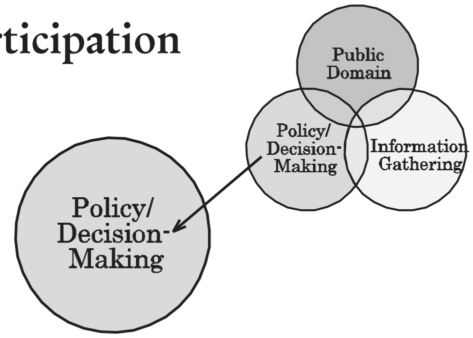
It is in this arena that the teacher can "show off" the educator skills they know so well. This is their area of real strength. However, as educators participate in the public domain and the policy decision-making arenas, they will need to form community partnerships since these are generally less familiar areas for them.

The lessons and activities included in this manual provide specific examples of how required content can be covered through community opportunities and experiences. The information gathering in the lessons is placed within the community context so students can learn as community participants.

Resource:

Lieberman and Hoody. 1998. Closing the achievement gap. www. seer.org

Community Participation



Upon completing monitoring and inventorying, the next step is to produce products useful at the community level. Participation by the student/citizen in the public domain is most often the piece missing from natural resource programs. If projects are selected from public domain documents, then the policy/decision-making bodies, agencies, businesses, industries and the rest of the community may want to know how things are going. The school, serving as a resource, can raise the awareness and capacity of the community by sharing their findings and information. This may take the form of presentations to policy/decision-making bodies as well as a variety of other community groups and educational institutions. Having students consider social, economic and ecological factors is an important part of this information dissemination and community renewal.

Providing public information through products such as signage and brochures can also be considered student products that impact policy and decision-making in the community. There may also be a variety of action items like tree planting or riparian restoration associated with the public products that allow students to develop a deeper and stronger connection to their community.

Some examples of participation and student products are:
—Presentations to various boards, agencies, organizations
—Interpretive information at study site (brochures, signage)
—Public information displays

By having students prepare materials for public use and participate in policy and decision-making processes, our educational institutions can better reach their mission of developing productive citizens.

EDUCATIONAL PROCESSES SUMMARY

In this section we have suggested a process of education that is similar to the process that occurs in communities. By accessing public documents, or being invited directly by agencies who operate by these documents, students become connected and engaged in the authentic experiences of community.

The learning and work students do now take place within the context of authentic community processes, and students now are viewed as a resource and as participants in these processes.

The products produced by the student-citizens can then be used to raise the awareness and capacity for change for the entire community. Modifications to current policy and decision-making can occur as students showcase their products.

In this arena, students may still study a chapter in a text on ecosystems or populations and do classroom activities and labs, but learning activities take place in the context of a real problem or project which they are working on in the public domain. In addition, content standards can be addressed in the selection of an appropriate project in the community. Research has shown that students actually perform better when the environment is used as the integrating context.

Depletion of Stratospheric Ozone

Abstract:
This unit is designed to have students apply the topic of stratospheric ozone depletion to a community context.

Age Group:
Grades 9-12

Time Needed:
If all five lessons are completed 6-10 days may be requireed. Refer to individual lessons for the time needed for each one.

Major Concepts:
Biosphere
Human Impact

Objectives:
Upon successful completion of this exercise, students will be able to:
- differentiate between tropospheric and stratospheric ozone
- understand natural ozone balance and the effect of halides
- determine the awareness of the ozone problem in the school community by developing and conducting a survey
- understand the alternatives to ozone-depleting chemicals
- create an outreach product for the benefit of and in partnership with the broader community

National Standards Addressed:
Science in Personal and Social Perspectives: Students should develop an understanding of personal and community health, natural resources, environmental quality, natural and human-induced hazards, and science and technology in local, national, and global challenges
Physical Science: Students should develop an understanding of structure and properties of matter, chemical reactions, and interactions of energy and matter

Teacher Background:
This unit is designed to take the conventional topic of stratospheric ozone depletion and have the students apply it practically in a community context. The students will go through the entire process of learning new information and then use that information to make a valuable difference in the community around them. Through this process students will not only learn the factual content of the topic but will also develop a number of analysis and assessment skills through applications. Students will be serving their peers as well as their broader community while working in partnership with established community organizations. The Environmental Protection Agency (EPA) as well as other state and local agencies and organizations are involved in monitoring our air quality and partnering with these groups would be an opportunity for students to be involved as citizens.

There are five lessons included in this activity. You are welcome to try all or select individual ones. Whatever is chosen it is important to note that forming partnerships with the community and reporting back to the community are essential elements of this activity.

The lessons appear below and student activities follow providing more detail.

LESSON I: ATMOSPHERE COMPOSITION
Student Activity:
Students learn the difference between tropospheric and stratospheric ozone by referring to the EPA publication listed below. This should provide a thorough background. A variety of student products can be generated from this information.
www.epa.gov/ORD/WebPubs/stratoz.pdf

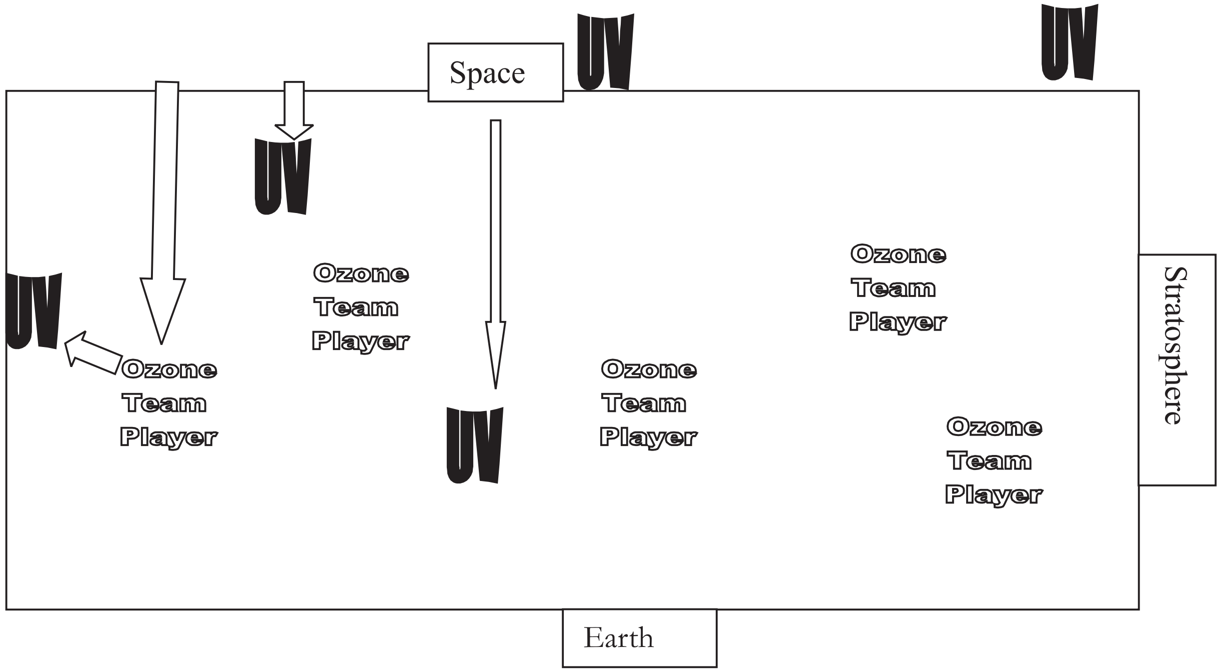
LESSON II: DECOMPOSITION OF OZONE
Student activity: "The Ozone Game"

LESSON III: EFFECTS OF INCREASED UV RADIATION
Refer to web pages listed below for background on UV radiation effects.
Background information on health related issues comes from the web sites listed below:
www.epa.gov/ORD/WebPubs/stratoz.pdf
www.nsc.org/ehc/sunsafe.htm
www.earthfiles.com/earth191.htm
Student activity: "Public Survey: Who Knew?"

LESSON IV: SOURCES OF HALIDES
Student activity: "Finding Alternatives"

LESSON V: WORKING TO IMPROVE OUR COMMUNITY
Student activity: "UV Health and Ozone Action Publication"

LESSON II: The Ozone Game



Introduction:
The objective of this activity is to understand natural ozone balance and the effect of halides on the ozone layer. This interactive game is designed to help students visualize an invisible process. The natural interaction of ultraviolet (UV) radiation and ozone, as well as chlorofluorocarbons (CFC's) and ozone are clearly illustrated by this game. It is best to provide the students with the basics of how the ozone and UV light and CFC's interact, play the game, and then discuss the implications of CFC use and sustainable industry.

Time Needed:
50 minutes

Materials:
Gym or playing field access
Flag belts
Signs for “”Earth” and “Sun”
Dry erase board for scoring

Procedure:

1. To begin playing the game, students are divided into two teams of equal numbers. One is selected to be the UV team first. These wear flag belts. Their goal is to cross from space to earth without losing a flag from their belt. The ozone team occupies the “stratosphere” playing field. Their goal is to prevent any UV players from reaching the earth by taking one of the flags from their belt.

The UV team scores based on how many reach the earth with both flags intact. Both teams may use the entire playing area.

After several runs, switch the roles so that the teams are playing the opposite roles. Switch the flag belts and run three more times. Allow teams to strategize to reach their goal.

2. Call students' attention and announce the score after three runs each. Describe the natural balance of ozone and UV with some getting through but most being absorbed.

3. At this point the CFC effect should be introduced. The UV team selects a fast member to be a CFC molecule for them. The CFC player has 30 seconds to tag as many ozone players as possible. These must leave the stratosphere. Then the game is begun again. Repeat this process two or three times so a majority of the ozone players is tagged out. Reverse the teams so all players have an opportunity for each role. Add up the scores and emphasize the effect of CFC's on the amount of UV radiation on Earth.

4. Safety concerns should be addressed. If there are enough flags, the each team should have their own to wear to save time and prevent physical contact. If there are not enough flags then tagging can be used by the CFC person to eliminate ozone players. Students should be prepared in advance to have appropriate footwear for vigorous activity. Students with unsafe footwear should not participate.

LESSON III: Public Survey

Introduction:
The objective of this activity is to determine the awareness of the ozone problem in the school community. The foundational element of individual safety with UV radiation is awareness. Does an individual know what is happening to them when they are exposed? Do they know what the risks are? Do they know what to do about it? These questions are important to answer affirmatively if a person is going to make conscientious decisions about appropriate exposure to the sun.

Since the students, after their lessons on stratospheric ozone and UV radiation exposure are now informed citizens, what is the next thing to be done? To inform their peers and community about healthy living is the goal, but the first step is to assess what the general understanding is already. If the public is already informed, there is no need for an educational step. To assess the need for ozone and UV education, a survey must be created, administered, and assessed.

Time Needed:
2- 50 minute periods

Materials:
Word processing and spreadsheet applications
Computer access
Candy or other token incentive

Procedure:

1. Develop the survey (45 – 60 minutes)
   Record on the board as the students brainstorm a list of all the things they think are important for people to know about the atmosphere, ozone, and UV radiation. The list should be exhaustive. Refine the list so there is minimal overlap between items. You should end up with between 15 and 30 "things to know". Assign each item to a student or group of students and have them create one or more questions that would assess a person's understanding of that item. When drafts of questions are complete, groups should review each others' questions to look for ways to improve. The goal is to create a question that cannot be answered correctly without knowing the answer. Once the students have finished their survey questions, they should be compiled into one form and copied.

2. Administer the survey (homework)
   During the following day after developing the survey the students will each receive 5 copies of the survey and 5 pieces of candy. They each are responsible for finding five people who will complete the survey (taking only a few minutes). The candy is an incentive for those taking the survey. It is important

that the students giving the survey do not prompt or assist them in answering the questions. A sample of more than 100 students can be made in a short time.

3. Assess the survey results (45 – 60 minutes)
   It is ideal to do this piece in a computer lab where students have access to spreadsheet software. It can also be done on graph paper or simply in a data table if materials are limiting. The goal is to create a bar graph comparing the number or percent of times each question was missed. Divide the students into small groups to create the graphs. Students then compare the graph to the survey to identify the topics that are the least and most understood. Have them create a list of the top ten topics that were missed. These are the target topics for the community outreach component.

LESSON IV: Finding Alternatives

Introduction:
The objective of this activity is to understand that although alternatives to ozone-depleting chemicals are available, these alternatives usually present challenges of their own.

Time Needed:
50 minutes

Materials Needed:
Samples of common packaging material types (e.g., polystyrene foam, inflated plastic, folded paper, cellulose, and shrink wrapped cellulose)
Beakers of water
Bricks (or other heavy object)

Procedure:
Group the students and give them samples of polystyrene foam, inflated plastic, folded paper and cellulose packing materials. (Any other available varieties will be useful as well). Give each group a beaker of water, and a brick. Have them list the potential problems of each kind of packing material and then choose which material they think is the best alternative to polystyrene.

When the students investigate they will eventually find that paper and cellulose are vulnerable to water damage, inflated plastic is non-renewable and is vulnerable to sharp object punctures.

After the students have listed the problems with each of the materials, have them suggest what they think is the best way to overcome the problems of the alternatives to polystyrene. "If some can't handle water, and some can't handle sharp things, what can we do to create packing material that will replace Styrofoam?" Groups brainstorm for 5 minutes and record their best solution.

Each group then presents their solution to the class. After all have presented, bring out a sample of shrink-wrapped cellulose packaging (typically used in shipping computers) as one of the more attractive alternatives to polystyrene. Why?

Concluding Emphasis – Alternatives are available, but challenges must be overcome to make them as successful as possible.

LESSON V: UV Health and Ozone Action Publication

Introduction:

The objective of this activity is to create an outreach product for the benefit of and in partnership with the broader community. The survey conducted by the students has identified the information that their peers are lacking regarding UV radiation, the ozone layer and their relationship to human health. Since your students are now informed citizens, the final step of citizenship is outreach. This means extending the valuable resource that you have (information in this case) and helping improve the quality of life for those in the community.

One way to extend information to the community is through published brochures/ pamphlets that can be distributed. The students will be the designers of the published material. The critical step at this point is to secure a partnership that will take the effort of the students and guide it into the mainstream community. This will maximize the effectiveness of the outreach, taking it from the realm of a "token activity" into the real world of participating citizens. A community partner can also help with the publishing component.

There are numerous potential partners who already have an established mission that is aligned with the purpose of your students' publication efforts. Below are a few examples with some excerpts from their mission statements that reveal their purpose as it affects the students.

County Health and Human Services Department

"The mission of Lane County Health & Human Services is to promote and protect the health and well-being of individuals, families, and our communities. Health & Human Services (H&HS) is a broad-based organization which oversees health, mental health, social services, and offender programs in a largely subcontracted system. The subcontract providers are our community partners in a complex service delivery system." http://www.co.lane.or.us/HHS/default.htm

American Cancer Society for Teens

"*The American Cancer Society Teens is a network of teen volunteers working to meet The Society's mission: eliminating cancer as a major health problem by preventing cancer, saving lives and diminishing suffering from cancer, through research, education, advocacy, and service.*" http://www.acsteens.org/purpose/

Local Clinics and Hospitals

"At McKenzie-Willamette Hospital, we believe that the community should have access to current health and medical information in order to gain more control over the quality of their own lives." http://www.mckweb.com/comlib.html

Time Needed:
Varies depending on depth of project.

Materials: Varies with projects.

Procedure:
Before the students design their publication it is essential to arrange the partnership. You need to establish an understanding of the desired outcomes or products of the partnership and more importantly, both parties must have an understanding of their respective responsibilities. In this situation you are looking for the community partner to assist in the publication and distribution of an informational piece designed by the students. The community partner may have specific media in mind. The students can design the product according to the needs of the community partner. A hospital may prefer a poster series, pamphlets, billboard, radio or TV ad. The media is not what is important. The critical goal is to have the students designing content for a particular media to inform the public about their health and ozone issues.

Once the media and approximate format are agreed upon with the community partner, the student's need to create the actual layout and content of the publication. Not every students' work can be published. It is possible that more than one would be published but generally the partner will be looking for one design. This means we need a way for all students to contribute to the design. If a student doesn't have some personal ownership in the final design, they will have no ownership in the outreach process either. A competition will not achieve this since only one or a few will be vested in the final product. There are a few ways to improve on this. One option is to divide portions of a designated design to groups and then assemble them into one feature. This is particularly effective for pamphlets which have numerous components such as a cover layout and varying internal sections. Another method for broad investment in one final product is peer editing and critiquing. Several drafts allow for comment and assistance from others. If one particular design is chosen, even those who did other designs had a part in helping shape the one that was selected. The selection process should be a democratic event with nominations and arguments for and against nominated designs. It is essential to frame the arguments in the context of what will best communicate the message to the audience, not just the most aesthetic. When a final design is selected, commend the entire contributing class for their part in shaping and driving the final product and reinforce how they will have a positive impact on many lives as a result of their efforts. The internal rewards of outreach far outweigh any external efforts we could apply. This is what will continue to influence students as they take their knowledge beyond the walls of their school.

Assessments:

Lesson I: Report, flyer, brochure or other student product. Information can be included in final publication as well.

Lesson II: Summary of game results with ideas learned. Again, this could be part of the final publication.

Lesson III: Design of the survey, data analysis, and presentation of results.

Lesson IV: Presentations of solutions

Lesson V: Published materials and community education efforts.

Resources:

www.epa.gov/ORD/WebPubs/stratoz.pdf
www.nsc.org/ehc/sunsafe.htm
www.earthfiles.com/earth191.htm

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Biology, Natural Resources

The Effect of Change on Ecosystems

Abstract:
Changes in ecosystems are studied through the analysis of two adjoining sites, one recently disturbed and one untouched. Comparisons of a variety of biotic and abiotic factors will highlight changes that have occurred in the disturbed area.

Age Group:
Grade levels 6-12

Time Needed:
This project will take place over a few months and may continue over a number of years. One day a week or one day every other week should be used to collect data from the chosen outdoor site. At the beginning of the lab, two or three days should be devoted to describe the project and review data collection methods. Data should be taken monthly and logged until enough data has been collected to complete the final documents.

Major Concepts:
Ecosystems
Succession

Objectives:
Upon successful completion of the exercise, students will be able to:

- analyze past maps, aerial photos, and/or GIS layers
- collect data by conducting soil testing, monitoring various abiotic factors, and inventorying plant and animal life.
- develop an environmental impact statement
- keep a field journal of their data and answers to questions posed.

National Science Standards Addressed
Science as Inquiry: Abilities necessary to do scientific inquiry
Life Science: Interdependence of organisms
Science and Technology: Understandings about science and technology
Science in Personal and Social Perspectives: Science and technology in local, national, and global challenges

Teacher Background:
Students will understand how environments that have been altered are changed through the analysis of abiotic and biotic factors of a recently disturbed area and a more natural and untouched area. Abiotic characteristics such as humidity, rainfall, temperature and sunlight can be monitored and compared between the two sites. Biotic factors such as vegetation and inhabitant species can be monitored as well. Organisms that once preferred a cooler, moister ecosystem are now subjected to changes in temperature, humidity and sunlight.

The location of this activity is important to the end result of the project. A site should be chosen that has undergone changes recently such as clear cutting, clearing for a new school, fire, landslides or logging. Choosing a site, which has an edge, will allow the students to make comparisons between the untouched ecosystem and the newly altered site. Try to find two sites that are similar in geography such as slope and sun exposure. If there is an edge near this site, this will be the best location to collect data. The more fragmented area has become the more edges that exist.

By comparing recent and past aerial photographs of the chosen sites students will be comparing and contrasting factors such as vegetation type and coverage as well as other events such as erosion. By examining the aerial photographs or using Geographic Information Systems (GIS) students will be able to identify areas which have lost trees or foliage due to the disturbance (logging, clear cutting, fires, landslides and volcanoes).

It will be absolutely essential that you find partners in the community to assist in this effort. A number of city, county, state, and federal agencies and organizations will have this expertise and equipment and are usually eager to help out. Contact them at the beginning of the project, as they will have a variety of suggestions on how to proceed and carry out your work. They can also assist students in completing the environmental impact statements, and the other abiotic and biotic monitoring and inventorying you will be doing.

The study site should be divided into areas for sampling so that as much as 5-10 acres is represented by the study. Students will be broken up into groups and assigned a section to sample. Samples should be taken from an edge between the two areas and in 10 yard increments moving directly away from the disturbed site as well as into the natural area.

Students will produce a groundwork EIS (Environmental Impact Statement) at the end of their extensive study. It will include specific measures designed to minimize the environmental, economic and cultural impacts of the changes on the ecosystem. This document ensures that all environmental impacts of the change to the ecosystem will be recorded and documented. The document that the students will produce will prove to be useful in many ways to the community in which the study is conducted. In many cases, schools are altering land to build new schools. These studies will be a useful tool for the school board, planning commission, local soil and water conservation districts, maintenance departments and/or to present at township or city council/rotary club meetings. There will be a rubric included that the students can follow to be as thorough as possible in their study.

Students should be expected to keep some type of a field notebook or journal of their work. You may have them answer a variety of content type of questions in this as well to check to see if they understand the scientific process or content material you want them to know.

The end result of all this work should be student products that provide some type of feedback to the community. These can take a variety of forms from presentations with *PowerPoint* to brochures and posters. In addition, the class may want to take on the restoration of their site or another like it in order to reestablish the natural diversity. This will produce a more aware and informed citizenry for future decision-making.

As a caution this project may seem overwhelming to anyone undertaking field studies and community involvement. You may want to pick out individual pieces of this activity to pursue. Small successful steps can build into a larger continuing project.

Introduction:

Ecosystems transformations are inevitable. They define and change the way that we all live. Human activity is changing the ecological role of Earth's ecosystems at a faster rate than at any time in the last 65 million years. As an example, forest ecosystems provide habitats for more species of flora and fauna than any of the earth's ecosystems. A well-grown forest is earth's primary biodiversity reservoir. They are a key component in global biogeochemical cycling. The economic consequence of cutting one tree down equates to $200,000 worth of oxygen production, air and water cleansing, habitat provision, soil fertility and erosion control. That same tree will be sold as timber on the commercial market for no more then $600. Through this activity you will become aware of the impact that our human activities are having on local ecosystems.

Since most species cannot generate their own nitrogen or obtain it from the atmosphere, they must rely on nitrogen compounds from soils. Organisms require nitrogen to make proteins, DNA, RNA, and other organic compounds. Multi-cellular organisms cannot directly use the nitrogen in the troposphere. Cyanobacteria in soils and water are required to turn nitrogen into a water-soluble ionic compound, which can then be absorbed through root systems and made available to consumer organisms. Nitrogen, soluble nutrients, and minerals are quickly lost through altered ecosystems. Mosses, lichen, and ferns when exposed to the sun decay and enrich the soil with nitrogen they fixed from the air. When these are present, it is a conclusive indicator that an ecosystem is nourishing its components. Nitrogen is one of the most important nutrients for regeneration. This nutrient availability will directly affect abiotic and biotic factors and in turn the inhabitant species.

Minerals and nutrients dissolve in rainwater and are many times are carried away by runoff. This newly exposed soil is now filling creeks, rivers and bays with silt and increases river sedimentation. New plant communities cannot reestablish themselves easily in areas where land has been depleted of soil nutrients. The loss of this vegetation and extensive root systems are no longer slowing erosion of soil and nutrients. This can be identified through analysis of aerial photographs or through GIS.

Materials Needed:

Aerial photographs or GIS info on the chosen areas (two maps will be needed, the most recent published and one at least published 20 years earlier)

Maps of your area are available through:

USGS
MS804 National Center
Reston, VA 20192
http://internet.er.usgs.gov/usgshome.html

Soil probe or auger (spade or a shovel)

Clean plastic containers

Overhead grids (graph paper copied onto a clear overhead)

Soil Test Kit (LaMottes)

Internet access (to monitor humidity and rainfall from local weather stations, NOAA or local and regional weather bureaus) http://www.nws.noaa.gov

Thermometers

Field guides http://www.enature.com

Procedures for Activity:

1. Examine the two sites.
   a. Describe how the one ecosystem has been disturbed.
   b. Show in a web diagram or in writing what you think happened to the organisms that were once there
2. Compare and contrast GIS or aerial photographs of the area that you have chosen to study. If you are using aerial photographs lay down the overhead grid over the photograph from at least 20 years ago. Trace the area of foliage and the river systems. Lay the same grid over the most recent aerial photograph, trying to align geographical features. Trace the newly cut areas (newly cut areas appear lightest in color and new growth appears light gray with well grown forests being the darkest spots on the map). Count the boxes that were once dark in color but have now been altered.
   a. Evaluate river systems, waterways and stream banks to show any changes between them on the two maps. Have the streams, rivers, lakes and banks changed in anyway? If yes, how might this affects the nutrients in the soil of the areas that you are studying?
   b. How does vegetation and extensive root systems slow erosion? How can a man make structure slow erosion rates?
3. Data Collection. Gather soil samples and examine abiotic and biotic data.
4. Produce a product or project that can be delivered tothe community, such as an environmental impact statement.

DATA COLLECTION

Soil collection procedures:

- Atypical areas should be avoided when collecting soil samples, such as old fence lines, old lime or old manure piles, windbreaks, snow fences, wet sites, dead and back furrows, regions near lime-rock roads and borders between bottomland and gradients.
- When collecting soil samples, use a soil probe or auger, when possible. These tools facilitate sampling uniform depths and quantities of soil. If these tools are unavailable, a spade or shovel may be used.
- Soil sub samples should be combined thoroughly to make up a representative sample for each area.
- Samples should be placed in a clean plastic container and labelled, as metal receptacles may lead to erroneous results and paper bags may contaminate the soil.
- Soil test kits may be purchased from a variety of science suppliers. (LaMotte)
- The standard soil tests will provide analysis of nitrate-nitrogen (NO3-N), phosphorous (P), potassium (K), soil moisture, and soil pH.

Abiotic Data:

- Keep data on the humidity and rainfall of the area over the extended period of the study (www.nws.noaa.gov)
- Keep data on temperature (readings taken at ground level, one meter above ground level and two meters above ground level)
- Keep data on the sunlight recorded: sunny, partly sunny and not sunny

*How did the soil compare at each of the sites.

Biotic Data:

- Keep data on plant and animal species
    - * Keep data on low grass, high grass, forested or scrub grass populations
    - * Keep data on what organisms were observed over the period of the study
- Report your data to the class in an informal presentation yet, one that should in clude data and graphs of your findings.
- List all the environmental characteristics that you think would be most suitable for a healthy ecosystem in your chosen location?
- If a developer constructed a paved road straight through this site, what impact might the road have on the sites suitability for its inhabitant species and ecosystem?
- When visiting new construction sites, what erosion control methods are they us ing? Evaluate the methods effectiveness.
- In what ways does light and nutrients determine the course of succession?
- How long do you estimate that it takes an ecosystem such as the one that you are studying to return to it natural state, taking climate conditions and plant species into account?

ENVIRONMENTAL IMPACT STATEMENT

Write a groundwork environmental impact statement by following the rubric and the following guidelines.

Site description:

- Topography, geology and description of superficial deposits
- Climatology of area
- Vegetation of area
- Fauna of area

Project Description:

- Possible impact on fresh water, superficial and groundwater
- Plans for minimizing negative environmental impacts
- Plans for sit restoration
- Report on public consultation
- Environmental follow-up and monitoring

*Present EIS to community partners

Assessment:
A variety of assessments can be given from the field work and data that is collected to community products and presentations. Below are some rubrics that can be used for questions and data collected for the Field Journal and for the EIS.

Rubric for assessment

Questions	6 points	4 points	2 points	Zero points
Describe how the ecosystem has been disturbed? (Procedures 1a)	You clearly explained your hypothesis to how the ecosystem has been disturbed.	You roughly explained your hypothesis to how the ecosystem has been disturbed.	You weakly explained your hypothesis to how the ecosystem has been disturbed.	You did not meet the requirements of this question.
Show in a web diagram or in writing the probable fate of the ecosystems organisms and what you think has happened to the soil. (Procedures 1b)	You expressed your thoughts clearly in your web or writing about the probable fate of the ecosystem and what has happened to the soil.	You expressed your thoughts clearly in your web or writing about the probable fate of the ecosystem and what has happened to the soil.	You expressed your thoughts clearly in your web or writing about the probable fate of the ecosystem and what has happened to the soil	You did not meet the requirements of this question.
Procedures 2a	You clearly explained how streams, rivers, lakes, and banks have changed and how this affected the nutrients in the soil of the areas that you are studying.	You roughly explained how streams, rivers, lakes and banks have changed and how this affected the nutrients in the soil of the areas that you are studying	You weakly explained how streams, rivers lakes and banks have changed and how this affected the nutrients in the soil of the areas that you are studying.	You did not meet the requirements of this question.
Procedures 2b	You explained clearly how vegetation and extensive root systems slow erosion and how a man made structure can slow erosion rates.	You explained roughly how vegetation and extensive root systems slow erosion and how a man made structure can slow erosion rates.	You explained weakly how vegetation and extensive root systems slow erosion and how a man made structure can slow erosion rates.	You did not meet the requirements of this question.

Data Collection	15 points	10 points	5 points	Zero Points
Data Logged of both sites	Your group used good lab technique, kept accurate records and logged findings of the biotic or abiotic factors.	Your group used acceptable lab technique, kept accurate records and logged findings of the biotic or abiotic factors.	Your group used deficient lab technique, kept accurate records and logged findings of the biotic or abiotic factors	You did not meet the requirements of this question.
Soil comparisons	You accurately compared the soil at each site.	You compared the soil at each site.	You inaccurately compared the soil at each site.	You did not meet the requirements of this question.
Report data to the rest of the class in an informal presentation. Include data and graphs	Your report included adequate data to help the class determine what would make the ecosystem suitable for the native organisms by showing graphs of your findings.	Your report included moderate data to help the class determine what would make the ecosystem suitable for the native organisms by showing graphs of your findings.	Your report included deficient data to help the class determine what would make the ecosystem suitable for the native organisms by showing graphs of your findings.	You did not meet the requirements of this question.
List environmental characteristics suitable to healthy ecosystem	You thoroughly listed all the environmental characteristics that you think would be most suitable for a healthy ecosystem in your chosen locations	You listed most the environmental characteristics that you think would be most suitable for a healthy ecosystem in your chosen locations	You listed some of the environmental characteristics that you think would be most suitable for a healthy ecosystem in your chosen locations	You did not meet the requirements of this question.
Impact of a paved road	You described clearly what impact a paved road might have on the sites suitability for its inhabitant species and ecosystem.	You described what impact a paved road might have on the sites suitability for its inhabitant species and ecosystem.	You tried to described clearly what impact a paved road might have on the sites suitability for its inhabitant species and ecosystem.	You did not meet the requirements of this question.
New construction erosion control methods	You explained clearly what erosion control methods new construction is using.	You explained what erosion control methods new construction is using.	You either explained the erosion methods focused or their effectiveness	You did not meet the requirements of this question.
Light and nutrients affect on succession	You described clearly ways that light and nutrients determine the course of succession	You described ways that light and nutrients determine the course of succession	You described poorly ways that light and nutrients determine the course of succession	You did not meet the requirements of this question.
Estimate time for ecosystem restoration	You estimated how long it takes an ecosystem such as the one that you are studying to restore itself by providing evidence.	You estimated how long it takes an ecosystem such as the one that you are studying to restore itself by providing some evidence.	You estimated how long it takes an ecosystem such as the one that you are studying to restore itself but did not provide evidence.	You did not meet the requirements of this question.

Rubric for EIS

Description of objective	6 points	4 points	2 points	Zero points
Topography	You provided a visual or a great description of the topography of the site.	You provided a short description of the topography of the site.	You provided minimal information about the topography of the site.	You did not meet this requirement.
Geology	You provided clear information on the formation of the area of your study.	You provided information on the formation of the area of your study.	You provided minimal information on the formation of the area of your study.	You did not meet this requirement.
Rock, minerals, bedrock	You provided extensive information on the soil and bedrock of the area.	You provided information on the soil and bedrock of the area.	You provided minimal information on the soil and bedrock of the area.	You did not meet this requirement.
Climatology	You provided extensive data and trends of the climate of your area during your study.	You provided data and trends of the climate of your area during your study.	You provided minimal data and trends of the climate of your area during your study.	You did not meet this requirement.
Vegetation	You provided extensive information from the study on low grass, high grass, forested or scrub grass populations	You provided information from the study on low grass, high grass, forested or scrub grass populations	You provided minimal information from the study on low grass, high grass, forested or scrub grass populations	You did not meet this requirement.
Impact of surrounding water sources	You included a hypothesis and extensive data on the state of the watersupply at your study site.	You included a hypothesis and data on the state of the watersupply at your study site.	You included a hypothesis and minimal data on the state of the watersupply at your study site.	You did not meet this requirement.
Minimizing negative effects	You included a extensive plan on minimizing the negative effects of the disaster on the ecosystem and soil.	You included a plan on minimizing the negative effects of the disaster on the ecosystem and soil.	You included a minimal plan on minimizing the negative effects of the disaster on the ecosystem and soil.	You did not meet this requirement.
Plans for reconstruction	You included significant evidence and a plan to aid in the native species returning to your test site.	You included evidence and a plan to aid in the native species returning to your test site.	You included minimal evidence and a plan to aid in the native species returning to your test site.	You did not meet this requirement.
Public Consultation	You have an extensive plan to share your information with your community partners and have included visuals with data.	You have a plan to share your information with your community partners and have included visuals with data.	You have a minimal plan to share your information with your community partners and have included visuals with data.	You did not meet this requirement.

Extensions:

- There are a variety of community products that could be produced such as developing a web site, a video, and brochures.
- Establish the sites as long term ecological study sites. Document changes over a number of years. Develop a photo record of the sites throughout the year and from year to year.
- Develop a restoration project at a disturbed site that can restore it more quickly to its natural state.

Resources

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Aliens Among Us

Abstract:
The study of populations and related concepts is central to a unit on ecology. Exploring these ecological principles in the context of real life environmental issues can further promote student understanding. Invasive plants represent a real and present threat to our natural areas. Providing students with authentic learning experiences dealing with such species can serve to enhance student comprehension of ecological concepts, while providing opportunities for them to function as members of their community.

Age Group:
Grades 9-12

Time Needed:
1 – 4 periods, or longer, as part of an ongoing research partnership

Major Concepts:
Competition
Predation
Biomass
Crowding
Exponential and logistic growth

Objectives:
Upon successful completion of this exercise, students will be able to:

- conduct an authentic scientific investigation and develop an understanding of the process of science
- convey their findings to the community
- describe factors that limit population growth
- describe the ecological impact of invasive plants

National Standards Addressed:
Science as Inquiry: Abilities necessary to do scientific inquiry, Understandings about scientific inquiry
Science in Personal and Social Perspectives: Natural resources, Environmental Quality
Life Science: Interdependence of Organisms

Teacher Background:
The study of populations is a traditional piece of a unit on ecology. Hands-on field experiences examining populations in a given environment can provide students with an opportunity to observe and learn essential concepts in population studies, such as: density-dependent limiting factors (competition, predation, parasitism, and crowding), trophic levels, roles and niches, demographics (birth/death/growth rates), biomass and community interactions while allowing them to utilize basic scientific research procedures to observe common living plants and animals. Having students collect, organize, summarize and, report such information to an interested audience can make the learning experience more meaningful. Research has shown students to be more attentive to protocols and detail when the data collected are being used in an authentic manner.

Introduction:
Limiting factors are environmental factors that stabilize populations and keep species from reaching their biotic potential. Limiting factors that come into play as population density increases are called density-dependent factors. Such factors for plants may include sunlight, space, water, and soil temperature and nutrients. Invasive plants are often successful in out-competing natives for these factors.

Although public awareness lags behind, invasive plants have been identified as major contributing factors for decline and endangerment of many species in North America and around the world. As introduced plants expand their range and increase in abundance they are able to out-compete native plants. Associated with these changes in plant communities are changes in ecosystem processes, species diversity and abundance.

The loss of natural habitats to settlements and modern agriculture in combination with the range expansion of invasive species and associated changes in plant communities are the largest threat to the integrity of our natural ecosystems. It is estimated that in the US alone invasive plants infest over 100 million acres and continue to expand their range by 8-20% annually (twice the size of the state of Delaware).

Materials:
1-meter square frames (PVC piping or meter sticks)
Clipboards
Pencils
Data sheets

Procedure:
Before hand, make contact with your local natural resource management agencies (e.g., Wildlife/Forest preserves, Public Works Departments, Soil and Water Conservation Districts, Department of Natural Resources, U.S. Fish and Wildlife Service) and inquire about ongoing invasive plant programs. Such organizations may be interested in having your students assist with data collection, conducting a survey or plant removal, particularly if a new invasive plant has been spotted. Partnering with such agencies will give your fieldwork more relevance and purpose. It may also provide you and your students with access to experts, equipment and, established protocols. If such partnerships are not available or, are logistically impossible, check with your local public library, garden club and/or elementary schools for an audience interested in having your students report back to. Your students can then produce products (brochures, posters, power point presentations) that summarize their findings while educating others.

Preliminary Research
You may wish to have students begin by conducting some preliminary research on the topic. You might assign the following questions to individuals or groups of students. Information can then be shared, discussed and studied before moving ahead.

Possible research questions:

- Why is biodiversity an integral component of a healthy functioning ecosystem?
- What invasive species are found locally?
- How can invasive species alter fire, hydrologic, carbon or nutrient cycles?
- How can native plants prevent erosion, improve water quality or provide for animals?
- What limiting factors can be imposed by invasive species?
- What are some means of controlling invasive plants? What are the pros and cons of such techniques? (Fire, cutting, mowing, flooding, herbicide, biological control)
- What are protocols? Sampling methods? Data collection? Why is standardization important?

Data Collection
Select a site that is feasible and of interest to you and your students and/or partners. Unless guided by protocols and requests from a partnering agency, have students construct their own protocols (consistency and documentation are important). If possible, select four distinct areas (sunny, shady, dry, wet, slope...) within your site, to place the 1-meter square frames. Data collected may include: Date, time, location, temperature, weather conditions, type of area (wetland, meadow, forest, or ditch), plant species present and their counts (when stem density is low enough to count) or percent ground cover of each species (when stem density is too great to count). Students may also check for patterns in distribution and abundance of given plant species, whether the soil is virgin or disturbed, animal species present, and percent cover of rocks, soil and, organic debris (wood & leaf litter).

Data Analysis

Using the data collected, students can generate a variety of maps and graphs (habitat type/ percent cover invasive plant species; number of different native species in areas without invasives/with invasives: percent cover invasives in disturbed areas/undisturbed areas) to summarize their findings. Frequency tables and other simple statistical calculations can also be computed. Students may wish to look for strong correlations between areas with high invasive plant densities and other specific environmental factors (disturbed soil, proximity to other invasives). Conversely, one may wish to examine which environmental factors have stronger correlations with native plant communities as compared to those plant communities dominated by invasives. Such analysis techniques will assist in data interpretation and, may stimulate students to make their own hypotheses and, consequently, develop their own experiments or studies to address those questions.

Assessment:

If partnering with a natural resource agency or organization, your students will be collecting, summarizing and presenting authentic and needed data. You may also wish to have students share their findings at school/town board meetings, or other public hearings. Such presentations may include poster exhibits, PowerPoint presentations, slide shows, pamphlets and such. Letters to the editor can also be sent to local newspapers and/or to a district newsletter if one exists.

In addition to the presentation of data collected, emphasis should be made to educate the given audience regarding the threat invasives pose to biological diversity in general and, to local native communities specifically. The limiting factors involved in the decline of native species should also be addressed. Finally, possible efforts to remove, eradicate, or prevent the spread of local invasive plant species should be discussed.

Extensions:

- Have students write letters to the editor, give public presentations, or create informational brochures that describe their findings
- Have students conduct additional research and conduct community workshops on the issue of local invasive plants and potential solutions
- Have students organize and conduct local invasive plant removal efforts
- Have students keep a journal that documents how the community interacts with the invasive plant population they have
- Discuss the concept of carrying capacity and limiting factors in the context of conservation

Extended Collaboration

Student-teacher-scientist partnerships are unique collaborations that offer a win-win opportunity for research scientists, teachers and their students. Student collected data on the distribution and abundance of a particular invasive species can be of value to research scientists studying their population dynamics. Locally collected data can be shared with such partners, increasing the significance of the student's efforts.

Resources

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Effects of Increased Atmospheric CO_2 on Photosynthesis and Cellular Respiration in Plants

Abstract:

Atmospheric CO_2 is produced by processes as diverse as the decomposition of organic materials in wetlands, volcanic eruptions and the burning of fossil fuels. This activity examines the effect of increased atmospheric CO_2 on photosynthesis and cellular respiration.

Age Group:
Grades 9-12

Time Needed:
Five 1-hour lab periods. If you are not using grass plots that have already been established, this lab requires approximately 3 weeks total time to allow for plant growth.

Major Concepts:

Photosynthesis
Cellular respiration
Regulation of cell functions by outside stimuli

Objectives:
Upon successful completion of this exercise, students will be able to:

- identify the chemical equations for photosynthesis and cellular respiration
- describe the correlation between CO_2 and rate of photosynthesis
- measure CO_2 levels
- measure net primary productivity
- understand the mathematical relationship between net primary productivity, gross primary productivity and cellular respiration

National Standards:
Life Science: The Cell

Photosynthesis and cellular respiration
Regulation of cell functions by external stimuli

Teacher Background:
This is an ideal project to partner with government agencies (e.g., EPA, state agriculture departments, county soil and water conservation districts) interested in atmospheric CO_2 levels.

Atmospheric CO_2 is produced by both natural and human-driven processes. The decomposition of organic materials, volcanic eruptions, forest fires and the burning of fossil fuels all contribute to the concentration of CO_2 in the Earth's atmosphere. The relationship between global temperature and atmospheric levels of CO_2 has been well-studied and debates continue about the consequences of human-induced climate change as a result of elevated CO_2 levels. Rising sea levels, increased extinction rates and more devastating storms have all been proposed as potential impacts. Some consequences, however, could be beneficial. For example, since CO_2 is a raw material for photosynthesis, higher CO_2 concentrations may result in enhanced growth for some plants including agricultural crops. As a result, fewer fertilizers may be needed to achieve the same amount of production. This may result in an environmental benefit since runoff of commercial fertilizers from agricultural lands has been shown to be a major source of water pollution .

Informing the community of areas of high atmospheric CO_2 would allow them to reduce their fertilizer use and reach the same desired result. For example, a golf course near a high traffic area could reduce the amount of fertilizer applied due to the additional atmospheric CO_2 from combustion of fossil fuels. This could reduce the amount of nitrates and phosphates reaching the watershed from runoff.

Introduction:
The **gross primary productivity (GPP)** of an ecosystem is the rate at which solar energy is captured during photosynthesis and is stored in the form of carbohydrates. GPP is typically measured in units such as the amount of carbohydrate produced per unit area per unit time (e.g., grams/square meter/week). We also know that plants, like other living organisms, must carry on **respiration (R)** to provide energy for life processes such as growth, reproduction and metabolism. This uses some of the energy originally produced by photosynthesis. The energy that remains in plant tissues after respiration has occurred is called **net primary productivity (NPP)**. NPP therefore represents the rate at which organic matter (**biomass**) is actually incorporated into plant tissues to produce growth. The relationship can be expressed as follows:

net primary productivity = gross primary productivity - plant respiration
(plant growth) (total photosynthesis)

Only the energy represented by NPP is available for consumers, and of that energy only a small portion is actually used by them. Both GPP and NPP can be measured as either "energy per unit area per unit time" (e.g., kilocalories/m^2/week) or "dry mass per unit area per unit time" (e.g., grams/m^2/week).

In this lab you will determine what impact, if any, elevated atmospheric CO_2 levels, have on NPP (plant growth) and cellular respiration (R). This will be done by growing plots of grass under different CO_2 levels and comparing their productivity.

Background for calculations:
The process of photosynthesis uses solar energy to convert carbon dioxide and water into carbohydrates. Oxygen gas is produced as a byproduct. The reaction is summarized by the reaction:

$$6CO_2 + 6H_20 + energy \longrightarrow C_6H_{12}O_6 + 6O_2$$

Photosynthesis provides the fuel (carbohydrate) for cellular respiration which is nearly the reverse of photosynthesis. The energy resulting from respiration is used to drive all life processes such as growth and metabolism. Cellular respiration may be summarized by the reaction:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_20 + energy$$

Note that CO_2 is *consumed* by photosynthesis and *produced* by respiration.

To Summarize:

Net primary productivity (NPP) – the amount of carbohydrate that accumulates as plant growth after respiration

Gross primary productivity (GPP) – the total amount of carbohydrate produced as a result of photosynthesis

Plant respiration (R) – the amount of carbohydrate that is used during cellular respiration to produce energy

$$NPP=GPP-R$$

Photosynthetic rates, and thus GPP, are highly dependent upon the amount of solar energy available. Tropical areas are generally more productive than temperate areas and GPP is higher on clear, sunny days than on cloudy days. Not *all* solar radiation, however, is used by plants to drive photosynthesis. That portion of solar radiation that *is* used in photosynthesis is referred to as **photosynthetically active radiation (PAR).** PAR can be used as an approximation for GPP.

Total Photosynthesis Calculation:
The solar radiation constant is 2.0 cal/cm^2/minute or 28800 kcal/m^2/day. Not all of this reaches the Earth's surface, however. The atmosphere absorbs approximately 18% of this energy and about 21% is reflected back into space by clouds.

Calculating weekly photosynthetically active radiation (PAR) available:

- Measure daily PAR
- Account for percent of reflected and absorbed light by multiplying the daily PAR by the percents above for solar energy absorbed (18%) and reflected (21%) and subtract these from the total daily value. This is your actual PAR for the day.
- Repeat the process for each day and add the seven values for the week together to obtain your weekly PAR.
- As indicated above, PAR can then be used as an approximation for GPP

Sample Calculation to Determine Respiration (R):
Weekly PAR is estimated to be 544320 kcal/m^2/week. This value can then be plugged into the mathematical relationship between GPP, NPP and R:

$$GPP - R = NPP$$

resulting in:

$$544320 \text{ kcal/m}^2\text{/week} - R = NPP$$

If we have an estimate of NPP, then R can be determined by solving the simple equation above. Recall that both GPP and NPP can be measured either as energy (kilocalories/m^2/week) or dry mass (grams/m^2/week). NPP will be determined by direct measurement of the biomass that accumulates over time on a sample plot and will be expressed as "grams/m^2/week".

Materials
For measuring atmospheric CO_2 levels:

- Containers for water reservoirs (the more surface area the better) 2 per plot. The water reservoirs need to be at least 10 cm X 10 cm X 10 cm, plastic milk jugs work well.
- 30 ml test tubes-1 per CO_2 sample
- Phenolphthalein indicator solution
- Sodium hydroxide (NaOH needs to be pure and free of carbonates that would interfere with accurate results)

For Measuring Net Primary Productivity:

- Digital or triple beam balance
- Drying oven or other means of drying samples
- Drying paper or large beakers
- Grass seed of several different species
- Lightweight potting soil
- Drying paper or large beakers
- Materials to make flats for sample plots (if flats are used)

Procedures:

Overview:

At least two study sites with different CO_2 levels will be selected. Net primary productivity will be estimated by measuring the amount of grass biomass that accumulates over one week at each site. Two grass plots are established at each study site. The grass biomass (dry weight) of the first plot is determined and then, one week later, the second plot is harvested and weighed. The difference between these two dry weights is an estimate of plant growth or net primatry production. If PAR is used as an estimate of gross primary productivity (GPP), two of the three terms in the equation, GPP – R = NPP are known and respiration (R) can be determined by subtraction.

Selection of Study Sites:

Two study sites should be selected - one near a high traffic area and another more remote and isolated from heavy traffic. You could also select sites that your community partner has an interest in monitoring for CO_2 levels.

Establishing plots:

Two plots of planted grass must be established for each study site. Plots may either be established in the field or in "planting flats" which are then placed in the field. Flats may be constructed from a variety of materials (10 cm X 10 cm, works well) or commercial flats can be used. Be sure to measure the area of the flats and make appropriate adjustments in your calculations.

1. Mark off 1 meter x 1 meter plots, two at each study site.
2. Prepare plots for planting grass seed.
3. Count out the number of seeds you wish to plant, for each sample plot. Use planting guidelines provided with the seeds to estimate the appropriate seed density for your plot size. All plots must have the same number of seeds planted.
4. Record your plot size (in m^2) and number of seeds used per plot.
5. Spread the seeds evenly over the plot and cover with a thin layer of potting soil.
6. Water the plots as needed with identical amounts of water for the next two weeks. The grass should be 7-10 cm tall before the actual experiment begins.

Measuring atmospheric CO_2:

Carbon dioxide levels at each test site must be estimated to determine which sites have "elevated CO_2 " and which do not. If available, a CO_2 monitoring device may be used to measure CO_2 directly. Otherwise, atmospheric CO_2 levels may be estimated as follows:

1. At the time of planting, place water reservoirs in or next to plots. Reservoirs can be submerged to ground level.

2. After one week, siphon 25 ml water from just below the surface of the water reservoirs.

3. Place water sample in test tube and add one drop of phenolphthalein indicator solution to sample.

4. Add the sodium hydroxide solution drop by drop to the sample. Count each drop as it is added. Swirl the test tube to mix after each drop is added. Continue adding drops until a light pink color forms, and persists for at least 30 seconds.

5. Each drop of sodium hydroxide solution used equals 1.25 mg/l carbon dioxide.

6. Multiply number of drops by 1.25 mg/l to determine CO_2 concentration in mg/l.

Measuring net primary productivity:

1. Calculate weekly PAR at each plot. (See data table)

2 From one plot (we'll call these "#1 plots") at each sample site carefully remove the entire grass plants from the soil. Remove as much of the soil from the plants as possible trying to keep all roots intact.

3. Carefully rinse off any remaining soil from the roots and gently shake off the excess water. Place the plants on drying paper or in a large beaker, and label with plot number and grass species.

4. Place all samples in the drying oven for seventy-two hours (3 days). Continue to water the second plots (we'll call these "#2 plots") at each site as before. These will be pulled and dried after an additional week of growth.

5. After the 3-day drying time, remove the samples from the drying oven and let them cool. When cool, weigh each sample and record these weights as **starting dry weight** in the appropriate place in TABLE A.

6. One week after you removed the #1 plots, repeat steps 2 through 5 above for the #2 plots.

7. Record these weights as **final dry weight** in the appropriate place in TABLE A.

CALCULATIONS

1 Determine PAR and use as an approximation for GPP. Enter these values in TABLE B.
2. Determine NPP by subtracting "starting dry weight" from "final dry weight" for each grass plot. Enter value for NPP in TABLE B
3. Determine R using the known mathematical relationship between GPP, NPP and R. Enter value for R in TABLE B.

SAMPLE CALCULATION

An experiment is conducted as described above at two sites. Site A is a “high CO_2 site” and Site B is a “low CO_2 site”. Weather was clear and sunny throughout the experiment and photosynthetically active radiation (PAR) is determined to be 544,320 kcal/m²/week. This value would be reduced by 10% if partially cloudy and by 20% if cloudy. This value will be used as an approximation for GPP.

Net primary productivity (NPP) will be determined by measuring the amount of biomass that accumulates over one week in plots that have been planted at each of the two sites. Two 1 m^2 plots have been planted at each site. Two weeks after planting, the #1 plots have grown sufficiently to harvest and **starting dry weights** are obtained. One week later, the #2 plots are harvested and **final dry weights** are obtained. Data are recorded as follows:

Site Identification	Final dry weight (g)	Starting dry weight (g)	*NPP (g/m2/week)
Site A	60,000	20,000	40,000
Site B	55,000	18,000	37,000

* NPP is obtained by subtracting the starting dry weight from the final dry weight as illustrated in the table

Since both GPP and NPP are now known for each site, respiration (R) can be determined by solving for R in the equation GPP – R = NPP

For Site A:

$$544{,}320 - R_A = 40{,}000$$

$$R_A = 504{,}320 \text{ g/m}^2\text{/week}$$

For Site B:

$$544{,}320 - R_B = 37{,}000$$

$$R_B = 507{,}320 \text{ g/m}^2\text{/week}$$

TABLE A (for calculation of NPP)

Site Identification	Final dry weight (g)	Starting dry weight (g)	*NPP (g/m^2/week)

* NPP is obtained by subtracting the starting dry weight from the final dry weight

TABLE B (for calculation of R)

Site Identification	PAR (kcal m^2/week)	GPP (g/m^2/week)	NPP (g/m^2/week)	*R (g/m^2/week)

* Respiration (R) is determined by subtracting NPP from GPP

Analysis:
Answer the following questions by examining Tables A and B.

1. Did plants at the "high CO_2 site" exhibit higher net primary productivity (NPP) when compared to the "low CO_2 site"? What explanation can you offer?

2. Did plants at the "high CO_2 site" exhibit higher respiration (R) when compared to the "low CO_2 site"? What explanation can you offer?

3. Briefly discuss the relevance of your findings to agricultural production.

4. Briefly discuss the relevance of your findings to other impacts of global warming.

Assessment:

Prepare the information you have gathered for a presentation to the agencies involved. The presentation should include graphs that illustrate the relationship between CO_2 levels and net primary productivity and respiration. Technical terms that the public may not understood (e.g., net primary productivity) should be defined and discussed early in the presentation. The significance of your findings to community members should also be included.

Extensions:

Previous studies have shown that when atmospheric CO_2 increases, plant growth also increases. It has also been observed that as soil nitrate increases, plant growth increases. When both were elevated, net productivity was enhanced more than the sum of their individual contributions. One possible extension would be to measure nitrate levels to determine the level of nitrates that would yield optimum growth for the CO_2 level of a particular area. In this way, the use of nitrate fertilizers could be minimized thus reducing the harmful effects of nitrate runoff into water supplies.

Government agencies and community members who may be able to provide information and/or be interested in the results include:

- U.S. Fish and Wildlife
- U.S. Forest Service
- U.S. Environmental Protection Agency
- Local Native American tribes
- Water management agencies
- County Parks and Recreation
- Ranchers and farmers

Resources:

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Natural Variation Within Species

Abstract:
The physical attributes (traits) of an organism are controlled by DNA, which is selected by the environment in which it lives. This activity will clarify the connection between traits, DNA and the environment via field studies and community interaction.

Age Group:
7-12 (although easily adapted to lower grades)

Time Needed:
50 minute class period to collect samples in the field
50 minute class period to classify and make observations of variations
Field study of area to inventory organisms may take 3-5 class periods depending on the size of area.

Major Concepts:
Genetics, variation, species, plant and/or animal external anatomy

Objectives:
Upon successful completion of this exercise, students will be able to:

- understand that variations occur within a species
- classify organisms based on physical features
- observe life in a natural setting and gain an appreciation of life around us
- identify species within an area
- understand how genetic make-up is expressed through an organism's physical features

National Standards Addressed:
Unifying concepts and processes: Systems, order, and organization
Science as inquiry: Abilities necessary to do scientific inquiry
Life sciences : Molecular basis of heredity
Matter, energy and organization of living systems
Interdependence of organisms
Science in Personal and Social Perspectives: Environmental quality

Teacher Background:
Students and the general public often lose sight of the variation of living things around us. Students in particular think that all plants are the same, or all snakes are the same, though

when we look at people we can easily recognize the variety of sizes, skin color, nose shape, and eye color, which are used for our individual identity. Animals are also able to tell themselves apart. Somehow the penguin always seems to find its baby after a day at sea though they are nesting with thousands of other penguins, which to most humans look exactly alike until we really start to observe them closely. This activity is meant to get students to look at living creatures in a natural setting, beginning to create an inventory of species found in that setting and distinguish between individuals of a given species.

Contact local organizations and agencies to see if there are local sites that need to be inventoried for plants or animals. The local Audubon Society or natural resources agencies such as Bureau of Land Management, U.S. Fish and Wildlife Service, and Soil and Water Conservation Districts are good places to start looking for partnerships. Depending on your school district, it may be easy to arrange an all day field trip for your class to inventory the plants and animals of a site and also to bring in specialists in plant identification and a wildlife biologist to train the students on how to sample the area for the organisms. If a field trip option is unavailable, try a Saturday and give the students some extra credit for taking time out of their schedule to learn this information. This adds community awareness and aids in the student connecting with the environment and feeling a part of the community, especially if they can publish this information or they can act as education specialists in some way to get their information out. Once an inventory is accomplished, this activity will bring greater depth to their understanding and can be used to tie in genetics and natural selection.

Plants can be easier than animals to work with as they don't move and can be easier to collect. There are many identification books and field guides with color pictures, so students can identify them based on their physical features. Animals are also great to work with and many kids love to find wriggling snakes, millipedes, bugs, and insects. It reduces the frustration level if the plants or animals selected to study are abundant, easy to identify, and have notable variations within the population.

In this activity, either you can direct students as to which traits you want them to observe and measure, or you can make it more inquiry-based and have them pick their own trait to measure. Examples of traits you may wish to observe include leaf color, weight, length, width, vein pattern, surface area, leaf shape, and leaf margins. Working with specialists may help to identify traits and characteristics to focus on.

Notes:

1. You may need to discuss random sampling techniques with your students before you get out in the field, or when you are in the field and ready to turn them loose. This will help set the stage and improve results after this discussion.
2. Definitely take the time to debrief about problems/limitations by using this sampling protocol – some variations may be due to age of specimens, position in the stand, amount of shade/light, etc.
3. Feel free to adapt this lab – other ideas which may be of interest to study is the number of stoma on the leaf surface, leaf color, amount of pigments, types of pigments, etc.

Introduction:
Variations among individuals in a population are caused by the interaction between DNA and the environment those individuals are exposed to. DNA is the heredity material that tells an organism what it is and how it works. There is enough variation within a species of organisms to allow for individual differences. For example all humans have 99% of the same DNA code, but the 1% difference among us results in the variation we observe such as height or eye color. This variation exists in all creatures and is the basis for **natural selection** - the idea that variations, which are desirable for an area, give the organism a better chance at using the resources and surviving to pass on its genetic material to the next generation. Therefore, the physical attributes (**phenotype**) of an organism are determined by its DNA, which in turn is "selected" by the environment in which it lives. We are going to connect these two concepts in this activity.

Materials:
Pencil and paper for sketching in the field
Plastic bags with wet paper towels to collect plant specimens
Screw-cap bottles
Nets to collect animal specimens
Hand lens or dissecting microscope

Procedure:

1. Prior to going out to the field, students should select an organism (species) they would like to work on. You may want to provide them with a list to choose from that can be obtained from a variety of natural resource agencies. Once the selection of organism is completed, students need to gather the necessary materials they will need in the field and have them ready for the next day's trek to the field.

In the field

2. Students will collect information from at least 10 individuals of their chosen species. For example if you have chosen an oak tree, you would collect a leaf or two from each of 10 different oak trees. (You may also want them to collect other plant parts such as flowers or fruits) Store all of the collected plant material in a plastic bag with the specimens wrapped in a moist paper towel. Refrigerate samples when you get back in the lab to help preserve them.

3. While in the field have students sketch and describe at least 4 entire individuals of their selected species. In this way you can note branching patterns in oak trees, for example, and possibly use this information for comparisons. Record your observations on Data Sheet 1.

In the classroom

4. Students should make detailed observations of the individual organisms collected. A hand lens or dissecting microscope may be needed to observe the variations that you find. For example, with oak leaves pay close attention to leaf venation, color, leaf margin, and thickness. Then, discuss the possible reasons for these variations. Students should record their observations on Data Sheet 2.

Assessment:
A number of products can be developed by students for the partnering organization or agency and for the local community:

- Inventory chart of plants and animals in given area
- Sketches of plants/animals and their variations
- Pamphlet that lists the amount of varieties of organisms found in the area
- Poster showing community organization and energy flow

Extensions:

- Depending on the care of collecting and recording data, students could go back to the same tree the following year and see if the variation was consistent from year to year. Would this be expected based on its genetics? If you compared one area to another, would you find other variations of the same species?
- If historical data already exist for the site, the information the students get can be used to compare against the historical data and can determine how the site has changed and why.
- Research local legends about the uses of local plants and animals and how these uses have changed.
- Make a brochure of the plant and animal types in the area and address the city council with issues and concerns raised by doing this research.
- Use the site for vegetation sampling for population studies, monitoring health of the ecosystem based on biodiversity.

Resources:

Kozoloff, Eugene. 1995. Plants and Animals of the Pacific Northwest . 264 pp.

Gilkey, Helen and La Rea Dennis. 1992. Handbook of Northwestern Plants. 507 pp.

Oregon Department of Fish & Wildlife. 1993. Naturescaping.

Minnesota State. 2001. Natural Selection in Natural Populations. www.emeuseum.mnsu.edu/biology/evolution/genetics/naturalselection.html. Accessed 10 November 2001

Access excellence. 1996. Sampling variation in a natural population. www.accessexcellence.org/AE/AEC/AEF/1996/macphee_population.html. Accessed 10 November 2001

Theoretical Bichemistry Institute. 1996. Charles Darwin's Origin of Species www.tbi.univie.ac.at/Origin/origin_toc.html. Accessed 4 August 2002

Hands on the Land. 2000. Mammals of the Hanford Reach. www.handsontheland.org/classroom/04/index_eng.html. Accessed 9 June 2002

Microscopy of the United Kingdom. 1994. Pond life www.microscopy-uk.org.uk/pond/x_index.html. Accesssed 6 April 2002.

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NATURAL VARIATION WITHIN SPECIES

DATA SHEET 1

Give the genus and species name of your organism.

Describe the general biology (where does it live, how does it get food and nutrients, etc) of the particular species which you have selected and indicate the source of your information.

Describe in detail your method of collection and identification.

Explain how you will ensure that all individuals collected or identified are members of the same species.

What are other sources of variation which your sampling may not have taken into account.

Sketch of Individual 1:

General location found:

Specific identifying characteristic:

Sketch of Individual 2:

General location found:

Specific identifying characteristic:

NATURAL VARIATION WITHIN SPECIES

DATA SHEET 2

Describe the phenotypic traits you will be measuring and why they are biologically relevant.

Describe in detail your method of measuring the traits of interest.

Fill in the data table below.

Trait	Surface Area	Weight	Length	Width	Vein Pattern
Individual 1					
Individual 2					
Individual 3					
Individual 4					
Individual 5					
Individual 6					
Individual 7					
Individual 8					
Individual 9					
Individual 10					

Analysis:
From your data table, were all of the individuals the same or were there differences?

List the traits which show differences.

These differences are variations. Why is it biologically important for members within a species to show variations?

What part of the cell is responsible for these variations?

What molecule found in the nucleus controls the variations which we see in all beings?

Conclusion:
Based on your observations and data, what can you conclude about the role of DNA in the nucleus to control variations in leaf size and shape?

Invasive Plant Species and Your Community

Abstract:
This activity initiates the study of evolution through the context of a community project to manage a field site and educate the public on the identification and dangers of invasive plant species.

Age Group:
Grades 9-12

Time Needed:
8-10 days

Major Concepts:
Adaptation
Invasive vs. native species
Competition

Objectives:
Upon successful completion of this exercise, students will be able to:

- define and research local invasive species and their effects on the community
- study the adaptations of invasive species that allow them to out-compete native species
- adopt a plot of land and remove invasive species
- create an informational pamphlet to be distributed throughout the community
- gain an appreciation for the local environment.

National Standards Addressed:
Unifying concepts and processes: Systems, order, and organization, Evolution and equilibrium
Life Sciences: Biological evolution, Interdependence of organisms

Teacher Background:
This activity is to be used as a bridge between studying ecology and evolution. It would best be used as a culminating activity at a field site that has been used to demonstrate the principles of ecology. From the study of how a specific environment functions, it will lead the students into a study of how species have traits and characteristics that allow them to adapt successfully to particular environments.

The first step is finding a possible field site to study. This site can be a schoolyard, community park, state park, nature center, or corporate site such as those managed by non-profit organizations. This activity is to be used in coordination with a community partner. Possible partners include the Department of Agriculture, the Bureau of Land Management, your local Parks and Recreation department, or other non-profit volunteer organizations. Many areas also have local native plant societies. These organizations may be able to help in determining an appropriate field site, as well as supplying tools and materials for invasive plant removal and copy costs for the community informational pamphlets. Also, many counties employ a weed control agent who is usually quite willing to give presentations and offer assistance.

The "Community Action Survey" can be used as a pre- and post-assessment. It is designed to measure the students' progress toward the lesson objectives. Valuable data can still be collected on the success of the lesson if it is used only as a post-assessment.

Introduction:
Evolution shows us that natural selection works on variation within populations to allow species to adapt to their local environment. Commonly species, which are transplanted to new environments by human activities, are easily out-competed by native species that are well adapted to the environment. A minority of introduced species however, have adaptations that allow them to out-compete the local native species. The ecological impacts of these invasions are extremely difficult to predict and take years to fully understand.

Invasive species can have negative impacts on native species in a variety of ways. They compete for food, water, nutrients, and space as well as altering ecosystem composition and processes. Introduced diseases and parasites can attack and eliminate dominant native plant species. For example, the chestnut blight fungus from Asia all but wiped out the American chestnut, thus changing the makeup of eastern forests (U.S.D.A. Forestry Service, 2000). Invasive species impact nearly half of the species currently listed as Threatened or Endangered under the U.S Federal Endangered Species Act (National Invasive Species Council, 2001). They are second only to habitat loss as a cause for species decline and extinctions in modern times.

The best way to control invasive species is to prevent them from invading in the first place. Once they are established, however, there are several control methods including chemical, biological, and ecological methods. On a small scale, direct physical removal of the invader gives the native species time to re-establish themselves, hopefully giving them the foothold they need to out-compete the invasive species in their environment.

Materials:
Local plant field guides
List of local invasive plant species
Tools for clearing the study site
Digital camera(s)
Publishing software

Procedure:

1. Create a list of local invasive species by contacting local natural resource agencies, plant societies or accessing information on the Internet. A listing with pictures may be useful for the students to more easily recognize the plants.
2. Lead students on a walk around the school grounds or the immediate neighborhood (such as a park or local wetland). Student pairs or small groups should all have the list of local invasive plants and a field guides. Make a class list of all plant species that can be recognized and indicate which ones are introduced or invasive species.
3. Have the students look up any invasive species they encounter and record their origin and known effects on the local ecosystem. Make special note of any adaptations that allow the invasives to out-compete the native species. Internet sites are useful in quickly looking up the plants.
4. Discuss adaptations and how they allow a species to better compete in their environment. As a class, first brainstorm a list of characteristics plants require to be competitive in an environment. Then, brainstorm a list of possible adaptations that would make a species more competitive. Was there any evidence of these adaptations in the invasive species seen on the walk?
5. Assign each student a local invasive plant species to research. Have them research and answer the question on the "**Adaptations of Invasive Species**" worksheet dealing with their adaptations and native environment.
6. Introduce the idea of developing a pamphlet to the students. The pamphlet will cover the local invasive species and will be an educational reference to be handed out throughout the community. Decide on a list of topics to include and a basic layout. Possible topics include a basic pictorial reference of common invasives of the area, before and after photos of the study site with a brief description, and basic information and background on invasive species and their impact on the environment. Break the students into groups and assign each group one of these topics.
7. With the help of local agencies and organizations, establish a community study site to visit. Discuss the role of the invasive species at this site and discuss the possible succession once they have been removed. If possible, find a nearby plot with little or no invasive species for comparison. Begin any research or photography needed to begin making the community pamphlet. Identify camera points for the "before" and "after" images.
8. Once the pre-documentation and research is complete, plan a day or two to clear the site of invasive species. Tools and supplies need to be procured (perhaps by your community partner or school). Before beginning the clearing, once again point out the invasive species to make sure that native species are not cleared as well.
9. After clearing the study site, finish documenting and researching the site for the community pamphlet. The longer the interval between the clearing and the final documentation the more obvious will be the "before" and "after" difference.
10. To begin compiling the community pamphlet, each group will write and design their section in rough draft form. Complete the pamphlet in publishing software.
11. Decide on the community groups you want to distribute to and distribute the pamphlets and/or provide presentations.
12. Give the "**Community Action Survey**" to the students to measure their understanding and personal commitment to the role of invasive species in their community. Have a discussion on the effects of their work with the community.

Assessment:

- The students will be assessed by their participation in producing and distributing the community pamphlet.
- Students can present their pamphlets to the city council or partner community organization.
- Success of the lesson will be assessed using the "Community Action Survey" which is designed to measure students' involvement and understanding of the lesson.

Extensions:

- Conduct plant and animal inventories before and after the clearing.
- Conduct before and after measurements of different environmental factors.
- A community survey could be added to narrow the focus of the final pamphlet.
- Plan a community work day to help in the clearing of the study site and other areas around the community.
- Plant native species after removal of invasive species.
- Prepare a report that compares and contrasts biological and chemical control methods of invasive species.
- Distribute pamphlets to educate prison work groups who are commonly used to clear areas of invasive species.
- During the clearing process, partner with a middle school class and provide mentors.
- Distribute the pamphlets to local neighborhood associations.

RESOURCES:

- http://www.invasivespecies.gov/search.shtml
- http://www.nps.gov/plants/alien/factmain.htm
- http://plants.usda.gov/cgi_bin/topics.cgi?earl=fact_sheet.cgi
- http://www.enature.com

References:

U.S.D.A. Forestry Service. 2000. Chestnut Blight. http://fhpr8.srs.fs.fed.us/idotis/diseases/chestnut.html Accessed: 10 March 2003

National Invasive Species Council. 2001. What are the impacts of invasive species? http://www.invasivespecies.gov/impacts.shtml. Accessed: 10 March 2003

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Adaptations of Invasive Species

What is an adaptation?

What is an invasive species?

Your invasive species to research: ______________________

Where did your invasive species originate and when and how did it arrive? Describe the natural environment to which this species is native. If this information cannot be found, predict what the environment would look like.

What adaptation(s) does your invasive species have which helps it compete with the native species of your community?

What impact have these adaptations created in your community (or around the world)?

Create a diagram of your invasive species and the environment around it making special reference to the adaptations that allow it to out-compete its native neighbors.

Community Action Survey

On a scale of 1 to 10 (10 being the highest), do you... (circle your answer)

1. Feel that invasive species have a major impact on your local environment?

1 2 3 4 5 6 7 8 9 10

2. Believe that educating the community about invasive species was a meaningful goal?

1 2 3 4 5 6 7 8 9 10

3. Feel that clearing your field site of invasives was a worthwhile time commitment?

1 2 3 4 5 6 7 8 9 10

4. Think that your community pamphlet will have an impact on your community?

1 2 3 4 5 6 7 8 9 10

5. See your local environment as something that needs to be saved?

1 2 3 4 5 6 7 8 9 10

Local Ethnobotanical Field Guides

Abstract:
The students will investigate native species of plants in their local area. Connections to Native American cultures will be encouraged as they produce a community oriented ethnobotanical field guide accompanied by an inquiry based research report.

Age Group:
Grades 8-12

Time Needed:
Several days for research question development
1 class period for collection
Several days of drying and plant pressing time
2 class periods for identification and key development
Several days for research group discussion and work
Student homework/work outside class is expected

Major Concepts:
Science as a process
Classification
Diversity

Objectives:
Upon successful completion of this exercise, students will be able to:
- analyze how human populations use resources in the environment to maintain and improve their lives
- describe the roles of plants in Native American culture
- understand the importance of biological diversity
- understand the scientific basis for biological classifications
- identify native plants and develop a dichotomous key using physical features
- develop and conduct a research study that incorporates questions that interest them and are amenable to an investigation in ethnobotany

National Standards Addressed :
Life Science: Biological Evolution
History and Nature of Science: Science as a human endeavor
Science in Personal and Social Perspectives: Personal and Community Health, Natural Resources

Materials:

- Plant presses can be purchased through nearly any biological or scientific supply catalog although it is possible to do the activity without them. Heavy cardboard placed between two boards and tied tightly together works just as well. Even large, old, discarded hard covered books can be used to press plants.
- Sturdy, heavy cotton paper is best for mounting specimens, but drawing paper works fine.
- Professional herbarium specimens are sewn onto the paper with a needle and thread but if this is a safety concern for you, glue or tape may be used instead.
- Scissors and/or pruning shears.
- Clear contact paper for laminating specimens (optional).
- A collection of field guides for plants in your area such as weeds, wild flowers, trees or edible plants.
- A binder or folder for storing the finished specimens.
- Student-provided research notebooks.

Teacher Background:

Ethnobotanists are scientists who study the role of plants in a society. To better understand how a particular culture interacted with plants in the past, ethnobotanists look for clues in many places. They can learn a lot by finding out how an area's current society uses plants.

Botanists have devised a way to catalogue and keep track of all the known plant species with herbarium collections. A herbarium collection is an assortment of plant specimens. A herbarium specimen is a pressed, dried plant (or the important parts of a plant), which is glued or sewn onto a durable piece of paper. Also recorded on the sheet should be the name of the plant, where it was found and other important information.

Field guides are books that contain photographs or accurate illustrations along with clear descriptions of plants or other groups of organisms such as insects or birds. Field guides are used by scientists, students, and amateurs to help them identify species that are encountered.

In this activity students will become familiar with making herbarium specimens as well as using field guides and keys to help identify the species that they gather. They will use their herbarium collection to create local native plant field guides including a dichotomous key. The collection also serves as data for their inquiry-based research report.

There are a number of ways that this activity can connect students to authentic experiences and opportunities in the community. The students can make presentations to local community groups or organizations such as elementary school classrooms, elder care facilities, garden clubs, neighborhood associations, and youth clubs. After the presentation, some of the field guides can be donated. Consider suggesting alternative language versions to the students such as Spanish. Students could also develop brochures and/or plant displays based on their field guides for local/state parks, nature reserves, or wildlife refuges. The different agencies could choose a design from the submitted brochures/displays.

There is a lot of modern interest in "Native plant medicines" both from big drug companies and from people who want simple treatments. It would be helpful to remind students of two things about studying plants and ethnobotany:

1. Ingesting plants can be dangerous. If you are a person ignorant of plants, and go out hunting and trying to use "medicines" you can make yourself or others very sick, even die. Plants are not in and of themselves "healthy" or even necessarily safe. There are very powerful plant poisons, and some of the most powerful chemical poisons were originally developed from those of plants. There is also a consideration of how the plant parts must be processed or treated properly, what parts to use, what proportions, and what mixtures.
2. A sacred or religious aspect is involved in much Native plant medicine, of most kinds, and for most tribes. Native American Indian medicines tended to be complex mixtures of many kinds of different parts of plants, gathered and treated at different times of year, mixed in specific proportions, and administered in scheduled doses of particular size and dilution. This was never public knowledge, and much of it was learned only by apprenticing to a particular doctor to learn his or her particular medicines. Prayers and thanks are to be given to the "Great Mystery" who provides and reveals their proper uses by people. Usually an offering is made of tobacco or sometimes silver is buried by the "chief plant" of a group, representing the spirit of those particular plants. A prayer often accompanies this offering. All of this is part of an attitude, a culture, a religious outlook, a local society, and a history unique to each tribe. Contacting the cultural or education committees of local tribes could be a valuable experience.

Introduction and Concepts:

Native Plants and Ethnobotany

Native plants are unique kinds of plants. The native plants of a given area are those that grew there prior to European contact. Native plants evolved in local areas over a very long period, and are the plants which the first humans knew and depended on for their livelihood. Native plants have co-evolved with animals, fungi and microbes, to form a complex network of relationships. These plants are the foundation of native ecosystems, or natural communities.

Specimens, seeds and drawings of New World plants were taken to Europe by early explorers over many years. Thus, American plants were included in ongoing botanical studies of the world's flora. In modern times, the science of paleobotany allows scientists to carry out detailed studies of plant fossils. By comparing fossil records with modern plants, researchers can confirm their theories as to which plants are native to an area.

Before northern European people even set foot on the region now known as the Americas, Native American Indians had refined the use of plants for uses in their everyday lives. The study of such plant use is called ethnobotany. This project will give you the knowledge that was once essential to the survival of past American Indians, in an easy to use manner. It can be considered a field guide.

To begin with, Native American Indians had four basic uses for plants. Of most importance was food. From the woody trees to the swampy marshes, the grassy fields to the tidal shores, the Indians relied heavily on the food they collected for sustenance. Berries were dried, tubers were stored, and fresh greens were gathered so that vegetable matter was eaten all year round. Next in importance came the materials. The American Indians built their houses, sewed their clothing, caught their fish, and cooked their food in and with materials that they obtained from their environment. The third major use of the indigenous plants was medicine and charms. Many plants were made into poultices, teas, and concoctions, to cure or attempt to cure the illnesses that the American Indians faced. Lastly, the American Indians used plants for art and entertainment. Most importantly, the American Indians relied heavily on plants for their survival.

Plants native to particular areas, having evolved here, are best suited to perform the tasks that plants do, such as manufacturing oxygen and filtering impurities from our water. These plants also do the best job of providing food and shelter for native wild animals. Maximum diversity in animal populations requires maximum diversity of plants. Biological diversity is vital to humans, because ultimately, we all live off the land, whether we admit it or not. Native plants continue to play a crucial role in the development of new foods, medicines and industrial products.

Biological Evolution, Diversity and Classification

The general concept of biological evolution involves the idea that species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life and, (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring. The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms. Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms. The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.

Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. The species is the most fundamental unit of classification.

In general, a classification is a method for organizing information. Human beings classify things spontaneously. Classification groups similar things together. This definition is necessarily vague; there are many reasonable ways of defining similarity and hence many alternative classifications for the same things.

Taxonomy is that branch of biology dealing with the identification and naming of organisms. The ancient Greek philosopher Aristotle apparently began the discussion on taxonomy. British naturalist John Ray is credited with revising the concept of naming and describing organisms. During the 1700s, Swedish botanist Carolus Linnaeus classified all then-known organisms into two large groups: the kingdoms Plantae and Animalia. Robert Whittaker in 1969 proposed five kingdoms: Plantae, Animalia, Fungi, Protista, and Monera. Other schemes involving an even greater number of kingdoms have lately been proposed, however most

biologists employ Whittaker's five kingdoms. Recent studies suggest that three domains be employed: Archaea, Bacteria, and Eukarya.
Phylogeny refers to the evolutionary relationships among species. In making a phylogenetic classification, taxonomists name groups of organisms that are all close relatives of one another.

Linnaean hierarchical classification was based on the premise that the *species* was the smallest unit, and that each species (or *taxon*) nested within a higher category. Linnaeus also developed the concept of binomial nomenclature, whereby scientists speaking and writing different languages could communicate clearly. For example "Man" in English is "Hombre" in Spanish, "Herr" in German, "Ren" in Chinese, and "Homo" in Latin. Linnaeus settled on Latin, which was the language of learned men at that time. If a scientist refers today to *Homo sapiens*, all scientists know what organism/taxon he or she means.

The naming of species and other taxa follows a set of rules, the International Code of Botanical Nomenclature (ICBN) for plants, the International Code of Zoological Nomenclature (ICZN) for animals.

Some general rules for nomenclature:

1. All taxa must belong to a higher taxonomic group. Often a newly discovered organism is the sole species in a single genus, within a single family...etc.
2. The first name to be validly and effectively published has priority. This rule has caused numerous name changes, especially with fossil organisms: *Brontosaurus* is invalid, and the correct name for the big sauropod dinosaur is *Apatosaurus*. *Eohippus* (the tiny "dawn horse") is invalid and should be referred to as *Hyracotherium*. Sometimes, however, names can be conserved if a group of systematists agrees.
3. All taxa must have an author. When you see a scientific name such as *Homo sapiens* L, the L stands for Linnaeus, who first described and named that organism. Most scientists must have their names spelled out, for example *Libopollis jarzenii* Farabee et al.

An example of classifying humans (*Homo sapiens* L.):

<u>Kingdom</u> Animalia
<u>Phylum</u> (Division for plants) Chordata
<u>Class</u> Mammalia
<u>Order</u> Primates
<u>Family</u> Hominidae
<u>Genus</u> *Homo*
<u>species</u> *sapiens*

An example of classifying "moss rose" (*Rosa gallica* L.):

<u>Kingdom</u> Plantae
<u>Division</u> Tracheophyta
<u>Class</u> Angiospermae
<u>Order</u> Rosales
<u>Family</u> Rosaceae
<u>Genus</u> *Rosa*
<u>Species</u> *gallica*

Procedure:
After an introduction including background and concepts in this lesson, have the students develop some research questions that interest them about this topic. The research question(s) in their final form should incorporate most of the objectives for this lesson and may take multiple iterations and guidance from the teacher in the development of suitable questions. Students should record the questions and all aspects of a research plan into a student research notebook. Encourage them to work in groups of 2-4 students. Each student will be responsible for recording the group's preliminary plan for conducting the investigation and keeping extensive records of the work by the group.

The students will be required to go to their assigned area of the selected site and responsibly collect and press plant specimens. Back in school, they will dry and prepare herbarium specimens and utilize field guides to help them identify species. Laminated herbarium collections can then be organized to create field guides. A dichotomous key will be developed for the specimens in the field guide.

Be sure NOT to collect or disturb any species which may be endangered or at risk. The teacher should become informed of rare and endangered species within the selected site. Discuss safety issues with the students. Potentially poisonous plants are a concern. Poisonous plants can be separated into different groups based on their toxicities. Some plants will cause a systemic toxicity resulting in a range of symptoms from mild abdominal cramping to serious cardiac arrest. The degree of toxicity depends on the quantity ingested or the part of the plant eaten. Other plants contain insoluble calcium oxalate salts. Contact dermatitis can result in a burning sensation due to the irritation of mucous membranes or skin layers. See more information at Cornell University Poisonous Plants Informational Database website:
http://www.ansci.cornell.edu/plants/index.html

Each group of students is responsible for submitting ten (10) 5x7 index card(s) with the following information on the lined side of the card:

- Names of students on team
- Date
- Common name of plant
- Scientific name of plant (Family, Genus, species)
- Description of how the plant was used by local cultures historically.
- Other interesting information about this plant.
- Reference / source of information

A plant drawing should be drawn on the unlined opposite side of the card. Draw in detail one or two leaves including leaf shape, margin, tip, base and venation pattern, and show the attachment to the stem

Plant Drawing Guidelines:

1. Describe the location of the plant (wet, dry intermediate, disturbed area, slope, light conditions, aspect, etc.)

2. Describe the habit of the plant (vine, shrub, tree, forb, etc.)

3. Identify unique characteristics to help remember each plant (smell, color, fruit, etc.)

- Gently place the plant or plant parts onto a page of the plant press and cover it with another page. Each specimen should be placed in-between a new page or piece of cardboard. Slip the 5x7 inch card, with as much information filled out as you can, in with the specimen. Then cover all of them with the cardboard and wooden boards and tie them tightly together. Keep the plants in the press in a dry, warm location for about a week until they dry out and get flattened.

- When the specimens are ready, carefully place each species on an individual herbarium sheet and glue them onto the sheet.

- Use your field guide(s) to help you identify the plants that you have collected. The field guide will have instructions on how to identify the plant. Some are easier to use than others. Find as much information as you can. Finish filling out the information for your card.

- Laminate the herbarium specimens with clear contact paper. Real herbarium specimens are never laminated but this may make your collection more durable.

- Punch holes in your herbarium specimens and put them in a 3-ring binder.

- Distribute the plants in the collection into their respective families, genus and species. Develop a dichotomous key and place it at the beginning of the guide. This key can be used to help identify other plants in the field.

- Give the book a name such as “Local Wetland Plants”. Now you have both a homemade herbarium collection and your own personal field guide customized for your area.

Research Report Guidelines:
Based on the notes of individuals from their student research notebooks, the group prepares a written report, describing the research. That report also includes data that have been collected and preliminary analysis. Students should be provided an outline of report requirements including: research question and rationale, data collection, the analysis, and conclusions.

Assessment:

- The completed field guides and group research reports are the final products and can be used for evaluation.

- If the plants have been correctly identified, then the student has successfully used the keys from the professional field guides.

- There should be a sufficient amount of supplemental information showing that the student has learned a lot about the species, for example: plant brochures, plant displays, and presentations should contain cultural, historical, taxonomic, and phylogenetic information.

- Public presentations/brochures/displays can be evaluated using a rubric.

- Evidence for the quality of a student's ability to reason scientifically comes from the rationale for the student's own (or group's) research question and from the line of reasoning used to progress from patterns in the collected data to the conclusions.

Extensions:

- Test plants for biological activity such as anti-bacterial studies.
- Test plants for nutritional content through starch analysis and comparison studies.
- Test plants with paper chromatography to separate various chlorophylls.
- Develop phylogenetic trees of collected specimens and related species.

Resources:

Plant classification

http://plants.usda.gov/

Ethnobotany

http://www.econetwork.net/~wildmansteve/
http://guallart.dac.uga.edu/#anchor1024613
http://www.sfu.ca/halk-ethnobiology/html/main.htm
http://www.ethnobiology.org/
http://www.rbgkew.org.uk/peopleplants/wp/wp8.html
http://www.rbgkew.org.uk/peopleplants/wp/index.html
http://www.rbgkew.org.uk/peopleplants/index.html
http://www.kew.org/scihort/eblinks/biblio.html
http://www.kew.org/scihort/eblinks/

Indigenous knowledge

http://www.unesco.org/most/bpikreg.htm
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Curriculum and Instruction

Bacteria and Water Quality

Abstract:
Water quality is determined by testing for the presence of fecal coliform bacteria.

Age Group:
Grades 8-12

Time Needed:
45-90 minutes (can be repeated over several weeks or months for a more detailed study)

Major Concepts:
Bacteria
Bacterial populations
Role of bacteria in the ecosystem
Correlation between fecal coliform levels and the presence of pathogens in water

Objectives:
Upon successful completion of this exercise, students will be able to:
- correlate the number of fecal coliform bacteria present in a waterway to the probability of the presence of pathogens
- conduct a fecal coliform survey of a local waterway
- create a presentation based on their findings.

National Standards Addressed:
Unifying Concepts and Processes: Change, constancy, and measurement.
Life Science: The cell, Interdependence of organisms.
Science in Personal and Social Perspectives: Personal and community health, Environmental quality.

Teacher Background:
This activity may be used as a part of a unit on bacteria to demonstrate their role in ecosystems. This can be accomplished through a variety of community contexts: students may test fecal coliform levels immediately upstream and immediately downstream of a sewer treatment facility, a tertiary treatment area and agricultural runoff areas. Students might compare fecal coliform levels in a waterway before and after the development of a plant buffer zone. Students could also conduct fecal coliform tests on water samples and compare the water quality at tertiary treatment sites to areas with retention basins or to areas that do not have any wastewater diversion systems currently in place. Contact the local wastewater treatment facility, Environmental Protection Agency, or other agencies that could partner with you and identify sites for testing. They may also have equipment to assist in the collection and testing of samples.

Introduction:
Bacteria are found throughout the biosphere, with the Archaebacteria living in the most extreme of environments (such as sulfur hot springs) and Eubacteria living in or on most other places on Earth.

Archaebacteria are thought to resemble the earliest prokaryotes due to the extreme environment of early Earth, and of these, the methanogens (or "methane-producers") are perhaps the most likely to be known to the general public. They live in anaerobic environments such as swamps, sewage treatment centers, and the guts of cattle, decomposing material and giving off "swamp gas" or methane gas as a byproduct of their metabolism.

The first eubacteria to appear in the fossil record are responsible for "poisoning" the atmosphere with oxygen, beginning a critical change in the geological record. This led to the appearance of more complex life forms on Earth. The eubacteria include cyanobacteria, *E. coli* and other bacteria found in the human intestines, and a wide variety of bacteria responsible for decomposing dead organisms and waste byproducts thereby releasing nitrogen, carbon and other elements back into the nutrient cycles. A breakdown of the organic molecules in the waste byproducts begins immediately as bacteria from the gut is released from the body in the feces.

Untreated sanitary (human waste) wastewater and storm runoff from urban and suburban areas may be diverted directly into local waterways rather than flood a wastewater treatment plant during a period of heavy rainfall. The raw sewage can lead to high levels of fecal coliform bacteria in the streams. Sources of fecal coliform include feces of humans or other animals, storm runoff and agricultural runoff. While fecal coliform bacteria is not necessarily pathogenic, the occurrence of abnormally high levels of colonies has been found to correlate to the presence of disease-causing organisms such as those that cause dysentery and typhoid fever. Viruses that cause hepatitis A and gastroenteritis are also more prevalent.

Two solutions have been developed to prevent untreated sewage and storm runoff from entering into waterways: retention basins and tertiary treatment systems. Retention basins serve to store excess wastewater and completely prevent it from entering waterways. Tertiary treatment systems are a fairly recent development, mimicking how wetlands act as natural filtering systems. Such systems result in filtered water that may be used for agricultural, urban and habitat use, or returned to a wastewater treatment center.

Materials Needed:

NOTE: *Actual materials required for this activity will depend upon the community partnership and the particular protocols and supplies set forth by that partner. Local water labs and wastewater treatment plants are possible partners to contact for testing support. Scientific supply catalogs also have the following:*

- Water Quality Kit (available from companies such as *Micrology Laboratories*)
- Liquid coliscan medium
- Sterile sample bottles (for water sample)
- Sterile droppers, calibrated
- Pre-treated *Easygel* Petri dishes
- Sterile sample bottles (for coliscan-water mixture)
- Non-latex gloves
- Extended rod sampler
- Medium-sized cooler with ice (for transport of samples)
- Incubator

Procedure:

1. The students will contact a local wastewater treatment center and express their desire to form a school-community partnership. They will ask if they can be shown how to sample and test water for the presence of total fecal coliform bacteria, as well as *E. coli*.

   NOTE: *Students may make initial contact via phone or formal business letter, dependent upon the goals of the teacher. If experience in communicating via phone is desired, students might make a preliminary script to use as a guide when calling. If experience in formal business letter writing is preferred, it might be required that a rough draft be peer-edited first, with a final draft and stamp of approval done by the teacher prior to mailing the letter. In either case, a brainstorming session by the students would help in generating ideas.*

2. In exchange for training by the partner, and the use of their facilities for processing samples, the students will agree to compile data for a particular site and report the results of their survey back to the community partner. Students should keep an accurate record of the data as it is collected.

3. The exact sampling sites, the frequency and the duration of the testing will depend greatly upon the needs of the community partner.

4. Students will write a thank-you note to the community partner upon completion of their research.

Assessment:

The students will compile the results of fecal coliform counts in a spreadsheet, using a pro gram such as *Excel*. Graphs may then be generated using these data. Students should analyze the data, making sure to describe and explain any trends present in the graphs. The resulting product, such as a *PowerPoint* presentation, may then be taken to the com munity partner, other interested organizations, and the general public where the students will present their findings. A report with a cover letter might be included as well to serve as a permanent record.

Extensions:

- As the students take water samples they can also record other water quality parameters as well as the precipitation for previous days.
- Present findings to the city health department, the city council or watershed council.
- Invite a speaker from the local wastewater treatment center or from a local Soil and Water Conservation District office.
- Have a panel discussion with the community members living along the waterway, along with representatives from the wastewater treatment center, regarding ideas for improving water quality.
- Create a booklet to educate community members about the importance of water quality.

Resources:

U.S. Environmental Protection Agency. 18 June 2002. Drinking Water Pathogens and Their Indicators: A Reference Resource. http://www.epa.gov/enviro/html/icr/gloss_path.html. Accessed: 24 June 2002

Fecal Coliform. http://www.switzerland.k12.in.us/watershed/fecal.html. Accessed: 24 June 2002

The Trustees of Indiana University. 1996. Fecal Coliform Test, Classroom Activity. http://www.bradwoods.org/eagles/fecal.htm. Accessed: 24 June 2002

Oregon Gardens. http://www.oregongarden.org. Accessed: 24 June 2002

City of Salem (Oregon). Willow Lake Wastewater Treatment Plant and Demonstration Natural Reclamation System. http://salemnatural.net/nrs.htm. Accessed: 24 June 2002

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Biology, Physical Science

Lichens as Indicators of Air Pollution

Abstract:
Air pollution levels are determined by identifying and comparing lichen populations in the field.

Age Group:
Grades 8-12

Time Needed:
45-90 min (can be repeated over several months for a more detailed study)

Major Concepts:
Symbiotic relationships
Lichens as indicators of air pollution
Impacts of air pollution on living organisms

Objectives:
Upon successful completion of this exercise, students will be able to:

- identify the structures of lichens
- identify lichens growing in their local area
- determine air pollution levels using lichens as indicators

National Standards Addressed:
Life Science: Matter, Energy, and Organization in Ecosystems

The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.

Teacher Background:
As nations have become industrialized, air quality has become an increasing concern. Air pollution monitoring instruments can only provide a picture of the air quality at the time of the sampling and so can have limited use in providing long-term observation of changes in air quality.

As early as the mid-1800's, scientists observed that lichens are sensitive to air pollution and can be used as a bio-indicator of air pollution changes. Since that time, many studies have been undertaken to monitor air pollution levels using lichens.

Your classroom can provide data on lichen populations in your region for several of the national and international organizations that track air pollution using lichens. These organizations can be accessed on the Internet using the addresses located under "Resources". On a local level, you may partner with and provide data on air pollution levels to a number of agencies and community organizations. These groups include:

- City Council/Mayor/City Manager
- City Planning Department
- State Department of Transportation
- Local and state agencies and environmental organizations
- Department of Environmental Quality

Your classroom could assist these groups by:

- Educating groups about the use of lichens to monitor pollution
- Developing a field guide to lichens that others can use to monitor air pollution
- Reporting on data of pollution levels in the area
- Detailing variation in pollution levels in different parts of city or region

Introduction:
Organisms in the kingdom Fungi play an important role in ecosystems. Mushrooms, lichens, molds, slime molds, yeasts, rusts, smuts, and water molds are all members of this kingdom. Fungi are eukaryotic organisms; most species are multicellular. The cell walls of most fungi contain chitin, which is also found in the hard outer skeletons of insects.

Most fungi possess the following structures:
Hyphae: Many individual filaments that make up the body of a fungus. Each hypha contains cytoplasm and one or more nuclei. They secrete enzymes that digest food.
Mycelium: Intertwined hyphae that make up the body of a fungus. Most of the fungus lives under the substrate, or material in which the fungus is growing.
Fruiting Body: The visible part of the fungi that produces spores.
Sporangia: Specialized hyphae that produce tiny spores.

Fungi are decomposers, meaning that they use enzymes to break down organic matter and then digest this food. This process of fungal decay breaks down dead organisms and the wastes of living organisms, thereby returning valuable nutrients to the soil. Living organisms can then use these nutrients for new growth. To survive, fungi need moisture, food, warmth, and darkness. Fungi are either saprophytic, feeding on dead matter, or parasitic, feeding on living organisms.

Fungi are an important food source for animals and people. People also use fungi to produce antibiotics such as penicillin. Fungi are used in making breads and cheese. Fungi can also cause serious diseases and destroy millions of dollars worth of crops such as corn and wheat.

Lichens:

Lichens are organisms that consist of an alga and a fungus living in a symbiotic relationship. Fungal hyphae give the lichen its internal structure and shape. Algal cells are imbedded within the fungal mycelium. This symbiotic relationship has benefits for both the alga and the fungus. The fungus provides structural support for the alga and improves exposure to sunlight. The alga produces food for the fungus through the process of photosynthesis. As a result of this relationship, lichens can survive in harsh environments where alga and fungi could not live alone.

Although lichens are very hardy, they are among the first organisms to suffer from the effects of air pollution. Because lichens lack roots, they absorb rainwater directly into their cells. As a result, lichens absorb more dissolved toxic substances like sulfur dioxide than other plants. Eventually, these toxicants build up to a level where it breaks down the chlorophyll molecules. The alga can no longer photosynthesize the sun's energy and dies. The death of the alga in turn kills the fungus.

Some lichens are more tolerant of pollution than others. By knowing which species are most sensitive to air pollution and documenting their presence or absence, it is easy to determine how "clean" or "dirty" the air is. Lichens are very useful in monitoring a region's air quality trends. They are especially useful because they can easily be found in most urban environments. An easy-to-use lichen identification key can be found at The Natural History Museum's website at www.nhm.ac.uk/botany/lichen/twig/survey.html. This key identifies the pollution tolerance level of each lichen.

The air quality of an area can easily be determined by observing the lichens that are growing on older trees. Generally, the more lichens that are observed, the healthier the air is. Scattered orange and gray lichens usually mean better air quality. Black, scaly lichens are tolerant of higher pollution levels. Some areas are so polluted that no lichens can be found. These areas are called "lichen deserts". As the air quality in these lichen and moss deserts improve, lichens will begin to reappear in a slow process of recovery.

Many regions in North America and Europe are beginning to track changes in lichen populations to monitor air pollution. Results of these studies can be found on the web sites listed at the end of this activity.

Materials:
Knife
Sandwich bags
Permanent pens
Flagging tape
Magnifying glass
Misting bottle
Bleach
Eyedroppers
Clipboards
Writing materials
Dissecting scope (optional)
Field guide of local lichen or online access to lichen identification page

Procedure:

PRIOR TO ACTIVITY:
Select 3-10 different sites representing a range from inner city to outlying rural areas where lichens can be obtained. Number these sites on a map for easy organization of data. Lichens grow on most trees. Look for trees where students can reach the lower branches avoiding those branches that are heavily shaded. Lichens can also be found on concrete and rocks in areas where few trees are present. Be sure to ask for permission to sample trees on private property

SAMPLING:

1. Once a tree suitable for sampling has been located, select and mark 10 twigs. Mark each twig with a piece of flagging tape. Assign a number to each twig and write it on the flagging tape with the site number first and then the twig number (example: 1:4).

2. Gently pull down a branch to observe lichen colonies. Do not break off twig. If possible, identify lichen in the field. For each lichen observed, record in lab notes:
    a. Lichen species
    b. Date
    c. Pollution sensitivity level (you may wish to create a color coding system for pollution sensitivity)
    d. Site and twig number

3. If a field identification cannot be made, use a knife to scrape a small piece of bark with lichen sample into a sandwich bag for identification back in the classroom. Mark the sandwich bag with the site number, twig number, and date. Then, use the identification guide at The Natural History Museum's webpage to identify the lichen.

TIPS FOR IDENTIFYING LICHENS:

<u>Color</u>: Color in lichen varies depending on the amount of sun or rain. Wet the sample with a misting bottle and recheck color if uncertain.

<u>Reproduction</u>: The best means of identifying a lichen is observing the lichens means of reproduction. Use a magnifying glass for easier viewing of these features. These features consist of fruiting bodies called **apothecia** that allow for sexual reproduction or finger-like outgrowths, **isidia**, or sugar-like granules, soredia, that allow for asexual reproduction.

<u>Bleach</u>: The identification of some lichen species can be confirmed in the field by a spot test with bleach. For the bleach test, simply scrape away the upper surface of the lichen, add a small drop of household bleach using an eyedropper and watch the reaction. Organic compounds in some fungal partners will turn the bleach red or orange, while others have no reaction at all.

For a easy-to-use dichotomous key to lichen identification, visit The Natural History Museum's website. This key also includes each species' sensitivity to air pollution.

Analysis:
After students have sampled and identified lichens from all sites, compile data using charts and graphs that demonstrate difference in pollution levels from site to site.

Assessment:
- Chart the variation in lichen populations at different study sites
- Compare lichen diversity and abundance to proximity to potential sources of pollution
- Develop a field guide to local lichens for use by other schools to monitor air pollution
- Present data to city council or local or state agencies and organizations to assist in development of air quality standards
- Link with another school via the Internet to share data on lichen populations
- Submit data to national or international lichen monitoring organizations (see Resources)

Extensions:
- Monitor lichen populations over several years to observe changes in populations
- Research source points of air pollution in your region
- Research environmental laws on air pollution
- Develop a chart of air pollution in your region compared with other cities the same size or other cities in your state

Resources:

William C. Denison. 1973. A guide to Air Quality Monitoring Using Lichens. Lichen Technology, Inc.

Northwest Mycological Consultants, Inc. Online Lichen Survey http://ocid.nacse.org/classroom/lichens/denison. Accessed 6-26-02

Mapping of Pollution in Russia and Norway using lichens:
http://www.itek.norut.no/vegetasjon/13so/tekster/teksten.htm

Encyclopedia of the Atmospheric Environment
http://www.doc.mmu.ac.uk/aric/eae/index.html

Lichen and Air Quality Work Group
http://ocid.nacse.org/airlichenPDF/Mission.pdf

Online Lichen Survey
The Natural History Museum
http://www.nhm.ac.uk/botany/lichen/twig/survey.html

Field Guide to Lichens
http://www.utoronto.ca/envstudy/cew/ resources/lichenprotocol.pdf

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English

Conducting a Plant Survey

Abstract:
This plant survey can be conducted in any schoolyard or natural area in the community.

Age group:
Grades 7-12

Time Needed:
60 minutes

Major Concepts:
Plant communities
Plant identification
Invasive species

Objectives:
Upon successful completion of this exercise, students will be able to:

- establish plots to inventory plants
- identify plants as part of a plant inventory
- create a map that illustrates the distribution of dominant plant species

National Standards Addressed:
Content Standards 5-8 Life Science: Populations and ecosystems, Diversity and adaptations of organisms, Use appropriate tools and techniques to gather, analyze and interpret data.
Content Standards 9-12 Life Science: Design and conduct scientific investigations, The interdependence of organisms

Teacher Background:
The protection of native plant communities and the problem of invasive plant species are a great starting point for plant studies anywhere in the nation. Without their natural controls, some non-native plants became invasive, reducing the diversity and quantity of native plants. Weeds are continuing to spread rapidly in many areas across the country. Weeds spread an estimated 4,000 acres (over 6 square miles) each day on public lands managed by the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS). But weeds know no boundaries. They also are spreading on private and public lands.

By learning basic methods of plant identification and how to conduct a plant survey, students will be prepared to look at problems in local plant communities. You will find many willing partners in your community for invasive species projects. Each area has its own problem plants. Your local county will have lots of information and resource people to help you with invasive species projects.

This is a basic activity that can be performed in any schoolyard or nearby natural area, but there are many ways to partner with organizations in the community and do plant surveys that will be useful to the community. Each agency will have their own methods of conducting the survey based on how they will be using the information. They will usually train the students so that they will be assured of getting usable data. Partnering with community agencies may also bring with it the ability to use more technical mapping equipment such as Global Positioning Systems (GPS) units. Local community partners are probably already involved in weed control and invasive plant eradication. They may need to have the sites of a particular weed identified and mapped. Students would learn how to identify the weed and then map areas for future eradication or they may be surveying an area to measure how well a previous weed control project is working.

Wildlife agencies have habitat projects in which they are trying to improve the forage and cover for wildlife in some areas. These agencies may need people to survey areas to determine how well their habitat improvement plan is working. Government agencies such as the BLM or USFS may be looking for data on re-growth in areas impacted by fires, floods, drought or pests. Sometimes they also have programs to return an impacted area to native species and they need data to monitor the program.

City parks and recreation departments may have areas that they are monitoring for invasive species, wildlife habitat or erosion. Parks also may want to have a survey of the plants in a natural area to make brochures or signs to educate the public. Every area of the country has local needs for people to help in plant surveys. All you need to do is find the right partner in your community.

Introduction:
Plants are essential to our survival because they are the producers in food webs. We eat plants either directly or indirectly by eating animals that consume plants. Plants also provide medicines, clothing, paper and many other products. They play a major part on the continuous recycling of the Earth's water, oxygen, carbon dioxide and mineral nutrients. They act as a ground cover to protect the soil and prevent erosion.

Plants exhibit tremendous diversity. They have dominated the land and many bodies of water. They range in size from 1 mm in width to 100 meters in height. There are 12 divisions of the plant kingdom including more than 270,000 species. Some plants can live nearly 5,000 years.

In nearly all plant communities across the country noxious weeds are invading the landscape like an explosion in slow motion. All citizens need to learn and work together to preserve and protect our native ecosystems from further invasion by invasive plant species. Noxious weeds disrupt natural communities and agricultural lands. Non-native species were introduced without their natural controls that keep their populations under control in their native lands.

Most of our noxious weed species are native to Eurasia. Many originated in the Mediterranean region, where agriculture and domestic livestock have been part of the landscape for thousands of years. Plants from this region evolved under these conditions of disturbance. Therefore, when Europeans brought their land practices with them to the New World, some of the plants that tagged along with them were better adapted than the native plants to human changes that were being made to the environment.

Each area of the country has its own group of noxious weeds. For a listing in your area check the website http://www2.montana.edu/weedcenter/queryweedsform.html . You will find a search page for weed listings for each state in the United States.

Materials:
Plant identification key
"Map Your Plant Community" activity sheet
Three rolls of flagging
Marking pens
2'X3' cardboard flip charts with paper

Procedure:
In this activity we will learn how plants are distributed in communities. We will lay out plots and map the plants growing there.

1. Divide the group onto three groups, one for each area to be studied. Assign each group an area.
2. Go over instructions to the group before they go to their plot:
   a. Select an area within your specific plant community that appears to be representative of the plant community.
   b. Use colored flagging to lay out a plot that is 12 steps by 12 steps.
   c. Once the plot is established and marked, as a group, determine the plants that seem to be most significant or characteristic of your site.
   d. Each team member should select one of these plants as a primary study plant to map. A secondary study plant could be included if time and circumstances allow.
   e. Work by yourself to map the location of your plant on your study plot. Follow the instructions on your "**Activity A**". Also, map significant features such as fallen logs, rocks, fences, or streams.
   f. Finally after mapping your study plants, work with the other team members to make a representative map of all of the study plot plants on a large sheet of flip chart paper provided. Your group will give a short presentation (2-4 minutes) describing your map and the distribution of study plants. Involve all members in the presentation.
3. Record the data
   a. Have teams lay out their maps side by side as they make their presentations
   b. If two or more teams describe the same plant a common symbol should be agreed upon so that composite maps in **Activity B** are comparable.
   c. As teams are reporting have students look for patterns (similarities and differences) among the plots. Tell students that they will be deducing reasons for the differences between the various sites. To help accomplish this, have students record information from the presentations on Activity Sheet B.
4. Discussion
   a. Which plots seemed to have the most plants? The most plant species?
   b. What factors could have led to the distribution of the plants on these plots?
   c. What similarities or differences did you notice between plots?
   d. What patterns seem evident after listening to the presentations and viewing the composite map?

Assessment:
Some of the products that your class could produce include:

- a brochure of local native species in a natural area
- a map of invasive species

Extensions:

- Produce signs that inform visitors to a natural area about the local native species.
- Develop brochures or a *PowerPoint* presentation for educating the public about invasive plants
- Create a slide show of local flora
- Teach elementary students about local noxious weeds
- Develop a local noxious weed display
- Design a plan to eradicate noxious weeds in a study area
- Design a plan to return native species to a study area

Resources:
Agencies to seek for partners:

- State Fish and Wildlife Department
- County Weed Supervisor
- City Parks and Recreation Department
- U.S. Forest Service
- Bureau of Land Management
- U.S. Department of Fish and Wildlife
- Soil Conservation Districts

Internet Resources:
Plant identification sites:
Lady Bird Johnson Wildflower Center. 2002. Native Plant Information Network. http://www.wildflower.org/?nd=clearinghouse_publications . May 18, 2003.

U.S. Department of Agriculture. No date. Northeast Wetland Flora: Field Office Guide to Plant Species. http://www.npwrc.usgs.gov/resource/1999/neflor/neflor.htm . May 18, 2003.

U.S. Department of Agriculture. No date. Southern Wetland Flora: Field Office Guide to Plant Species. http://www.npwrc.usgs.gov/resource/1999/soutflor/soutflor.htm. May 18, 2002.

Plant survey sites:
Colorado State University Department of Rangeland Ecosystem Science. April 2, 2001. Protocol for surveying and monitoring endangered species. http://www.cnr.colostate.edu/frws/research/rc/tes2.htm . May 18, 2003.

Washington State Department of Ecology. February 25, 2003. Aquatic plant survey methods. http://www.ecy.wa.gov/programs/wq/plants/management/survey.html. May 18, 2003.

Invasive species and weed sites:
Plant Conservation Alliance. April 23, 2003. Weeds Gone Wild. http://www.nps.gov/plants/alien/ . May 18, 2003.
Bureau of Land Management. January 12, 2000. How to Prevent the Spread of Noxious Weeds. http://www.blm.gov/education/weed/weed.html May 18, 2003.

University of Idaho. January 9, 2002. Idaho Weed Watchers. http://plantain.ag.uidaho.edu/ . May 18, 2003.

The Nature Conservancy. May 2003. Wildland Invasive Species Program http://tncweeds.ucdavis.edu/ . May 18, 2003.

Montana State University, Department of Land Resources and Environmental Sciences. 2001. Center for Invasive Plant Management http://www.weedcenter.org/education/educationhome.html . May 18, 2003.

Books:

Wilson, T. D. 1996. Weeds of the West. The Western Society of Weed Science. Pioneer of Jackson Hole. Jackson, Wyoming. 630 pp.

USDA Forest Service. 1993. Investigating Your Environment: Teaching Materials for Environmental Education, USDA Pacific Northwest Region, Portland, OR, 220 pp.

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ACTIVITY A: Map Your Plant Community

1. Select a representative area and mark the boundaries (corners and midpoints) with flagging. The plot should be twelve steps square.
2. As a group, decide upon the most significant or most characteristic plants of your plot.
3. Each student should choose one of these as a primary plant to map and describe.
4. Working individually, map the location of all occurrences of your study plant. Develop your own plant symbols.

Primary Study Plant (Name)______________________________(Symbol)_______________
Secondary Study Plant (Name)____________________________(Symbol)_______________
Other Significant Plants (Name)___________________________(Symbol)_______________

ACTIVITY B: Plant Distribution

As presentations are made, please characterize each plot by sketching general plant patterns that you see.

Plot

Observations: ____________________

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Observations: ____________________

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Observations: ____________________

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Developing Community Awareness of Local Animals

Abstract:
With community input students will survey a park, school grounds or other local natural environments. Students will identify animals and construct a dichotomous key, and design a brochure for community use.

Age Group:
Grades 9-12

Time Needed: From 5-10 class periods

Major Concepts:
Animals
Ecosystems
Classification

Objectives:
Upon successful completion of this exercise, students will be able to:
- gather lists from local and state agencies and organizations of sensitive species, or species of local concern
- research information about the animals from local tribes, local histories from farmers and senior citizens recollections, scientific papers, natural resource agencies and organizations, and the Internet
- collect data from a survey produced by students and given to appropriate community groups
- construct a dichotomous key that will allow the identification of local species
- produce a CD-ROM and web page on the Internet via the school home page

National Standards Addressed:
Unifying Concepts and Processes: Systems, order, and organization
Science as Inquiry: Abilities necessary to do scientific inquiry
Life Science: Interdependence of organisms
Science and Technology: Understanding about science and technology
Science in Personal and Social Perspectives: Science and technology in local, national, and global challenges

Teacher Background:
The research, data collection and publishing of information will be done as part of a unit on animals. With community input students will observe a local park, school grounds or other local natural area. With a list of expected animals from local agencies and organizations students will inventory the animals that are present. They will then construct a pamphlet, field guide, web page, and/or CD-ROM program that list scientific names, life histories, and local stories to help tie in animal interactions and impact in the local environment. Working with local tribes, senior citizens, and local farmers will add to the information available for students. In addition, forming partnerships with natural resource agencies and organizations will be critical for the protocols and equipment necessary to observe, collect, or identify animals. Call them, they are always eager to help.

Most city parks, local trails, and school grounds have not been inventoried for animal presence (insects, aquatic species, reptiles, birds, mammals). Scout troops, Audubon Society, native plant clubs could use the brochures, or CD-ROM as field guides and foster grassroots awareness of local resources. These data can also be used by city planners, fish and wildlife personnel, and concerned citizens to make informed decisions about how a local area should be managed. Examples of possible management practices include, but are not limited to, watering, spraying or cutting schedules.

Schools would have a community study site that will allow students to see how data are collected, recorded, presented, and built on by succeeding classes. Schools could pass on local information with programs like *Naturescaping* and the *GLOBE* programs that use local data and pass it on to regional, national, and international centers. This will allow students to see how their data can be merged into the bigger picture encompassing our biosphere.

Introduction:
Animals are a diverse group of organisms that include sponges, worms, arthropods, and vertebrates. Knowing what animals live in your community is important for the future health of our ecosystems. Animals and their diversity are important indicators of the health of an ecosystem and knowing where they are found in your community can affect land use and management practices.

Animals are an important part of the energy flow and nutrient cycling that takes place in an ecosystem. They are dependent on a variety of biotic and abiotic factors for their survival. Factors such as temperature and sunlight or plant species for food or shelter can affect the types and numbers of animals you find.

Animals have a variety of adaptations that allow them to survive and reproduce in particular ecosystems. They also fill various niches or roles in an ecosystem such as herbivores, carnivores, or omnivores. Removing one species from a system can put the entire system in stress and at risk. Information that is collected and disseminated on the animals present in an ecosystem will allow communities to make more informed decisions about how local ecosystems should be used and managed.

Materials:
Mapping materials (tape measures, trundle wheel, clipboards, rulers, templates, graph paper)
Investigating a Community Worksheet
Field guides and binoculars
Computer lab with Internet access, web page development and desktop publishing software

Procedure:
Students will:

- Map the site selected for study (agencies and mapping resources are available to assist in this)
- In teams of three, use the *Investigating a Community* worksheet to evaluate the mapped site
- Research the animals that could be present by talking to local parks dept., city planners, school district maintenance department, Audubon Society, and other city, state, and county agencies and organizations.
- Inventory the animals that are present (agencies can provide protocols).
- Research animal characteristics and life histories. Research both legendary or mythical and scientific information with the intent of animating stories of each animal.
- Construct a classification key of major animals
- Produce products for the community such as a brochure of the area with student drawings of all animals, create a CD-ROM with local histories and Indian legends of totem animals, and on the high school web site post all the data along with links to local fish and wildlife sites
- Present information to community groups

Assessment:

- Map of the site (laminated for outdoor use)
- Dichotomous key of local animals
- Community product such as a brochure of local animals associated with the study site, a CD-ROM of animals /plants of the site, or post the entire project to the Internet using schools web page.

Presentations to various community groups

Extensions:

- Participate in national programs such as *GLOBE* and *Naturescaping*
- Establish a long-term ecological study site

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INVESTIGATING A COMMUNITY

NAME: ________________________

A. Examine the non-living factors that affect the community you are studying.

1. Describe your community ____

____

____

2. Weather ____

____

3. How much sunlight does your community receive during the day? (any shade?)

____

4. Record the air temperature ____

5. How much moisture does it have at this time of year? marshy dry damp

B. Describe the different habitats found in this community. ________________________

____

____

____

____

C. List the different plant types found.

1. Which is the dominant plant type? ______________________________________

2. Which type shows evidence of having been eaten? ___________________________

____

3 How many different kinds of plants did you find? ___________________________

____

(Collect samples of each.)

D. List all the different types of animals you can find in the community. ________________

____

____

1.Which animals did you see? ____

____

E. Using the list of plants and animals, draw a food web for your community. Include all the feeding relationships you can think of.

1. Identify the ecological niche of each organism:

Producers ____

First Level Consumers ____

Second Level Consumers ____

Third Level Consumers ____

2. Which animals might be in competition with each other for food? ______________

____

____

3. Give examples of how some organisms in this community depend on each other.

____

____

____

____

4. How have humans affected this community? ______________________________

____

____

Determining Your Ecological Footprint

Abstract: An ecological footprint account is the day-to day journal of what each person uses to support a lifestyle and can provide a snapshot in time of the number of acres of biologically productive land needed to support that lifestyle.

Age Group:
Grades 9-12.

Time Needed: There are two surveys in which students can participate. One is a quick 10 minute survey. The second survey requires three days of data collection prior to the completion of a 20 minute survey.

Major Concepts:
Human impact on the environment and resource consumption

Objectives:
Upon successful completion of this exercise, students will be able to:
- calculate one's own ecological footprint as a measure of the impact each one of us has on the Earth.
- keep a journal (an ecological footprint account) that documents one's own resource use and waste generation
- make personal decisions consistent with a more sustainable lifestyle

National Standards Addressed:
Science in Personal and Social Perspectives: Environmental Quality: Natural and human induced hazards
Science and technology

Teacher Background:
This activity could be a self-invitation into the community to study how individuals and communities use resources. This can lead into other community connections such as participation in Earth Day, an awareness survey for schools, or a web link from a school web site. Students can estimate the school's ecological footprint and present this information to the school board with a plan to reduce that footprint (and probably, the costs for running the school). The students can survey other students and present this information in a public forum or poster presentations to other schools. Students could also conduct a community campaign and present this information to community organizations and schools.

Introduction:

The average American produces four pounds of garbage, uses about 7 gallons of non-renewable fossil fuel and generates 20 pounds of carbon dioxide in the atmosphere each day. The carbon dioxide released into the atmosphere contributes to global warming. Pharmaceuticals and personal care products are showing up in our waterways. Pollutants and pesticides released into our watersheds are placing strains on our water ecosystems, plants, animals and destroying their habitats.

The Earth has a limited amount of resources available to each person on an annual basis. The amount of impact on the environment is dependent on the productive area needed to generate resources and absorb each person's waste. This is called an **ecological footprint**. An ecological footprint is the amount of biologically productive land needed to support human life. An **ecological footprint account** is the recording of the amount and kind of transportation, water use, recreation, food and living space each one of us use and how we dispose of our waste.

Before the agricultural revolution, the human population was low and resources were readily available. When resources were used up, people would move on to new locations with accessible resources and start anew. This movement allowed the Earth time to replenish itself before people returned to an area. The agricultural movement allowed people to stay in one area for extended periods of time. Hunting and farming practices tended to have long-term impacts on local environments. Small areas and then larger areas were depleted of forests, tillable soil due to the depletion of soil nutrients, potable water and over hunting and in some instances, hunting some species to extinction. When a whole population exceeds its ecological footprint, the Earth is incapable of renewing itself.

At this point in human history, the Earth can provide us with 5.3 acres per person of biologically productive land. The average person is dependent upon 7.1 acres of productive land, which means some people do without while others exceed their limit. The average American needs the equivalent of 24 acres to support his or her lifestyle. Americans leave a footprint about twice the size of those in Western Europe.

Every choice that one makes can be a choice that allows our planet to regenerate itself or be potentially devastating. Recognizing how much is in our ecological footprint account and how much each individual uses will make the student aware of misuse, overuse and waste. This survey is designed to alert each student to daily activities one can eliminate or modify to make a significant difference in his or her ecological footprint.

Materials:

Computer with Internet access

Procedure:

Two quizzes can be utilized to allow students to have an increased awareness of how many resources they use on a regular basis. The short quiz allows one to estimate via a computer program, a quick estimate of one's ecological footprint. To access this program go to www.rprogress.org.

To use the longer quiz, students must keep a three day log of activities that include, the type of house they live in, how many live there, the amount of water consumed, how they travel, the type of food they consume, where it is purchased, etc. The teacher may download the quiz and print a copy for the students to keep their data or complete the quiz on line. This quiz may be accessed at www.educ.uvic.ca/faculty/mroth/438/environment/webstuff/footprint.html.

Assessment:

- Completed ecological footprint account
- Calculate the school's ecological footprint to present to the school board
- Design a method to reduce the school's ecological footprint
- Conduct a student/community survey and post results on school web site
- Develop a display for school awareness of ecological footprints

Extensions:

- Make an environmental album of newspaper and magazine articles
- Write letters to the local newspaper or state legislators
- Teach a lesson on ecological footprints to elementary students
- Submit surveys to magazines
- Create an advertisement for public service
- Create a slogan or bumper sticker for Earth Day celebrations
- Create a political cartoon for the school paper
- Invite local politicians or experts for a panel discussion

Resources:

Earth Day and The Ecological Footprint, 2002. A short quiz to determine one's ecological footprint by Redefining Progress, Center for Sustainability Studies, 2000, WWF, Gland, Switzerland. www.rprogress.org Accessed April 27, 2003.

Ecological Footprint. A three day quiz that includes many facets of everyday living that will determine one's ecological footprint.
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National Resources Defense Council (NRDC). A guide to cleaner living, ways to conserve water and energy as well as ways to live more simply.
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Appendix - NCSR Background

NORTHWEST CENTER FOR SUSTAINABLE RESOURCES — NCSR

What is the Northwest Center for Sustainable Resources?

Mission Statement

The Northwest Center for Sustainable Resources (NCSR) is a collaborative effort among educators, employers, and others which is enhancing natural resources programs at community colleges and high schools and providing a clearinghouse for information on sustainable natural resources. A Center of Excellence funded by the National Science Foundation's Advanced Technological Education program, the Center is incorporating innovative teaching methods, state-of-the-art technology, knowledge from cutting-edge research, and hands- on field experiences into natural resource technology programs. Major goals for the project include integrating community college programs into a "seamless education" from K-12 through university, working closely with employers in curriculum development, emphasizing work experience for students through internships, and developing core programs that prepare students to work as technicians for organizations dealing with aquatic and terrestrial ecosystems. Programs feature environmental monitoring, mapping, instrumentation, and other related skills woven within the context of managing complex ecosystems. Program graduates are receiving technician degrees, and have advanced skills, or they are receiving degrees which transfer to four-year colleges and universities. Combining improved curricula with an information clearinghouse for natural resources education, the Center is providing an effective model for education/employer alliances for the nation.

"NCSR—EDUCATION FOR A SUSTAINABLE FUTURE"

The Northwest Center for Sustainable Resources is a collaborative effort of partners from Oregon, Washington, northern California, and Maryland, including high schools, community colleges, four-year colleges and universities, private industries, government agencies, and Native American tribes. The Center's main activities focus on curriculum development, faculty and teacher enhancement institutes, and national dissemination of products.

The Center is developing natural resource technology programs which incorporate higher levels of mathematics and science, using an ecosystems-based approach which emphasizes sustainable methods for resource use.

KEY OBJECTIVES:

Curriculum development: Five “lead site” colleges and six “test site” colleges have developed advanced technological curricula in natural resource-based associate degree programs.

Faculty and teacher enhancement institutes: Field- and laboratory-based experiences are being offered for teachers from all levels of education around the country, along with tours of world-class research sites, and other professional development activities.

Promotion and dissemination: NCSR materials are being showcased at key national and regional conferences and symposia, and are being posted in an electronic clearinghouse. Promotional products are being disseminated, including a videotape and reports entitled “Visions for Natural Resource Education and Ecosystem Science for the 21st Century” and “American Indian Perspectives: Nature, Natural Resources, and Natural Resources Education.”

NCSR has over 100 partners from education, employment, Native American tribes, professional societies, and research groups.

RESOURCES WE CAN PROVIDE:

— Field- and lab-based faculty development institutes, including the Ecosystem Institute, Natural Resource Institute, and Adaptation Institute.

— Curriculum materials in natural resources technology two-year programs materials reflect an ecosystem approach, and advancements in science, mathematics, and technology. Programs include agriculture, fisheries, forestry, geographic information systems, and wildlife.

— Up-to-date publications, videotapes, and other materials for institute participants and other NCSR partners.

— A website with connections to model research sites, Native American tribal home pages, national secondary education ecology-based projects, job sites, and other natural resource-related information.

— A national model for natural resource educational programs which incorporate employers’ needs, science and research-based activities, Native American perspectives, and working partnerships.

FOR MORE INFORMATION:

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