Agriculture and the Environment, 3rd Edition

A teacher's guide for bringing the environment into the middle and high school classroom

AMERICAN FARM BUREAU FOUNDATION FOR AGRICULTURE®

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WELCOME TO AGRICULTURE AND THE ENVIRONMENT

Snapshot

The "Teacher's Guide on Agriculture & the Environment" is designed to show how most agricultural and environmental issues involve trade-offs. All decisions need to be supported by reliable, science-based information that is implemented carefully and in a practical manner. The following chapters offer background information for teachers on the interrelated agricultural and environmental issues concerning pesticide use, food safety laws and regulations, water quality, wetlands and endangered species. The material is designed for students in grades 6–9; however it may be applied to older grade levels as well.

The material was originally written by Linda Maston McMurry, an award-winning, former Texas middle school science teacher with more than 17 years of experience. All information was reviewed and updated in 2012 by American Farm Bureau® Foundation for Agriculture education specialists.

Each Chapter Includes the Following:

- Relevant **background information** that may be used to supplement educator knowledge or distributed to students for in-class reading.
- Thought-provoking **processing questions** that can be asked of students after reading background information, as a transition to the key learning activity.
- A **standards-based activity** that provides an opportunity for students to apply knowledge addressed in the background information.
- Issues **citations and resources** that can be used to guide follow-up investigation.

Contact

The "Teacher's Guide on Agriculture & the Environment" is one of the classroom resources provided by the American Farm Bureau Foundation for Agriculture, a 501(c)(3) nonprofit affiliate of the American Farm Bureau Federation, to fulfill its mission of building awareness, understanding and a positive public perception of agriculture through education.

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CHAPTER 1: AGRICULTURAL & ENVIRONMENTAL ISSUES

Introduction

Educators face a tremendous challenge in communicating complex agricultural and environmental issues to students. It can be difficult to sort through the abundance of issues while balancing changing public attitudes, scientific advances, information and opinions to provide a methodical, fair overview of the sector. New developments continually redefine agricultural and environmental capabilities.

Many Americans believe they know an adequate amount about environmental issues and problems. Yet, the 2005 National Environmental Education & Training Foundation (NEETF)/ Roper Survey found that "about 80 percent of Americans are heavily influenced by incorrect or outdated environmental myths," and, "just 12 percent of Americans can pass a basic quiz on awareness of energy topics." According to the NEETF/ Roper Survey data, most Americans have much to learn about the environment.

Parents want to be assured that agricultural activities, like those in every walk of life, do not pose unacceptable risks to themselves, their children or the environment, but such assurances can only be meaningful when they are based on sound science and reliable data. Allegations of harm or claims of safety based strictly on emotion do not serve anyone's interest. For example, federal regulations governing pesticides are scientifically based and provide an ample margin of safety for the public. Yet some groups allege that all pesticides should be avoided, not only raising unwarranted fears but raising concern among farmers that not just their crops but their livelihood itself might be threatened. Family farmers share a common goal with their urban neighbors-protecting the environment and preserving the traditions of agriculture. More than anyone else, American farmers and ranchers have a stake in the future of America's natural resources. With 97 percent of America's farms and ranches operated by individuals or families, maintaining and improving our nation's natural resources is vital to keeping the business in the family for generations to come.

The health of U.S. farms and ranches is directly related to the financial health of the U.S. economy. According to the most recent official USDA Census of Agriculture, there are 2.2 million farms in the United States, and the total workforce in agriculture is about 3 million. These workers are involved in a variety of jobs. For example, jobs in farm machinery manufacturing, milling, baking and food service are connected to the work of America's farm families.

Risk

Risk is part of our daily lives. Sometimes policy questions will be posed as though society has the option of a guarantee of safety when, in fact, nothing we do is risk free. We get on our bikes or ride in our cars knowing there is a risk that we might be involved in an accident. We watch toddlers take their first steps knowing they risk falling and getting hurt. We ingest tons of chemicals in the form of prescription drugs. We allow our children to eat grapes and peanuts even though there is a possibility they could choke on them.

We can do certain things to minimize risks. We can wear safety helmets and seat belts and ride and drive defensively. We can move toddlers away from furniture with sharp edges and keep unsafe items like electrical cords out of their way. We can encourage our children to chew their food before swallowing it and to not talk when their mouth is full. We can take medicine only when we absolutely need it. But, even with these measures, we realize that nothing is 100 percent safe.

Different Perspectives

People both young and old sometimes need help learning how to evaluate benefits and risk factors. According to Purdue Pesticide Programs, "We make judgments based on our values and experiences, on the information available and on the credibility of our source. Ideally, we should gather all the facts before passing judgment: to use or not to use; to allow or to ban. But **everyday situations often provoke spontaneous decisions**, even without all the facts and even when an immediate response is unnecessary."

A high school freshman doing a science project asked 50 people if they would sign a petition demanding strict control or total elimination of the chemical "dihydrogen monoxide" because it:

- Can cause excessive sweating and vomiting.
- Is a major component of acid rain.
- Can cause severe burns in its gaseous state.
- Can kill if aspirated.
- Contributes to erosion.
- Decreases effectiveness of automobile brakes.
- Has been found in tumors of terminal cancer patients.

Of the 50 people surveyed, 43 (86 percent) said they would sign the petition, six were undecided and only one said no. Yet, if the student asking the question had called dihydrogen monoxide by its common name—water—the results would have been a unanimous no. Perception and context can be critical to making the right decision.

Learning how to judge scientific information accurately can be a challenging task. When examining information, one should consider: validity, context, and tradeoffs.

- **Validity:** If a study was involved, was it conducted properly? Are the conclusions easy to understand? Is the disclosed information true? Has the study been replicated? Has the study been published and peer-reviewed?
- **Context:** Scientific studies are little snapshots of data. How is this data used?
- **Tradeoffs:** Since even the safest solution may not be totally safe, what are the tradeoffs? Do the benefits outweigh the potential costs? Does the proposed solution raise issues that are potentially worse than the original problem?

Risk is the chance of injury, damage or loss; the degree or probability of loss; the act of exposing oneself to a risk or taking a chance. Scientists and government officials usually address risk in terms of probability for *populations*, not individuals. The scientific classification for risk may range from low to high to absolute. However, individuals often associate the word "risk" with "danger" instead of "probability."

Risk Assessment & Risk Management

For agriculture, as in other sectors, the science-based processes of risk assessment and management help determine reasonable public safety and environmental risk levels. These processes measure and characterize risk, estimate the probability of occurrence and the nature and magnitude of potential adverse effects. For example, scientists may assess various risk factors from pesticide residues in or on the foods people buy and develop management strategies to control residues.

Risk managers make judgments and decisions according to the acceptability of the level of risk identified during risk assessment. They integrate social, economic and political factors into risk assessment results. For instance, professionals who manage pesticides think about their effectiveness in controlling target pests and the possible benefits and risks to the environment.

Processing Questions

Use these questions to prompt discussion with students after reviewing the content presented.

- How would you describe the role agriculture plays in America?
- How does agriculture affect the American economy?
- What can we learn from the student-led survey on "dihydrogen monoxide?"
- What is risk, in your own words?
- Why do you think the author makes a distinction between "danger" and "probability" when defining risk?
- How is risk managed?

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ACTIVITY 1: SHOULD THIS PRODUCT BE BANNED?

Standards Addressed

- NS.5-8.1/NS.9-12.1 Science as Inquiry: Abilities necessary to do scientific inquiry. Understandings about scientific inquiry.
- NS.5-8.6 Personal and Social Perspectives: Risk and benefits. Science and technology in society.
- NS.9-13.6 Personal and Social Perspectives: Natural and human-induced hazards.

National Science Education Standards come from the National Academies of Science and the American Association for the Advancement of Science.

Process

Ask students to work in small groups to identify the product in question. The product:

- Contains a chemical that causes cancer in laboratory animals.
- Causes serious injury to millions of people.
- Kills 40,000 people a year.
- Kills millions of animals a year.
- Causes fires when ignited.
- Requires tremendous resources for production.
- Causes major air pollution problems.
- Produces toxic gases.
- Causes billions of dollars in property damage every year.
- Destroys millions of acres of land for roads to facilitate it.

After students have shared their guesses, ask them to make an initial conclusion on whether this product should be banned. After deciding, inform students that the product referred to is an automobile. Ask students to do a risk/benefit analysis to reach a reasoned conclusion about whether the product should be banned. Ask each group to discuss its analytical process and conclusion with the entire class.

The automobile and its risks are an acceptable part of American life because individuals believe they have control over the risks and because there often is no good alternative to the automobile.

CHAPTER 2: PESTICIDES AND PEST MANAGEMENT

Introduction

Dandelions in the lawn, wasp nest on the front porch, caterpillars chewing up tomato plants or a mouse in the pantry—each of us have faced these or other pest problems. Often, the first response is to apply a pesticide or other chemical treatment designed to control the pest damage. Sometimes we even apply pesticides to prevent invasions by pests. Most of us do not think twice about using these products.

Although the overuse of pesticides can lead to environmental damage and health hazards, the availability and use of pesticides has improved our lives. When people think of pesticides and food, however, a variety of questions arise. One might wonder if it is safe to eat fruits and vegetables with pesticide residues on them. If pesticides kill or injure living organisms, do we really know what they are doing to us? The following chapters will investigate these issues.

What is a Pesticide?

The word *pesticide* is a generic term that refers to products meant to kill or control the entire spectrum of organisms that people consider pests. The specific categories of pesticides are:

1. Insecticides for insects
2. Herbicides for plants
3. Rodenticides for rodents
4. Nematocides for nematodes
5. Fungicides for fungi
6. Arachnicides for spiders, mites, ticks

Some pesticides are formulated to be effective on specific pests while others are useful for a broad spectrum of pests and therefore are multipurpose.

Who Uses Pesticides?

Farmers, ranchers, landscaping services, pest control services and others engaged in commercial use of pesticides must be trained and licensed, or certified, to apply pesticides. Certified individuals must demonstrate their competency to handle pesticides safely and judiciously through testing and training. Annual continuing education courses are required in order for pesticide applicators to maintain their certification. In the United States, stringent regulations exist to control how pesticides must be sold, mixed, applied, stored and disposed.

Farmers are strongly motivated to use pesticides responsibly because of the laws and regulations governing crop protectant use. As consumers and citizens, they also have a personal commitment to protect their families, communities and the environment from reckless chemical use.

Relatively few pesticides are licensed for "restricted use only" by certified applicators. The vast majority of pesticides are available to everyone. The primary difference in the pesticides used by homeowners or consumers and those that commercial applicators use is the size of the container. The concentrations often remain the same.

Unfortunately, some consumers mistakenly believe that if a little is good, then twice as much is twice as good. Consumers may not be sure how to properly dispose of excess product. Too often, remaining pesticides and containers are put out for regular trash pickup or residues are poured down a drain into the sewage system. Municipal sewage treatment systems generally are not designed to remove pesticides, so these untreated contaminants become another source of water pollution.

FARMERS' PRIMARY GOALS ARE TO GROW SAFE, NUTRITIOUS AND AFFORDABLE FOOD. GROWERS AND MARKETERS OF FRESH FOOD PRODUCTS ARE ESPECIALLY CONCERNED ABOUT PRODUCT SAFETY AND CONSUMER HEALTH.

Progressive Farming Practices and Pesticides

Pesticides, when used appropriately, can increase food production, decrease food cost and provide consumers with products that are free from insect damage. United States consumers are accustomed to these benefits; however, nations around the world struggle with pest destruction every day. According to CropLife America, "20 to 40 percent of the world's potential crop production is already lost annually because of the effects of weeds, pests and diseases." This is an important factor to consider when evaluating the projected population growth and demand on agricultural production worldwide. Today, farmers fight pests by incorporating pesticides with a variety of farming practices:

Conservation Tillage: Both soil erosion and the amounts of pesticide used have been drastically reduced with the introduction of conservation tillage. With conservation tillage (no-till or low-till) farmers do not mechanically till their fields to get rid of weeds or they only till in a limited way to prepare the seedbed. Instead, they leave crop stubble and dead plant material in between the crop rows and apply herbicide to kill the weeds that would otherwise rob a crop of moisture and nutrients.

Conservation tillage practices allow farmers to reduce fuel consumption from equipment use, leave the soil in place, use fewer pesticides and apply less fertilizer. This reduces associated costs as well. Although herbicide use has gone up with expanded use of no-till farming, overall U.S. farm use of pesticides continues to go down each year. In part, this is because of a new generation of pesticides that are effective when applied in smaller amounts.

New Pesticides: The new generation of pesticides used today break down faster in the environment and are effective in smaller doses—often at ounces per acre rather than pounds per acre. They are targeted to be harmful only to specific organisms. One of the best examples is glyphosphate (found in Roundup® herbicide), which kills targeted weeds by interfering with their photosynthesis. Because insects, birds and people do not carry on photosynthesis, it has no serious effect upon them. Furthermore, microorganisms found in the soil help quickly degrade glyphosphate, thus preventing its accumulation in the environment.

New Crop Plants: Because glyphosphate does not distinguish between weeds and crop plants, researchers have developed several crop varieties that are resistant to glyphosphate. Farmers who plant these crops are able to use one of the safest herbicides available to kill weeds in their fields without any danger to their valuable crop plants. New pest-resistant plant varieties enable farmers to control certain pests with less pesticide. The ability to use fewer applications and smaller amounts of pesticides means increased profit for farmers.

Global Positioning Systems: Global positioning system (GPS) units use computer technology linked to satellites to determine precise field locations where pest control is needed. This allows farmers to better regulate the amount of pesticide delivered in a more efficient manner than was previously possible.

Integrated Pest Management: Integrated pest management, or IPM, is a systems approach to pest management that integrates the use of chemicals with cultural, mechanical and biological control methods to minimize pest damage. The goal of IPM is not to completely eradicate pests, but rather to control pest populations in order to prevent both the pests and the pest management activities from having an adverse affect upon both crops and the environment. The methods of doing this vary among crops and among regions of the country.

IPM is not an anti-pesticide program. Rather, it involves selective use of pesticides designed specifically for an intended pest, and only in necessary amounts, since overuse can cause insects to build up resistance to pesticides. Healthy plants can withstand a surprisingly large number of insect pests. In an IPM program, both the pest populations and the beneficial populations are monitored. Naturally occurring organisms, such as ladybugs, preying mantises and lacewing larvae, frequently prevent pest damage by reducing pest numbers. Birds are also effective biological control agents on some insect pests. (Birds may also be a pest problem that needs to be controlled.)

A successful IPM program relies on farming practices such as uniform planting and plow-up dates to prevent pests from moving from field to field. Planting crops before insects become active and using varieties that are pest-resistant or faster maturing enable farmers to harvest before pests become too abundant. The use of intermixed plantings can help control

pests by attracting beneficial insects or by attracting pests away from one crop into other plantings. Planting alfalfa strips next to cotton is one example of this approach.

Pheromone Traps: Pheromone traps can be used to trap insects or keep them from mating. These traps also help farmers find out the kinds and numbers of insects in a field.

Other Strategies: Commercially available insect pathogens can kill certain pests but spare beneficial species. Nets, reflective mulches and planting distance from roads are other means of mechanically controlling the movement of pests into a field.

Together, these farming practices attempt to create favorable growing conditions for plants and unfavorable conditions for pests.

Pesticides and Groundwater

According to Extoxnet FAQs, approximately half of the U.S. population obtains its drinking water from groundwater sources. In agricultural areas, some 95 perent of the population use groundwater for drinking water. A pesticide's potential to contaminate water is based on its ability to dissolve in water, as well as environmental factors, and farm application methods.

Environmental factors such as soil, weather, season and distance to water sources are all incorporated into farmers' pesticide management plans. Rate and timing of pesticide application are critical in determining whether it will leach into groundwater. The larger the amount used and the closer the time of application to a heavy rainfall or irrigation, the more likely some pesticide will leach into groundwater.

For example, atrazine is one of the most common herbicides used to control weeds and, at the same time, prevent soil erosion. It is used only during three months of the year and is applied to a field once during the growing season. Not surprisingly, atrazine is one of the herbicides that frequently show up in groundwater supplies. But is it dangerous? Atrazine breaks down quickly in the environment and recent testing has shown that it is 10 times safer than previously thought.

The Safe Drinking Water Act establishes standards for drinking water and the Environmental Protection Agency sets Maximum Contamination Levels (MCLs) for pesticides in public water supplies. Private water supplies are not monitored or regulated by this act. Therefore, watershed communities and private well owners should monitor contaminant levels using the various testing and treatment options available to the public. Although there is a chance that pesticides are present in our drinking water, there is no evidence that they are present at levels that pose any real risks to our health and to the environment when properly monitored.

Based on scientific research and farming experience, reliable conclusions can be drawn that will help farmers make wise decisions about what pesticides to use in certain situations and the possibilities of risks to the groundwater environment. It is important to remember that pesticide and groundwater relationships are site-specific. Even minor changes in the soil-crop-environment-pesticide relationship can change the potential for groundwater contamination.

Farmers Take Preventative Measures

Farmers continuously evaluate the need, method and frequency of pesticide use. Before applying pesticides, farmers:

- Identify the vulnerability of the soil.
- Consider the location of the pesticide application in relation to surface water and groundwater.
- Become familiar with pesticides that may leach.
- Follow the directions on the pesticide label.
- Apply the pesticide at the appropriate time.
- Measure the pesticide properly and carefully.
- Calibrate and maintain spraying equipment.
- Avoid spilling.
- Direct the application to the target site.
- Leave buffer zones around sensitive areas.
- Dispose of pesticides properly.
- Store pesticides safely.
- Maintain records of pesticide use.
- Consider weather and runoff.
- Check the well system.

Food Production and Pesticides

In summary, pesticides reduce the negative impact of pests on crop production, enhance food production per acre, increase the variety of foods, and contribute significantly to our abundant, high quality, economical food supply. Without pesticides, we would pay higher prices for food that would invariably show signs of damage by insects or other pests. In addition, we would be forced to divert land into food production that is now being set aside as forests, wetlands and wildlife habitat. The land itself would suffer if farmers had to cultivate soils of reduced or marginal fertility.

According to Purdue Pesticide Programs, "Pesticides are an integral part of the crop production equation that enables one American farmer or rancher to produce enough food to feed more than 100 people per year. It takes less than 2 percent of the American workforce to produce enough grain, meat and fiber to feed the nation, freeing the remaining 98 percent to pursue other vocations."

Processing Questions

Use these questions to prompt discussion with students after reviewing the content presented.

- What are some reasons farmers have for being careful with pesticide application?
- Recall two progressive farming practices. How do these affect pest control and the use of pesticides?
- Why is groundwater protection important to consider when applying pesticides at one's home or on a farm?
- Of what benefit are pesticides?

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My Notes

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ACTIVITY 2: DILUTION SOLUTION

Standards Addressed

- NS.5-8.1/NS.9-12.1 Science as Inquiry: Abilities necessary to do scientific inquiry. Understandings about scientific inquiry.
- NS.5-8.3 Life Science: Regulation and behavior.
- NS.5-8.6 Personal and Social Perspectives: Risk and benefits. Science and technology in society.
- NS.9-13.6 Personal and Social Perspectives: Natural and human-induced hazards.

National Science Education Standards come from the National Academies of Science and the American Association for the Advancement of Science.

Introduction

Pesticides today are nothing like they were 30 years ago. They are increasingly effective in much smaller amounts, are not nearly the health hazard that they once were and are much friendlier to the environment. They are also increasingly expensive. This means that a farmer is not going to use any more than is absolutely necessary to control a pest.

As a general rule, the amount of pesticides farmers use is equal to spreading a pint of water evenly over a football field. In this activity, the learner will attempt to spread a small amount of vinegar evenly over a surface area in much the same way a farmer would spread a pesticide over a field.

Objectives

After completing the activity the learner should be able to explain why:

- Detection of a substance does not necessarily mean it is harmful.
- Pesticides can be used in such small amounts.

Materials

- ◯ Vinegar
- ◯ pH paper
- ◯ 25 mL distilled water
- ◯ Spray bottle
- ◯ Graduated cylinder
- ◯ Micro-pipette, eyedropper or syringe (Used to measure vinegar. Note: 1 drop from an eyedropper equals approximately .05 mL)
- ◯ Safety goggles
- ◯ Scale
- ◯ Table top
- ◯ Paper towels or newspapers to cover surface of lab table.

Procedure

1. Wearing safety goggles, test the pH of the vinegar and record it in the table provided.
2. Test the pH of the distilled water and record it in the table provided.
3. Pour 25 mL of distilled water into the spray bottle. Measure out 0.05 mL of vinegar and add it to the distilled water. Cap and shake to mix.
4. Test the pH of the vinegar/water solution and record it in the table provided.
5. Weigh the spray bottle and contents. Record weight in the table provided.
6. Cover your lab table with paper towels or newspapers. Measure the lab table covered and calculate the area you are about to spray in square inches. Record the area in the table provided.
7. Spray the vinegar/water solution evenly over the surface of the lab table.

8. Weigh the spray bottle and contents after spraying. Record the weight in the table provided.

9. Calculate the amount of spray mixture you applied by subtracting the current weight from the initial weight. Record in the table.

10. Calculate the application rate per square foot. Hint: Application rate = Amount Applied/Area Applied.

11. Calculate the amount of active ingredient (vinegar) applied for one square foot. Hint: First determine the percentage of vinegar in the total solution. Percent = mL vinegar/mL total solution. Multiply this percent by the application rate, determined in step 10 above.

12. An acre of land is 43,560 square feet. If you applied the vinegar/water solution at the same rate over a whole acre, how much active ingredient would be applied to the whole acre?

Table 1: Data Collected	
A. pH VINEGAR	
B. pH DISTILLED WATER	
C. pH VINEGAR/WATER SOLUTION	
D. INITIAL WEIGHT OF SPRAY BOTTLE AND CONTENTS	
E. AREA OF COVERED LAB TABLE	
F. WEIGHT OF SPRAY BOTTLE AND CONTENTS AFTER SPRAYING	
G. AMOUNT OF SPRAY MIXTURE APPLIED	
H. APPLICATION RATE PER SQUARE FOOT	
I. AMOUNT OF ACTIVE INGREDIENT (VINEGAR)	
J. AMOUNT OF ACTIVE INGREDIENT APPLIED TO ONE ACRE	

Summary Questions:

1. **THE pH OF THE VINEGAR/WATER SOLUTION WAS MOST LIKE THE pH OF ◯ *THE VINEGAR*, ◯ *THE WATER* OR ◯ *SOMEWHERE IN BETWEEN*.**

2. **HOW IS TRYING TO SPREAD 0.05 ML OF VINEGAR EVENLY ACROSS THE TABLE SIMILAR TO HOW A FARMER SPREADS PESTICIDE ON A FIELD? HOW IS IT DIFFERENT?**

3. **MOST ACCIDENTS WITH PESTICIDES HAPPEN DURING THE MIXING AND TRANSFER STAGE. WHY DO YOU THINK THIS HAPPENS? WHAT COULD BE DONE TO HELP PREVENT IT FROM HAPPENING?**

4. **EXPLAIN THE ROLE TECHNOLOGY PLAYS IN REDUCING PESTICIDE USE.**

5. **WHY DOES THE DETECTION OF A PESTICIDE IN DRINKING WATER NOT AUTOMATICALLY MEAN THE WATER IS UNSAFE TO DRINK?**

CHAPTER 3: FOOD SAFETY & REGULATION

Introduction

Juicy red apples, crisp green lettuce, golden ears of corn, crunchy orange carrots—all free from signs of disease, decay or insect damage. This is what we look for when shopping for produce. Few of us think about why we are able to buy food of this quality all year round at a reasonable price. And, we assume the foods we buy, whether fresh, frozen or canned, are safe to eat.

Regulating Food Product Safety

The U.S. Department of Agriculture and the Food and Drug Administration (FDA) have developed a variety of programs and policies to address food safety issues. Collaboration between USDA agencies, FDA and the Environmental Protection Agency (EPA) assures that officials make well-informed decisions concerning the safety of our food and drinking water supply.

Pesticides are regulated by both federal and state government agencies. At the federal level, the EPA, under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Food Quality Protection Act (FQPA), regulates pesticides and their effects. No pesticide can be legally sold or used in the United States unless its label bears an EPA registration number and establishment number. EPA approves a pesticide only for specific uses. The label tells where and how the pesticide may be used. A number of pesticides are labeled as restricted use pesticides, and only certified applicators may use these products

Before being registered, pesticides are subject to extensive testing to ensure that, when used properly, they will not present unreasonable risks to human health or to the environment. EPA calculates safe, lifetime human exposure levels in terms of the Acceptable Daily Intake, or ADI.

Updating Delaney

The nature of pesticides and the means of detecting them continue to evolve with technological advancements. In 1958, the Delaney Clause was enacted to prohibit the use of additives in processed foods that were shown to induce cancer in experimental animals. It allowed for zero tolerance. Any product that had a detectable amount of an ingredient known to cause cancer was banned, regardless of its potential benefits. However, at that time, scientists were able to detect substances only in parts-per-hundred (very high residue rates).

Currently, scientists routinely detect substances in parts-per-billion, and even in parts-per-trillion. This means that the same foods tested in 1958 and declared safe may today be considered contaminated simply because technology allows us to detect the presence of only a few molecules.

In 1996, after years of urging by leading scientific groups, the U.S. Congress repealed the zero-tolerance Delaney Clause and passed the Food Quality Protection Act (FQPA) to keep up with new technology. The law establishes additional safety standards for agricultural chemicals used on food crops. It also requires major supermarkets to provide consumers with information on the risks and benefits of agricultural chemicals and how to reduce their exposure. In 2006, EPA started a program called "registration review," which calls for a review of all pesticide registrations every 15 years. Congressional involvement and oversight is needed to ensure that EPA's decisions are reasonable, well-supported by reliable scientific information and balanced in order to avoid disruptions in agriculture and farmers' ability to compete effectively in international trade and in providing a steady, safe food supply that is affordable for U.S. consumers.

Updating Risk Factors

So how are we affected by amounts of pesticides equal to parts-per-million, billion or -trillion? Essentially, we are unable to eat or drink enough of a product to be affected by pesticides present at parts-per-billion and lower levels. The consensus among medical experts is that there is a *greater risk* of getting cancer and other diseases by *not* eating fresh fruits and vegetables than there is from consuming minute amounts of pesticides. Low pesticide exposures encountered in the workplace, in food and in drinking water do not necessarily cause harm. In order to understand pesticide risk, we must understand the importance of dosage.

For example, ingesting an entire bottle of aspirin would kill you. If you take two aspirin, however, you generally feel better. Taking just a little flake of one tablet would probably leave you feeling nothing, even though you have a detectable level of aspirin in your body. When thinking about pesticides, food safety and health it is important to consider several factors:

- The sophistication of modern detection methods.
- The new generation of synthetic pesticides.
- Naturally occurring plant pesticides.
- Consequences of not using pesticides.

As technology continues to improve, we may routinely detect amounts as small as one part-per-quadrillion.

Is it Safe to Ban Pesticides?

What about the possible consequences of not using pesticides? To protect our food crops, farmers and ranchers around the world must compete with approximately 1 million insect species, a thousand species of harmful nematodes, hundreds of weed species and enough varieties of fungi to cause 1,500 plant diseases. Without pesticides to control molds, much of our food supply would rot and consumer health would be at risk, since molds in high enough concentrations can be lethal.

Without the use of pesticides to control fungi, celery would produce its own natural pesticides, called *psoralens*, that can cause a severe skin reaction in humans. The use of a fungicide prevents this from happening. The fact is, most plants fend off predators by producing their own chemicals that act like pesticides. We ingest at least 10,000 times more of these natural pesticides than residues of manufactured pesticides, according to Bruce Ames, a cancer researcher at the University of California at Berkeley. He says that nearly all pesticides in the human diet occur naturally in plants. And, ounce for ounce, natural pesticides are at least as potent, if not more so, than synthetic ones. Ames says plants that are grown organically tend to have even higher total levels of carcinogenic chemicals than plants grown with synthetic pesticides because the plants produce more natural chemicals when attacked by insects.

On the whole, however, the amount of chemicals in *both* organic and conventional produce is smaller than the dose that would be expected to cause any harm. (Heartland Institute, March 1998)

Irradiation and Food Safety

Irradiation technology has long been used to sterilize medical supplies, surgical instruments, makeup, personal hygiene products, as well as irradiated food eaten by astronauts and patients with compromised immune systems. FDA approved irradiation as a means to preserve freshness and destroy illness—causing bacteria in a wide variety of foods. Since 1986, FDA has allowed low-dose irradiation of a variety of fruits and vegetables to delay maturation and/or to treat insect infestation. Much like pasteurization, food is irradiated to prevent insects, fungi, parasites and bacteria such as Salmonella, E. coli, Listeria and Trichinella that cause human disease and food spoilage. Irradiated food can be kept longer and in better condition.

Food moves through a radiation field at a set speed to control the amount of energy that passes through it. Both the speed and the amount of radiation are computer controlled. The irradiated food is no more radioactive than your luggage is after passing through airport security, or your teeth are after an X-ray at the dentist. In addition, irradiated food is as nutritious as food preserved by any other method, and does not pose a health risk.

Animal Health Product Safety

FDA is responsible for monitoring and regulating the use of animal health products. Strict regulations exist for use of animal health products to treat animals. These products also are tested to make sure they are safe for humans.

Milk production is one of the most regulated food production processes. Recently, concerns have been raised about the use of recombinant bovine somatotropin, or rBST, to increase milk production. Bovine somatotropin is a naturally occurring

cow hormone that shows up in their milk. The genetically engineered form of BST, rBST, simply enables more efficient milk production. Tests have shown that supplemental use of BST does not change the amount of the hormone normally found in milk, which is completely safe, natural and harmless.

USDA makes sure that all meat processors follow strict guidelines and handling procedures to assure that meat and poultry are safe. USDA inspectors test animals for more than 400 substances. Still, some bacteria may be present in raw meats if they are not appropriately refrigerated and prepared by consumers. Most of the food poisoning cases in the United States occur because of mishandled food at home, not in food service establishments. Ultimately, proper hygiene and safe food handling methods are our best protection from food poisoning.

Food Safety and Acceptable Risk

As a society, we have come to believe that certain benefits far outweigh the amount of risk involved. The risks involved in food safety should be no different. Yet, sometimes information gets distorted and it is difficult to determine exactly what the risks are. We have the right to expect that the food we buy is safe to eat and our water safe to drink. But we also need to realize that nothing is ever going to be guaranteed 100 percent risk-free. We need to weigh the benefits against the risks and decide if the risk is acceptable. When we do this, we find that our food supply is one of the safest in the world. And while there are certainly extremely small risks involved, very few come from the pesticides, chemicals or technologies used to produce them. For example:

1. Cyclamates and saccharine, both artificial sweeteners, were banned even though in the case of saccharine, a person would have to drink over 800 cans of soft drinks a day for years to reach the point where they might risk getting cancer. The public uproar over saccharine has kept it on the market despite the fact that the FDA has ordered it to be re-tested and has restricted its use to that of a controlled, over-the-counter, tabletop sweetener. Cyclamates, on the other hand, still have not regained approval.

2. Alar, a growth regulator used on apples to keep them from dropping off the tree too early, was voluntarily removed from the market because of a media scare that linked it to cancer in children. However, a child would have to eat 28,000 pounds of Alar-treated apples daily for 70 years in order for there to be any possibility for tumors to form.

What the Experts Say

Dan Nixon, MD, PhD
American Cancer Society

The cancer risk for children from eating fruits and vegetables as it relates to pesticides is very, very small. The benefits that you get from eating fruits and vegetables far outweigh any risk from pesticide residue in vegetables and fruits.

American Medical Association

Epidemiologic reports of the past decade reinforce the conclusion that fruit and vegetable consumption is linked to reduced cancer risk. The levels of synthetic pesticide residues in food seem so low as to be of no consequence whatever.

C. Everett Koop, MD
Former U.S. Surgeon General

To sell nothing except foods untreated by pesticides would not only leave storekeepers with rotting food, but would also fail to protect the consumer against molds that in high enough concentration can be lethal. People who are so worried about pesticides fail to realize that the cancer rates have dropped over the past 40 years.

American Institute For Cancer Research (AIRC)

Manufactured chemicals, such as dioxin, are believed to cause less than 1 percent of all cancers. When people are exposed to the small amounts of such chemicals usually found in the air, water, soil and food, they have very little added risk of getting cancer.

Nancy Wellman, PhD, RD

Florida International University; Former President, American Dietetic Association

Fruits and vegetables that have been grown with pesticides give very little increased risk of cancer. And, in fact, the benefits—the anticancer benefits from a diet that includes more fruits and vegetable—is much higher.

3. Atrazine, a popular herbicide, is frequently detected in extremely low levels in groundwater supplies, particularly in the Midwest during the growing season (approximately a four-month period of time), when farmers apply a one-time application to their fields. Even during times of peak usage, the levels detected are so low that a person would have to drink 154,000 gallons of water a day just to reach EPA's No Effect level of 20 parts-per-billion. Yet, there is a move to ban atrazine.

Processing Questions

Use these questions to prompt discussion with students after reviewing content presented.

- What federal agencies regulate food safety?
- Why do you think researchers take the No Observable Adverse Effect Level of a pesticide and multiply it by 10,000 percent to determine how much is safe to use?
- What is your opinion of the Delaney Clause and its subsequent revisions?
- Why is dosage an important factor when evaluating pesticide risk?
- What is irradiation used for, and how does it affect food safety?

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ACTIVITY 3: GIVING PLANTS THE "RAT TEST"

Standards Addressed

- NS.5-8.1/NS.9-12.1 Science as Inquiry: Abilities necessary to do scientific inquiry. Understandings about scientific inquiry.
- NS.5-8.3 Life Science: Structure and function in living systems. Regulation and behavior.
- NS.5-8.6 Personal and Social Perspectives: Risk and benefits. Science and technology in society.
- NS.9-12.3 Life Science: Behavior of organisms.
- NS.9-12.6 Personal and Social Perspectives: Environmental quality.

National Science Education Standards come from the National Academies of Science and the American Association for the Advancement of Science.

Introduction

Before EPA approves a substance, it is tested extensively on rats. These rats are either force-fed or injected with the substance at a level many times higher than a human could possibly consume. At a high enough dose, even the safest substances will cause death or cancer in rats. When these test results are applied to humans, many otherwise safe products are removed from the market or never approved in the first place.

Objectives

After completing the activity, the learner should be able to explain:

- Why the amount of a chemical, and not merely its presence, makes the poison.
- How EPA estimates the effect of substances being tested.
- Why the effects for one species are not necessarily the same for another.

Materials

- ◯ 6–9 potted plants (all the same kind)
- ◯ Labels (1 per plant)
- ◯ Vinegar
- ◯ Tap water
- ◯ 3 watering containers
- ◯ Graduated cylinder or other measuring device
- ◯ Eyedropper (Note: 1 drop equals approximately .05 mL)

Procedure

1. Divide the plants into three groups. Label each group A, B and C. Label each plant with the corresponding letter and a number (i.e. A-1, A-2, A-3, etc.).
2. Each plant in **Group A** is to be "watered" with 50 mL of pure vinegar daily.
3. Each plant in **Group B** is to be "watered" daily with 50 mL of tap water to which one drop (or .05 mL) of vinegar has been added.
4. **Group C** is the control group. Each plant will receive 50 mL of tap water daily with NO vinegar added.
5. Make sure the environmental conditions for all three groups of plants are the same, with the exception of what they are watered with. Keep the watering containers used for each group separate and marked so as to not accidentally use a contaminated watering container on a different group of plants.
6. For two weeks, record the daily changes in the plants. Common measurement data for plant growth include height (from soil to plan tip) and leaf count. This information can be recorded on the table provided. These records may also be made by taking photographs or using a video camera to record changes.

Height (cm)									
DATE	A-1	A-2	A-3	B-1	B-2	B-3	C-1	C-2	C-3

Leaf Count									
DATE	A-1	A-2	A-3	B-1	B-2	B-3	C-1	C-2	C-3

Summary Questions

1. THE PLANTS "WATERED" WITH VINEGAR ◯ *DIED,* ◯ *SHOWED NO EFFECT OR* ◯ *GREW RAPIDLY.*

2. THE PLANTS "WATERED" WITH THE WATER/VINEGAR MIXTURE GREW AT RATES SIMILAR TO THE PLANTS "WATERED" WITH ◯ *VINEGAR,* ◯ *TAP WATER.*

3. WAS THE SMALL AMOUNT OF VINEGAR HARMFUL TO THE PLANTS? ◯ *YES* ◯ *NO*

4. IS WATERING THE PLANTS WITH PURE VINEGAR A GOOD WAY TO ESTIMATE THE TYPE OF DAMAGE THAT A PLANT WOULD RECEIVE FROM A TINY AMOUNT OF VINEGAR? EXPLAIN.

5. HOW MIGHT YOU DESIGN A BETTER TEST TO DETERMINE THE EFFECT VINEGAR IN THE ENVIRONMENT MIGHT HAVE UPON PLANTS?

6. WHAT DO YOU THINK THE EFFECTS WOULD BE IF YOU DRANK THE SAME AMOUNT OF VINEGAR AS THE PLANTS WERE WATERED WITH ON A DAILY BASIS FOR TWO WEEKS?

CHAPTER 4: WATER QUALITY

Introduction

Few things are more enjoyable on a hot summer day than catching fish from a clear mountain stream, splashing around at the edge of a lake, canoeing down a river or a tall glass of cold water to quench your thirst. All of these activities depend on access to quality water supplies.

Since the nation's primary water pollution prevention legislation—the Clean Water Act—was enacted in 1972, we have made great strides in cleaning up our water supplies. Yet, much of the attention has been given to easily recognized point sources of pollution, such as factories and sewage treatment plants. Today, given the growth of our economy and increases in our nation's population, attention is on both upgrading our technology to deal with our aging sewage systems and more generally on pollution derived from expanding populations and land use trends that both affect non-point sources of water pollution.

Is Our Water Safe?

The United States is composed of thousands of local ecosystems, each with its own issues and challenges. Communities and networks of communities need to work together to solve local water quality issues that are simply beyond the scope of broad national policy.

Varying conditions and uses of water complicates the process of measuring water quality trends. The dozens of different pollutants and pathogens, variety of water conditions and seasonal variation in water flows make assessment a difficult task.

One of the greatest problems affecting the issue of water quality is the lack of adequate data. Because water testing is time-consuming and expensive, the majority of our rivers and streams have never been adequately monitored. Much of the testing is done downstream of urban areas where a problem is more likely to exist. Consistent, long-term monitoring is required if we are going to develop an accurate, scientifically sound picture of the overall health of our nation's water.

Students In Action

While a sophomore in high school, Barrett set out to prove that Nueces River pollution sources were incorrectly identified in the 1995 Texas "Draft 319 Assessment." This assessment automatically listed riparian grazing as a pollution source during the Environmental Protection Agency's early rounds of the Total Maximum Daily Loads (TMDL) listing.

"The Nueces River is not a very big river. But it is the only river I have," Barrett said. "I have swum in this river since I was a baby, camped on its banks, fished and canoed on it. So when the state said it was polluted and not safe for contact recreation, I didn't believe them." Barrett presented the scientific methods he used to test the health of the Nueces River and how his research ultimately proved that the pollution originated at an upstream housing subdivision, and not as a result of cattle.

Water Pollution Categories

Sources of water pollution can be grouped into two major categories: point-source pollution and non-point source pollution.

POINT-SOURCE POLLUTION

This type of pollution can be pinpointed directly to its source, such as a pipe discharging raw sewage or wastewater directly into a river. Prior to the Clean Water Act and the Clean Rivers Act, these types of activities were perfectly legal. Subsequent regulations detail what may be discharged and under what conditions.

Point-source pollution has been the primary focus for control efforts since the passage of the Clean Water Act in 1972. This type of pollution generally comes from the millions of gallons of wastewater discharged by municipal sewage treatment plants and industrial sources. Since 1977, all industrial and municipal dischargers have been required to have both federal and state permits. Do these federal and state permits mean zero pollution is discharged into our nation's waters? No, the permits do not guarantee pure water. They simply allow continued discharge of pollutants up to the "permitted level." Also, under high rainfall events that exceed the storage capacity of the treatment ponds, raw sewage and untreated wastes do occasionally overflow into streams and rivers. Permits do help minimize and prioritize our effort to achieve higher levels of water quality.

Wastewater is considered a potential source of pollution because it contains organic and inorganic materials that can be hazardous to humans and wildlife. Wastewater may lower the amount of dissolved oxygen in water because different organic materials require different amounts of oxygen to be broken down and stabilized in the environment. This is known as Biochemical Oxygen Demand, or BOD; the greater the BOD, the greater the oxygen depletion of the water.

NON-POINT SOURCE POLLUTION

The *exact* location and source of this pollution is difficult to pinpoint. Non-point source and natural background pollution accounts for a large part of the water pollution in our country's rivers, lakes, streams, bays and estuaries. Contributors to this type of pollution can be grouped into two general categories: urban/industrial and agricultural.

Most municipal wastewater treatment facilities are not equipped to treat pesticides, herbicides and toxic household chemicals. Consequently, these chemicals pass unchanged through the water treatment process to be discharged in wastewater.

Any construction can be a source of pollution as ground cover is disturbed and the underlying soil is eroded by wind and rainfall. Traditional agricultural practices such as irrigation, fertilizer and pesticide use, and animal waste are potential sources of non-point source pollution. Farmers apply nutrients, mainly nitrogen, phosphorous and potassium, to promote plant growth. These beneficial materials affect water quality if the nutrients are inappropriately applied or in excessive amounts. With the adoption of newer conservation practices, however, these pollution problems are less likely to occur. Confined feeding operations such as dairies or cattle feedlots are especially vulnerable to non-point source pollution. These types of operations are prohibited from allowing wastewater or animal waste to leave the property. All runoff must be controlled, except when excessive rainfall occurs. In these cases, it is not always possible to prevent runoff from fields or overflow from other types of holding structures.

Pesticides in Water

Over the past few decades, farmers have dramatically increased their use of conservation tillage techniques that keep crop residue, such as leaves and stalks, in the field. According to the Conservation Technology Information Center, conservation tillage was used on nearly 114 million acres, and reduced tillage on nearly 60 million acres, in 2008.

According to the University of Illinois Extension, as of 2005 over 40 percent of the acres of crops planted in the United States are included in these types of crop residue management. This greatly reduces field runoff and keeps crop protectants where they belong in the field and out of streams.

On the whole, the greatest human health hazard from pesticide exposure occurs in the mixing and transfer of chemical concentrates, not so much in the spraying, and not in the detectable levels in groundwater.

Natural Non-Point Source Pollution

One problem with controlling non-point source pollution is the lack of information about the amounts of pollution contributed by natural sources. Nitrogen is considered to be an agricultural pollutant. Yet every thunderstorm creates several thousand pounds of nitrogen. Wildlife waste also adds to the nutrient loading of streams and rivers.

In addition, the underlying geology of a region can add nitrogen, phosphorous, salts and heavy metals to water. Streams and rivers erode rocks, adding pollution to the water. Unfortunately, these sources can be difficult to measure and few baseline studies are

being done to determine exactly what effects these factors have on water quality. Additional information is needed for informed science-based decision-making.

Best Management Practices Protect Water Quality

Farmers and ranchers are the original conservationists. They realize that good management of natural resources increases the value and productivity of their land. Over the years, agricultural production practices have improved the environment by reducing pollution and, at the same time, reducing farm production costs. These best management practices include:

- Efforts to minimize the loss of nutrients applied to fields into surface and groundwater while still maintaining the soil fertility and nutrients at levels necessary for the best crop growth. Crop producers increase the efficiency of nutrient use by fine-tuning application rates, timing and placement to match plant growth.
- Conservation initiatives at the federal, state and local levels have helped farmers, ranchers and other landowners install conservation practices. Agricultural producers who install conservation practices can improve the soil, air and water quality; enhance wildlife habitat; restore biodiversity; and create scenic landscapes.
- Integrated Pest Management (IPM), a comprehensive approach to controlling pests through cultural, biological and chemical control systems. Pesticides are applied only when needed, which means fewer chemicals that could be lost to surface and groundwater, and substantial monetary savings for farmers.
- Waste management systems that temporarily store animal wastes such as manure, milk room wash water, and feedlot runoff for future application to croplands.
- Vegetative and tilling practices such as conservation tillage, contour farming, contour strip cropping and field borders are other types of best management practices that are reducing the movement of pollutants and lessening soil erosion by wind, rain and runoff.

All these practices are not only good for the environment because they reduce or eliminate pollution. They also conserve energy and save money.

Chemical Water Quality Indicators

Water quality tests generally attempt to determine the presence of heavy metals, pesticides, industrial chemicals and various types of toxins. Water quality is affected by factors such as: temperature, pH, salinity, nitrate-nitrite, phosphorus, alkalinity, dissolved oxygen and fecal coliform bacteria.

Oxygen: The amount of dissolved oxygen present is related to water temperature. Warm water holds less dissolved oxygen than cold water. Different species of fish require different dissolved oxygen levels in order to thrive. Consequently, raising the water temperature could be considered a form of pollution because it lowers the amount of dissolved oxygen in the water, which in turn can adversely affect the aquatic ecosystems of that particular body of water.

pH: The pH level of water is determined by a number of things. Distilled water has a pH of 7, which is neutral. Normal rainfall is naturally slightly acidic, with a pH of about 5.5. Depending upon the geology of the region, the waters pH may be higher or lower. Water running through rocks and soils that are of granite origin, for example, would be expected to have a pH of around 4 to 4.5. Water running through rocks and soils that are primarily of a limestone origin could be expected to have a pH of about 8 to 8.5. Over time, acid rain can change the pH of the water and have a negative affect upon the aquatic communities that are adapted to a particular range of pH.

Alkalinity: Alkalinity is a measure of waters ability to neutralize acids. It is a fairly reliable measure of the productivity of a lake or stream. Too low an alkalinity level will not support much life, even though the water may appear nice and clear. Geology and acid rain can contribute to low alkalinity. High alkalinity levels can result from respiration in water, the underlying geology (usually limestone or dolomite) or sewage pollution.

Nutrients: Water needs a certain level of nutrients to be productive. Overloading it with nutrients, however, can cause problems such as algae blooms. These blooms clog the water and block sunlight from reaching the lower levels of the water column. When the algae dies, the process of decay can use up the oxygen in the water and in some cases results in fish-kills.

Runoff: Runoff from nitrogen and phosphorus fertilizer applications and animal wastes is the most frequently cited source of nutrient loading in streams, rivers, lakes and bays. Runoff can

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come from unexpected sources. **The average homeowner uses *eight times* the amounts of fertilizers and other chemicals per acre as the average farmer.** Septic tanks, wastewater discharges and improperly functioning wastewater systems are other sources for high nutrient levels. It is also important to remember that nitrogen is also added through rainfall.

Phosphorus: Phosphorus is another nutrient necessary for productive water. Unlike nitrogen, very little phosphorus enters water bodies through runoff. This is because soil particles, particularly clay, can hold on to phosphate ions. Phosphorus is also believed to be a limiting factor in the production of algal blooms regardless of the level of nitrogen and other nutrients present in water. As a result, many sewage treatment plants have special units designed to remove up to 95 percent of the phosphorus from wastewater.

Bacteria: Fecal coliform bacteria found in the digestive tract of all warm-blooded animals are relatively harmless in and of themselves. However, because their presence is an indicator of other pathogens that cause infectious diseases like hepatitis and cholera, it is regulated at levels designed to prevent human illness.

Water Quality Standards

More than one set of water quality standards exists, depending on intended use. Maximum Contaminant Levels (MCLs) are the legally enforceable drinking water standards. Stricter quality standards are applied to water used for contact recreation, such as swimming, than water intended for non-contact recreation, such as boating. For bodies of water with more than one purpose, the more stringent water quality standards apply.

Processing Questions

Use these questions to prompt discussion with students after reviewing the content presented.

- Compare and contrast the two sources of water pollution (point and non-point).
- How does conservation tillage affect water pollution?
- Recall and describe one best management practice that protects water quality.

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My Notes

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ACTIVITY 4: CLEAN IT UP!

Standards Addressed

- NS.5-8.1/NS.9-12.1 Science as Inquiry: Abilities necessary to do scientific inquiry. Understandings about scientific inquiry.
- NS.5-8.5 Science and Technology: Abilities of technological design.
- NS.5-8.6 Personal and Social Perspectives: Risk and benefits. Science and technology in society.
- NS.9-12.6 Personal and Social Perspectives: Natural Resources. Environmental quality.

National Science Education Standards come from the National Academies of Science and the American Association for the Advancement of Science.

Introduction

Until the early 1970s people believed that groundwater was pretty well protected from surface contamination by the layers of soil, clay and rock overlying it. For the most part this is true. When combined with other agricultural best management practices (such as filter strips at the margins of production fields to prevent runoff), the ground and overlying vegetation does indeed act as a very efficient water filtering system.

Even with improved techniques, however, we have discovered that it doesn't filter out all contaminants. This means that we can now detect extremely minute amounts of substances that we were previously unable to. This does not necessarily have any effect on the safety of our surface and groundwater, just our ability to detect impurities in it. It is the dose that makes the poison, not merely the presence of a substance.

Objectives

After completing the activity, the learner should be able to explain:

- Reasons for water quality degradation.
- Challenges in determining water quality standards.
- How best management practices that use natural filtering properties of plants, soil, clay and rock can protect water quality.

Materials

- 3 clear disposable plastic cups (per group)
- Kitty litter
- Food coloring
- Clean, sterile sand
- Aquarium charcoal
- Almond extract
- Cleaned gravel
- Coffee filter
- Water

Scenario

You are in charge of water quality for your community's water system. Residents have complained that the water looks and smells funny. Using the materials provided, determine how you will provide them with high-quality drinking water and also convince them it is safe to drink.

Procedure

1. Fill one plastic cup half full of water. This cup will act as your water source. Add food coloring and almond extract, which will serve as the pollutant contaminating the water source. Set this cup aside.
2. Poke 5–8 small holes in the bottom of the second cup. This cup will act as your filtration (or water cleaning) system. Test each filtration material (sand, litter, gravel, coffee filter, charcoal) separately by placing it in this cup to clean up the water sample.
3. The third cup will be used to catch the cleaned up water supply.
4. When you are ready, hold the filtration system cup over the collection cup. Carefully pour water from your source into the filtration system. Evaluate the water collected and record your observations in the table provided.
5. Repeat this process using each filtration material.
6. If time and materials allow, create a system using a combination of the filtration materials you feel work the most effectively. Record your observations.

	Visual Observation	Odor Observation	Additional Notes
SAND			
LITTER			
GRAVEL			
COFFEE FILTER			
CHARCOAL			
MY SYSTEM			

Summary Questions

1. **WHAT MATERIALS WORKED MOST EFFECTIVELY TO CLEAN UP YOUR WATER SAMPLE?**

2. **WERE YOU SUCCESSFUL IN CLEANING UP YOUR WATER SAMPLE?**

3. **HOW DID YOU DECIDE THAT THE WATER WAS OR WAS NOT CLEAN?**

4. **WHAT CRITERIA DID YOU USE TO DETERMINE THAT THE WATER WAS SAFE TO DRINK?**

5. **GIVEN WHAT YOU KNOW ABOUT WHAT IT TAKES TO CLEAN UP WATER, SUGGEST SOME BEST MANAGEMENT PRACTICES THAT MIGHT PREVENT, OR AT LEAST REDUCE, ANY WATER POLLUTION.**

6. **HOW WOULD YOU ENCOURAGE THE IMPLEMENTATION OF THESE PRACTICES?**

CHAPTER 5: UNDERSTANDING WETLANDS

Introduction

Wetlands have long been an interesting component of America's development. Once demonized as wastelands that were drained and converted, wetlands today bear the image of romanticized preserves that need saving and restoration. Public policy and incentives have been employed at both ends of the spectrum. Throughout much of our history, wetlands were considered dangerous, unhealthy, insect- and disease-infested places with no economic value. Many programs actively supported and encouraged people to fill and develop these lands. Chicago, like many U.S. cities, was a low marshy area that was drained and filled as it became a city. The EPA headquarters in Washington, D.C., is built on former wetlands. Many of yesterday's wetlands now produce some of American's best crops of corn, soybeans and rice. As a result, over half of the original wetlands in the lower 48 states of the U.S. have been destroyed or converted to other uses.

We have come to recognize that wetlands are important and productive ecosystems. They not only provide products for human use, including fossil fuels and food, but also help to recharge groundwater, purify polluted waters, provide habitat for wildlife, protect from flooding and offer recreational settings. Although some 75 percent of U.S. wetlands are privately owned, federal policies exist that govern their use.

Types of Wetlands

Differences in climate result in different types of wetlands found in particular areas. Despite the many individual and regional variations, wetlands can be grouped into the following general categories, according to EPA.

Marshes: Defined as, "wetlands frequently or continually inundated with water," these wetlands are home to soft-stemmed vegetation that can grow in soil that is completely saturated with water. In marshes there are plenty of nutrients. Plant and animal life thrive because the neutral pH lends to continual growth. Marshes are important because they have the ability to filter water that may have become contaminated, while regulating water in and out of streams.

What is a Wetland?

Wetlands are transitional zones between aquatic environments and terrestrial environments. The term *wetland* covers a variety of wet environments. Each wetland is a little different and not all wetlands have equal value. Swamps, bogs, coastal and inland marshes, wet meadows, potholes, playas, mudflats, ponds and bottomlands are all types of wetlands. Wetlands occur in both freshwater and saltwater systems on every continent, except Antarctica, and in every climate from the tropics to the tundra.

It is sometimes difficult to pinpoint exactly what is a wetland, and what is merely wet land. Wetlands are defined as lands that meet three criteria:

1. They are saturated by surface or groundwater for at least part of the growing season.
2. They support hydrophilic vegetation (plants adapted to live in wet environments).
3. They have hydric soils (soils that develop under anaerobic, or low-oxygen, conditions).

Swamps: Defined as, "any wetland dominated by woody plants," these wetlands are flooded during some seasons of the year. They range drastically, from thick, forested swamps to bottomlands. Swamps play an important role in flood control, and as a result, they become collection sites for dark, organic soil. Unfortunately, over 70 percent of the swamps in the United States have been lost or converted to other use because of the rich soil available.

Bogs: Known for their "spongy peat deposits, acidic waters and a thick carpet of sphagnum moss," bogs are a unique category of wetlands. Unlike the previous wetlands described, bogs do not primarily get their water from flooding, but instead, from rainfall. They play an important role in preventing flooding, however, by absorbing precipitation. EPA notes that bogs have recently been recognized as having a positive impact on global warming because the peat found in bogs readily stores carbon.

Fens: Fens may appear similar to bogs, yet they are formed differently and serve a unique purpose. Defined as "peat-forming wetlands that receive nutrients from sources other than precipitation," these wetlands collect runoff from sources above them. The primary difference between bogs and fens is that fens have a higher nutrient content, which leads to a greater diversification of flora and fauna. If significant peat builds up, fens can be cut off from the groundwater source that supplies the area, and thus transitions into a bog.

Why are Wetlands Important?

Wetlands are very productive yet fragile ecosystems. They are critical to the survival of a wide variety of plants and animals, including many threatened and endangered species. In fact, nearly 45 percent of all threatened and endangered species in the United States are dependent upon wetlands.

Coastal wetlands are important wintering areas for migratory waterfowl and shorebirds, and they are breeding grounds for wading birds. Coastal wetlands provide critical habitat for 85 percent of the migratory waterfowl traversing the United States. Bottomlands are an example of a critical wetland. These forests are flooded seasonally, and they provide habitat for numerous plants, wildlife and invertebrates. They are found along rivers.

Wetlands are important for their economic value as well. For example:

- Commercially important fish and shellfish in the United States depend upon coastal wetlands and estuaries for spawning, nursery and feeding grounds. Estuaries and coastal waters provide habitat for more than half of fish commercially harvested in the United States each year.
- The southern U.S. timber industry produces more timber than any other country in the world. Some of this timber comes from forested wetlands.
- U.S. wetlands provide furs and hides worth over $400 million each year. Fur-bearing animals, such as nutria, muskrat, mink, raccoon, otter, bobcat and beaver rely on wetlands for habitat.
- Many farmers and ranchers, especially livestock producers, depend on wetland areas, especially in times of drought, to provide vegetation for haying and grazing.
- Each year, birdwatchers, tourists and waterfowl hunters visit state and national wetlands parks and sanctuaries. Wetlands tourism in the U.S. is a multibillion-dollar industry, from which much of the profits go back into management and preservation programs. Many other recreational activities, such as hunting, fishing, boating and hiking, take place in and around wetlands.

One of the most important functions of a wetland is erosion and flood control. The presence of only 15 percent wetlands in a watershed can reduce flooding by as much as 60 percent. The dense wetland vegetation slows down the velocity of water, reducing the severity of flooding. This same vegetation also reduces soil erosion by trapping and holding sediments that would otherwise be washed away into streams and lakes. The ironic part of this ability to trap and hold sediment is that every wetland is low land that is building to become high ground. The more sediment it traps, the quicker it ceases to be a wetland.

Wetlands can also serve as a buffer for severe storms such as hurricanes. Research has shown that for every mile of vegetative wetlands, storm surge height can be reduced by 1 foot. Hurricane Andrew in 1992 provided an excellent example of the importance of wetlands. Damage to southern Florida, where no wetlands existed, was much more severe than in Louisiana, where a large buffer of coastal marshes separate towns and cities from the Gulf of Mexico.

Wetlands play an increasingly important role in water quality. Sometimes referred to as the kidneys of the planet, wetlands can effectively filter contaminants from water. Wetlands also help in groundwater recharge. Wetlands are being used for erosion control and waste treatment with increasing frequency.

Wetlands do have shortcomings as well. What do we do with the filter when it plugs up? When an oil filter on a car plugs up, it becomes a hazardous waste that must be disposed of or possibly recycled at considerable cost. Wetlands are also significant generators of methane as vegetation dies and decays.

Methane is 20 times more potent than carbon dioxide at contributing to global worming. Low-lying areas tend to collect and stagnate water. Mosquitoes like stagnant water to breed. Large mosquito populations increase the risk of transmitting diseases such as West Nile Virus and Encephalitis to humans and animal populations.

Causes of Wetland Loss

Wetland conversion for agriculture and development has historically been the main cause for loss of wetlands. All conversions have become a minor cause due to legislation and regulation. About half of the population in coastal states lives along the coast and that number increases every year. Other important activities like the construction of dams for drinking water, canals and levees to prevent flooding and dredging operations that enhances transportation of vital goods and services, can be factors that can contribute to loss of wetlands.

But natural causes also affect wetlands. Though wetlands act as a buffer to protect areas against excessive flooding from storms and hurricanes, these events do take a toll. When delta marshes no longer receive flood-borne sediments, they eventually compact and subside under open water. This can happen naturally because of conservation tillage that keeps soil on the land and/or because of dams upstream that prevent these sediments from reaching the delta. Saltwater intrusion destroys wetlands by killing the plants and converting productive vegetated marshes into less productive open bays.

Wetlands and Agriculture

In the past, wetlands were viewed as too wet for farming, too shallow for swimming and, therefore, generally undesirable. It was easier and more economical to fill them in and cultivate them. Until recently, this activity was encouraged and supported by the federal government.

However, the 1985 farm bill contained so-called swampbuster provisions that eliminated federal financial incentives and technical assistance for conversion of wetland to cropland. Under these provisions, farmers who filled in wetlands forfeited their farm program benefits until such time as the land in question was restored to its prior wetland condition.

The legislation also created the Conservation Reserve Program, a voluntary program that aims to reduce soil erosion, improve water quality, and maintain fish and wildlife habitat. This program encourages farmers to enroll highly erodible cropland or land contributing to serious water quality problems into the Reserve for 10 years to 15 years in exchange for annual rental payments. As of September 2012, farmers enrolled 29.53 million acres of their land in the Conservation Reserve Program to protect the environment and provide habitat for wildlife. The 1990 farm bill established the Wetlands Reserve Program offering landowners payments for restoring and protecting wetlands on their property through 30-year or permanent conservation easements. Since its inception, over 11,000 private landowners have enrolled 2.3 million acres of wetlands in the Wetlands Reserve Program. In addition, a private program called Adopt-A-Pothole now has 35,000 acres protected for duck habitat through its programs in North Dakota and Minnesota.

According to the 2009 report submitted to Congress, the U.S. Fish and Wildlife Service identified an estimated wetland loss rate of about 13,800 acres annually from 2004 to 2009, down significantly from the annual loss of 59,000 acres reported in the period from 1986 to 1997. The previous decade experienced a substantial loss of 290,000 acres. By gathering scientific site-specific data and subsequent research and analysis in a timely manner, we can effectively plan wetland conservation activities. It is important to examine how to define wetlands, the current rate and pattern of wetland losses, and the importance of these losses. Furthermore, we must look at whether all wetlands should be treated the same in federal programs and which wetlands should be subject to regulation. According to the National Council for Science and the Environment, "Private property questions are raised because almost three-quarters of the remaining wetlands are located on private lands, and some property owners believe they should be compensated when federal programs limit land use and thereby diminish its value."

No Net Loss

Today, authorization for a project that will have an adverse effect upon wetlands will not be given unless some sort of mitigation is carried out. Mitigation means to lessen the impact of. Generally, mitigation takes the form of restoration, creation, replacement or enhancement of a certain number of acres of wetland. Monetary compensation paid to nature projects can also be a condition of permitting. The goal is *no net loss* of wetlands. For each acre of wetland lost to a project, an equal or greater amount of wetland acreage must be added.

Processing Questions

Use these questions to prompt discussion with students after reviewing the content presented.

- How has the perception of wetlands changed over time?
- Which classification of wetlands do you find most interesting and why?
- What are some of the benefits provided by wetlands?
- What are some of the contributing factors to loss of wetlands?
- Describe the trend in wetland loss over the last 20 years.

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My Notes

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ACTIVITY 5: MAKING WAVES

Standards Addressed

- NS.5-8.1/NS.9-12.1 Science as Inquiry: Abilities necessary to do scientific inquiry. Understandings about scientific inquiry.
- NS.5-8.3 Life Science: Structure and function in living systems. Regulation and behavior. Populations and ecosystems.
- NS.9-12.3 Life Science: Behavior of organisms.
- NS.9-12.6 Personal and Social Perspectives: Natural resources. Environmental quality.

National Science Education Standards come from the National Academies of Science and the American Association for the Advancement of Science.

Introduction

Some of the more important functions of a wetland involve improved water quality, reduction of erosion and flood control. Wetlands can improve water quality by processing some nutrients, filtering out some contaminants and reducing non-point source pollution that would otherwise degrade rivers, streams and lakes. Because wetlands slow down and hold water, sediment particles such as sand, silt, clay and heavy metals can settle out. Excess nutrients in the water are then broken down by bacteria and other microbes and absorbed by plants in a process called *nutrient uptake*.

Wetland soils and vegetation act like sponges that have a tremendous ability to absorb excess nitrogen and phosphorous from run-off waters. The vegetation helps to slow down the velocity of water, allowing sediments to settle out. The root systems hold soil in place that would otherwise be carried into streams and rivers.

For this reason, many farmers are voluntarily planting filter strips and other vegetative buffers between production fields and drainage systems to help reduce pollution from non-point source pollution.

This water storage capacity can reduce flood damage from storms and hurricanes. Some of the excess floodwater stored in wetlands evaporates, while some may be fed slowly into streams. Still more may seep underground to recharge groundwater. Research has shown that for every mile of vegetated wetland along the coast, storm surge from hurricanes can be reduced by 1 foot.

Learning Objectives

After completing the activity, the learner should be able to explain how a wetland:

- Helps to control shoreline erosion.
- Can reduce flood damage from storms.
- Provides a good nursery for aquatic life.

Materials

- ◯ 2 rectangular cake pans (foil will work)
- ◯ 2–3 lbs. of clay
- ◯ 2 plastic soda bottles
- ◯ 1 carpet scrap (9x6 inches)
- ◯ Water
- ◯ Tape
- ◯ 2 bamboo skewers
- ◯ Topsoil
- ◯ Sand

Procedure

1. Pile topsoil into the middle of one pan and sand into the other. It should go all the way across the pan and be about 1½ inches below the edge in one pan. The pan with topsoil should be slightly lower than the one with sand. Push the sand and soil away from the front of the pan and slope it downwards toward the back of each pan. The front of the pan should be bare.

2. In the pan with soil, sink the piece of carpeting into the top of the soil mound. It should fit all the way across the pan. This will be the wetland vegetation. Carefully sprinkle about a handful of topsoil into the carpeting and work it down to the base. Cover the remaining area of soil with clay to create a slightly elevated lagoon.

3. In the pan with sand, build up a small sand mound in the center of the pan, and use clay to cover the remaining sand to create a slightly elevated lagoon behind the mound.

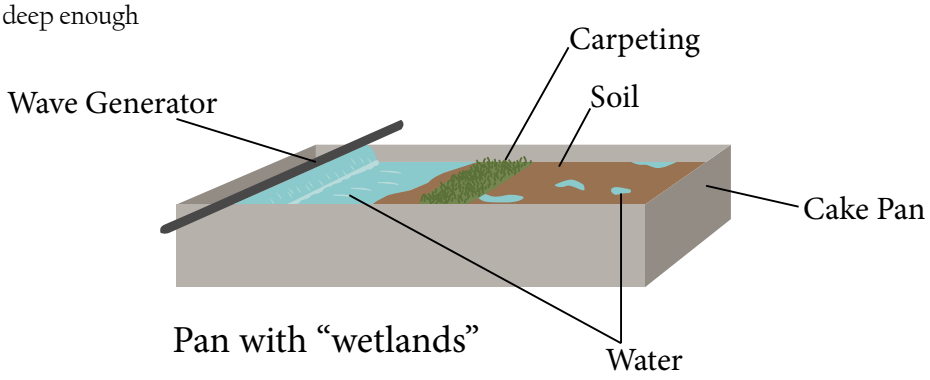
4. Cut two pieces of plastic (plastic soda bottles work well) just long enough to go across the pan and just deep enough to barely clear the bottom of the pan.

5. Center the bamboo skewers over the bare end of each pan. Tape the pieces of plastic to each of the skewers. These will be used to generate waves.

6. *Carefully* fill each pan with water. Be sure to saturate each mound of soil, including the carpeting. Be sure you get water into your lagoon. *See diagram below.*

7. Place the wave generator into the end of the tray and *gently* turn it back and forth about once every 5 seconds to create waves washing up on each shoreline. Observe what happens.

8. Now create as many waves as you can, as quickly as you can. Observe what happens.



Summary Questions

1. WHICH PAN SHOWED THE MOST EROSION?

2. HOW DID THE PRESENCE OF WETLANDS (CARPET) AFFECT EROSION?

3. HOW DID EROSION DIFFER BETWEEN THE SAND PAN AND THE SOIL PAN?

4. WHICH LAGOON (CLAY AREA) RECEIVED THE MOST PROTECTION FROM WAVES?

5. WHY WOULD THIS LAGOON MAKE A GOOD NURSERY AREA FOR AQUATIC ORGANISMS?

6. EXPLAIN HOW WETLAND PRESERVATION CAN BE A WIN-WIN SITUATION FOR LANDOWNERS, FOR WILDLIFE AND FOR THE GENERAL PUBLIC.

CHAPTER 6: ENDANGERED SPECIES

Introduction

The Endangered Species Act listed 2,029 species of plants and animals as endangered or threatened as of October 2012. Over 1,400 of these species are native to the United States. Most people are in favor of protecting endangered species. Many, especially large landowners, like farmers and ranchers, are ready and willing to make some sacrifices to do so because they recognize they are helping to preserve the world's natural resources. Unfortunately, too many do not recognize the full impact that an endangered species, and the legislation protecting them, can have on the lives of those most affected.

How Do Species Become Threatened or Endangered?

A principal threat to any species is loss of habitat, which occurs as the result of both natural and man-made causes. The spread of an invasive species is another equally significant threat to species. Human activities that can adversely affect the environment and habitat that a particular species depends upon include:

- Urban development
- Logging
- Mineral extraction
- Introduction of exotic species
- Pollution

While these activities are the result of conscious decisions over which we have some control, other factors are beyond our control. While perhaps not apparent in our daily lives, the Earth in fact is a dynamic place, where the environment, the climate and natural conditions change not so much over decades but over centuries and millennia. Continents shift, ocean basins open and close, ocean currents alter course, sea levels rise and fall, global weather patterns change, and climates cool down and warm up. If a species cannot adapt to these changes, they are in real danger of extinction.

Throughout history, extinction has been the rule rather than the exception. Some scientists suggest that only 1 in 1,000 species that have lived on Earth survives today; the other 99 percent are extinct. Thus, while human activities are a factor, they should be viewed in the context of a planet that has been constantly changing over its history and that will continue to change.

The Endangered Species Act

The Endangered Species Act of 1973 was designed to identify plants and animals threatened with extinction; add them to a list of federally regulated species; devise and implement recovery plans aimed at increasing their numbers to safe and stable levels; and then to remove them from the list.

A species is considered *endangered* if its numbers are so low that it faces extinction within a short period of time. A species is considered *threatened* if its numbers are decreasing to a point where it faces the possibility of becoming endangered.

Who decides which species should be labeled as either threatened or endangered? The U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) are the government agencies responsible for overseeing the protection and recovery of endangered species. While either agency can initiate the process, the fact is anyone may request that a species be listed. The agencies have 90 days to respond to requests from private parties and if a request is deemed worthy of consideration, they have a year from the time of the request to produce the supporting studies, documentation and background research necessary for listing a species. This timeframe means

that, in many cases, rigorous scientific studies are not initiated or conducted by the government; instead, the FWS or NMFS must use the best data available to them.

At times, the only data available is researched and submitted by the person or organization making the request. Because the data is not necessarily as rigorous as other scientific data and may rely on biased sources, tax dollars, in fact, may be spent on listing species that are not in imminent danger of extinction.

Which Species Are Protected?

When thinking about endangered species, the tendency is to think of large animals such as grizzly bears, humpback whales, manatees, bald eagles, California condors or whooping cranes. Yet, more than 97 percent of all animals are invertebrates such as snails, spiders and insects. According to the Center for Biological Diversity (CBD), invertebrates account for approximately 30 percent of animals considered for extinction. The CBD itself is a private, environmental organization that has, by one count, filed 600 lawsuits to force the federal government to expand protections to certain species. By its own estimate, it has secured 110 million acres of critical habitat.

The Endangered Species Act makes no distinction between a species and a *subspecies*, or *a distinct population segment* of a species. Any of these can be listed separately. As a result, the number of threatened and endangered species may seem high. For example, the northern spotted owl and the Florida panther are listed as endangered species. The northern spotted owl belongs to the same species as the California spotted owl and the Mexican spotted owl, which are not endangered. The Florida panther is merely an eastern version of the panthers (also called cougars, mountain lions or pumas) found elsewhere in the western United States. This lack of distinction between truly endangered species and subgroups of the species has generated increasing controversy and confusion in recent years.

In a number of cases, a species is listed as endangered simply because a particular part of the United States is at the extreme limit of its range and, therefore, the species is peripheral or uncommon in that region. That the species is common elsewhere is not taken into consideration. A case in point is the gray wolf. Gray wolves in the United States, while increasing in numbers, are not as plentiful as they are in Canada, where they are quite common. Likewise, the southwestern United States is the extreme northern range of the ocelot, which is much more common in South America.

Habitat Protection and Private Property

The Endangered Species Act prohibits anyone from harming an endangered or threatened species by harassing, hunting, chasing, trapping, shooting, wounding, killing, collecting or engaging in any other harmful activities. The act also requires *critical habitat* to be defined; critical habitat is land and other natural resources considered necessary for the recovery of a species to the point where it can be removed from the list. Modification or degradation of habitat is strictly prohibited and is punishable in the same manner as actually harming the species itself.

People assume they are entitled to do as they wish on their own land, within reasonable limits. This is, after all, one of the guarantees of the Bill of Rights. The reality is, however, that under the Endangered Species Act, some landowners may be unable to use their property for activities such as farming, ranching or forestry, even if they have already been doing so for many years. Ironically, these very activities by the landowner may have attracted the species to the land in the first place. But once an endangered species is established on a piece of property, these activities may become illegal or restricted because they constitute a modification of "critical habitat."

On private land, the Endangered Species Act treats plants differently from animals. Landowners may "take" plants found on their own property without penalty, while they are prohibited from "taking" animals. Despite this distinction, property owners bear the financial burden for providing habitat for any endangered species found on their land.

Normally, if private property is taken for public projects, the landowner is compensated and paid a fair-market price for the property. In the case of the Endangered Species Act, however, the situation is far different: while the land is not technically "taken," it may be rendered essentially unusable for normal activities like farming or timbering. Yet the landowner receives no compensation for the loss of land value, even if the owner makes his or her living from this land.

Moreover, the presence of an endangered species on a particular piece of property is not required before designating the property as critical habitat. The burden of proof that land is not critical habitat, or that the endangered species is not present, rests with the landowner. And although the landowners retain title to their land, they may well end up losing control or use of the land due to the restrictions and constraints placed upon it by the Endangered Species Act. Special-interest groups have recognized this mechanism in the law and in some cases have used critical

habitat designations as a way of halting development of unwanted projects or preventing certain activities. In such cases, the primary concern has not been the presence of an endangered species; it has been some other land use to which the groups object and for which the Endangered Species Act is a means to an end.

Impacts of the Endangered Species Act

Since the Endangered Species Act was enacted, species have been added to the list and very few have been removed. Some species were removed because inadequate data resulted in underestimation of their range, including the tumamoc globeberry in Arizona, the barbate June beetle in California and the pine barrens tree frog in Florida. The Mexican duck was determined to be just a variation of the common mallard.

Very few species rely solely on public lands for their critical habitat. The USDA Forest Service reports that approximately 75 percent of endangered species can be found on private property and, as a result, people in various areas of the United States have found themselves in conflict with the law. For example:

- In the Klamath Basin, which stretches from southern Oregon to Northern California, water and fish issues have generated national attention. The U.S. Fish and Wildlife Service ordered the irrigation gates from the Upper Klamath Lake closed to protect the endangered short-nosed suckerfish. As a result, more than 1,000 farmers could not water their crops and many fields dried up. In 2002, a committee of the National Academy of Sciences issued a report that found the government's action was based on inadequate scientific information. Controversy continues to surround the Klamath Basin Restoration Agreement and the Klamath Hydroelectric Settlement Agreement, which called for removing four hydroelectric dams and downsizing agriculture.

- Twenty-nine homeowners in southern California needlessly lost their homes to wildfires because the presence of the endangered Stephens kangaroo rat in the area prevented them from complying with a county ordinance requiring a firebreak or the clearing of tall brush. The few homeowners who ignored the ESA ruling did not lose their homes to the fire.

- Property owners in Texas and Florida have been unable to build homes on land they already own because of the potential use of that land by endangered birds. In both cases the birds were not actually present on the property.

- In California, Texas, Florida, Arizona, Utah and Colorado, landowners whose families have been farming the same land for 50 years or longer were threatened with lawsuits. Farmers were told that they could not do routine plowing and clearing because these activities would be disruptive to endangered species that potentially could be on their land.

Many environmental laws, including the Endangered Species Act, do not provide government agencies the luxury of waiting until they have all the science. Rather, scientists base decisions upon the data that is available to them. With this in mind, efforts to preserve and protect species should not pit one group against another. Instead, they should promote cooperation on environmental problems where they exist in order to maximize their effectiveness. Unfortunately, as with many issues, perception and reality can often collide and lead to different conclusions. The general public, as well as farmers and ranchers, needs to work with state agencies to resolve the issue of insufficient data. By demanding that responsible state agencies produce reliable and timely data, we will be able to restructure environmental programs so that the money spent on environmental protection truly results in environmental progress.

Agriculture and Habitat

America's farmers and ranchers have traditionally provided most of the nations wildlife habitat. Wildlife is a source of income from hunting and nature-centered activities such as birding and, in many cases, not much is required to provide good wildlife habitat. In the open plains, the presence of fence posts to provide a lookout for raptors is all that is needed for these birds to move in. Fence lines make excellent habitat for insects, small birds and mammals, and provide a source of food for raptors. Wetlands can provide forage and pasture for livestock while also providing habitat for migrating waterfowl.

Through voluntary state, federal and private conservation programs, landowners can set aside land for wildlife habitat enhancement.

- **The Conservation Reserve Program** allows landowners to enroll highly erodible land, or land contributing to a serious water quality problem, into the program for a period of 10 years in exchange for annual rental payments, cost-sharing and technical assistance to plant vegetation for conservation.

- **The Landowner Incentive Program** provides grants from the U.S. Fish & Wildlife Service to state agencies to provide financial and technical assistance to private landowners who undertake voluntary projects to enhance species or their habitat on private lands.

- **The Wetland Reserve Program** allows landowners to receive payments and technical assistance for wetland restoration in exchange for 30-year or permanent conservation easements of these lands. While these programs are not aimed specifically at endangered species, these species have nonetheless benefited.
- **Habitat Conservation Plans** offer another way for different interests to collaborate on providing habitat for endangered species while, at the same time, developing land within the habitat area. Participants agree to mitigate impacts, set aside habitat elsewhere in exchange for developing the land and abide by certain land use restrictions within the HCP area.
- **Safe Harbor Agreements** encourage private landowners to enhance habitat in areas that could potentially attract endangered species. Most landowners have a natural incentive to improve habitat on their land, and these agreements allow them to do so without incurring liability. These agreements are successfully operating in South Carolina and in parts of North Carolina and Texas. Three steps are involved:

1. The U.S. Fish & Wildlife Service conducts an inventory of the property.
2. The private landowner agrees to manage the property for the baseline inventory.
3. If an increase in a target species occurs, the landowner is not penalized.

Even if they are not involved in a program designed to enhance wildlife habitat, many farmers and ranchers voluntarily set aside and plant acreage specifically to provide food and cover for wildlife. They receive no monetary compensation for doing so. They do it merely because of the personal satisfaction received.

Updating the Endangered Species Act

Controversies surrounding the Endangered Species Act since its enactment have led to calls for its modernization. As an example, there is relatively little controversy over the time, effort and public funds spent on what are referred to as charismatic megafauna including popular species like bald eagles, manatees and seals. But there is greater scrutiny and concern with large expenditures for snails, slugs, flies and spiders, while the needs of people are ignored and their livelihoods are threatened.

Risk managers and legislators make judgments and decisions based on their perception of which species merit the most attention and funding, simply because we cannot afford to save all of them. Therefore, sound scientific studies subject to peer review need to be done to determine the status of each species before it is listed.

In addition, recovery plans need to take economic factors into consideration. Landowners should be given tax concessions or other financial compensation when their property use is restricted because of the presence of endangered species or its designation as critical habitat.

For example, when regulators found the endangered red-cockaded woodpecker at Fort Bragg, N.C., in 1988, nearby private landowners actively avoided management practices that would have benefited the rare bird. The red-cockaded woodpecker threatened the logging of many stands of privately owned tree lots. To deal with this situation, a few private landowners, government regulators and the North Carolina Cooperative Extension Service worked together to develop an innovative "safe harbor" plan. The plan removed disincentives to maintaining and improving the woodpecker habitat. Voluntarily participating landowners would not be subjected to additional regulation if habitat improvements attracted the woodpecker or increased its population. Since many people considered their lots as an investment for the future, this approach became a successful and popular preservation option.

Overall, we need to understand the perspective of landowners and adopt policies that encourage them to manage their land in ways that enhance the presence of endangered species, rather than a making the species' presence a liability and something to be avoided. We can do this by offering incentives such as conservation contracts. The Landowner Incentive Program by the U.S. Fish & Wildlife Service is a step in the right direction. With this kind of reform, the Endangered Species Act could be updated and modernized so that it provides a positive experience for people, landowners and the wildlife it is meant to protect.

Processing Questions

Use these questions to prompt discussion with students after reviewing the content presented.

- What is the main threat to any species?
- What is the difference between a species being considered "endangered" and "threatened?"
- In your own words, describe the intent of the Endangered Species Act.
- What are some of the controversial issues surrounding implementation of the Endangered Species Act?
- How would you improve the Endangered Species Act if given the opportunity?

Chapter Citations & Additional Resources

Carroll, Natalie, Ph.D. "Pfiestria piscicida: A Case Study." Purdue University. (The questions posed at the end of the case study can be used in class discussion and will help students examine different perspectives in detail.) http://www.bioethics.iastate.edu/classroom/fishkill.html

"Counting Every Erop in the Klamath Basin." Radio High Country News. Vol. 3. No. 7. Sept. 3, 2001 http://www.hcn.org

"Deep Time." Public Broadcasting System (PBS). http://www.pbs.org/wgbh/evolution/change/deeptime/low_bandwidth.html

"ESA Basics." The U.S. Fish and Wildlife Service. http://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf

"Endangered Species Act REFORM: Let's Make it Work!" American Farm Bureau Federation. 600 Maryland Ave, SW, Suite 1000W, Washington, DC 20024.

"Endangered Species Blueprint." National Wilderness Institute. P.O. Box 254766 Georgetown Station, Washington DC 20007. Volume 5. Issue 1, Fall 1994.

"Endangered Species Coloring Book: Save Our Species." Endangered Species Protection Program (H7506C). U.S. Environmental Protection Agency. 401 M Street, SW, Washington, DC 20460.

"The Endangered Species Program." U.S. Fish & Wildlife Service. http://endangered.fws.gov/

"The Endangered Species Bulletin." U.S. Fish & Wildlife Service. http://endangered.fws.gov/esb/99/11-12/toc.html

Lambert, Thomas. "The Endangered Species Act: A Train Wreck Ahead. Policy Study Number 126." Center for the Study of American Business. Washington University, St. Louis, MO 63130-4899. October 1995.

Learn more about Threatened and Endangered Species. U.S. Environmental Protection Agency. http://www.epa.gov/espp/coloring/especies.htm

National Endangered Species Act Reform Coalition. http://www.nesarc.org

Stossel, John. "Missing Lynx: Are Animals More Important Than People?" ABC News. Aug 2, 2002. Broadcast "20/20" http://www.abcnews.com/

Texas Environmental Almanac. The Texas Center For Policy Studies. Austin, Texas. 1995.

"The Extinction Crisis." Center for Biological Diversity. http://www.biologicaldiversity.org/programs/biodiversity/elements_of_biodiversity/extinction_crisis/index.html

"This Land is Whose Land?" National Wilderness Institute. P.O. Box 254766, Georgetown Station, Washington DC 20007. Volume 6. Issue 1. Spring 1995.

"Threatened and Endangered Species and the Private Landowner." USDA Forest Service. http://www.na.fs.fed.us/

ACTIVITY 6: FOOD FIGHT!

Standards Addressed

- NS.5-8.1/NS.9-12.1 Science as Inquiry: Abilities necessary to do scientific inquiry. Understandings about scientific inquiry.
- NS.5-8.3 Life Science: Regulation and behavior. Populations and ecosystems. Diversity and adaptations of organisms.
- NS.5-8.6 Personal and Social Perspectives: Populations, resources and environments.
- NS.9-12.3 Life Science: Interdependence of organisms. Behavior of organisms.
- NS.9-12.6 Personal and Social Perspectives: Environmental quality.

National Science Education Standards come from the National Academies of Science and the American Association for the Advancement of Science.

Introduction

A good habitat provides food, water, shelter, and a certain range of temperature and climate. Some species also require a lot of space, or territory. Taking away any one of these conditions reduces the quality of the habitat. If other places can more completely meet the organisms needs, it probably will move into that area. If the organism cannot adjust to changes in the existing environment, it faces the possibility of extinction.

Some changes in an organism's habitat are man-made, like urban development, logging, mineral extraction, agriculture, fishing, pollution and the introduction of exotic species. Other changes are natural, such as shifts in climate, sea level or ocean currents.

Learning Objectives

After completing the activity, the learner should be able to explain:

- Characteristics of a good habitat.
- Reasons a species may not always be able to use available resources.
- Ways in which endangered species coexist with people to the benefit of both.

Materials

- ◯ 1 package of large, thick rubber bands
- ◯ 1 large box of paper clips
- ◯ 1 package of marbles
- ◯ 100 pennies
- ◯ 5 oz paper cups (1 per person)
- ◯ Plastic spoons
- ◯ Clothes pins
- ◯ 1 sheet, blanket, or tablecloth
- ◯ 1 pad of small sticky notes
- ◯ 1 large piece of chart paper or poster board

Procedure

1. Spread the sheet, blanket or tablecloth on the floor to represents the feeding ground.
2. Completely cover the sheet with the pennies, marbles, rubber bands and paper clips. These represent items that potentially could be used as food.
3. Give each person a paper cup, representing a stomach.
4. Divide the group into two smaller groups. Give each member of one group a plastic spoon. Give each member of the other group a clothespin. These are the tools each person will use to gather the food needed to survive.
5. Participants with clothespins may only eat rubber bands. Participants with spoons may eat any of the items.
6. At the signal, participants are to gather as many food items into their stomachs as they can in 30 seconds. The following rules apply:
   A. Only one food item at a time may be picked up and only with the implement received.
   B. Food must be brought to the stomach; the stomach cannot be used to help pick up food.

C. Only one hand can be used to pick up food items.

D. Participants must return to the edge of the feeding ground for the start and end of each round.

Results

1. Once time has been called, count up the number of items you have in your cup. For each *five* items you collected, take *one* sticky note (round up to the nearest 5).
2. On the large sheet of chart paper, use the sticky notes to make a bar graph to record how well each species did.
3. Since it takes 10 rubber bands for the *clothes pin species* to survive and reproduce, anyone who did not collect 10 rubber bands is now considered dead and sits out the remaining rounds.
4. The *spoon species* also requires 10 food items to survive and reproduce. Anyone who did not collect 10 food items is considered dead and sits out the remaining rounds.
5. Repeat the rounds until either one species is extinct, or no food items are left.

Summary Questions

1. WHICH SPECIES DID THE BEST OVERALL? ◯ *THE SPOON SPECIES* OR ◯ *THE CLOTHESPIN SPECIES*

2. WHICH FOOD ITEM WAS COLLECTED THE LEAST? ◯ *PENNIES*, ◯ *MARBLES*, ◯ *RUBBER BANDS* OR ◯ *PAPER CLIPS*

3. AS MORE AND MORE OF THE RUBBER BANDS WERE EATEN, WHAT HAPPENED TO THE FEEDING SUCCESS OF THE *CLOTHESPIN SPECIES*? ◯ *DECLINED*, ◯ *STAYED THE SAME* OR ◯ *INCREASED*

4. WHAT DO YOU THINK WOULD HAVE HAPPENED IF THE *SPOON SPECIES* WAS UNABLE TO EAT RUBBER BANDS?

_____

_____

5. SUGGEST SEVERAL POSITIVE WAYS YOU COULD ENCOURAGE PEOPLE TO SAVE THE *CLOTHESPIN SPECIES* FROM EXTINCTION.

_____

_____

6. ASSUME THE LAND THESE SPECIES FEED ON IS USED FOR AGRICULTURAL PRODUCTION.

A. HOW MIGHT REGULATIONS ON USE OF THIS LAND AFFECT THE SPECIES?

_____

_____

B. HOW MIGHT REGULATIONS AFFECT FARMERS?

_____

_____

C. HOW MIGHT REGULATIONS AFFECT CONSUMERS?

_____

_____

ADDITIONAL RESOURCES

Assisting others in developing more environmentally beneficial practices while still protecting the farm is not a simple task. Yet students, farmers, families, regulators, administrators and teachers all have the capacity to significantly improve agriculture and the environment. The basic requirements: a vision for a better future, willingness to work with others and a positive attitude. The following are suggested methods and resources for locally led conservation efforts.

Locally Led Conservation

"Locally led conservation offers an opportunity to bring together, under the leadership of local conservation districts, the people who care about their home place. Included will be the landowners, as well as all the others whose lives and futures might be affected by what happens on the land. Locally led conservation brings downstream neighbors into the process of developing effective, voluntary approaches to conservation. People working together as neighbors find solutions to common problems and agree on ways to implement those solutions. Those who participate in locally led conservation efforts often include people and groups who value the land for very different reasons and in very different ways. As they come together to understand the land in a particular area, they are often able to focus far more clearly on the shared visions they may have for their home place."

Barrios, Anna. "Agriculture and Water Quality." Center for Agriculture and the Environment, American Farmland Trust. June 2000. http://www.farmlandinfo.org/documents/28572/wp00-2.pdf

Make a Connection

Discover relevant resources, learn more about the environment, experience stories from farmers and ranchers, and share your thoughts using the following resources:

- Agriculture's Lasting Heritage: Celebrate long-lasting American century farms and discover how these agriculturists care for the environment. http://www.agriculturelastingheritage.org
- American Farm Bureau Foundation for Agriculture: Access up-to-date educational resources for all ages. http://www.agfoundation.org
- Earthwatch Institute: Discover how volunteers work with researchers to positively impact the environment. http://www.earthwatch.org/
- Environmental Examiner: Newsletter for students. http://www.examiner.com/environment
- My American Farm: Explore this interactive gaming and educational resource site for students K-5. Play games like "Keys to Sustainability" to learn more about the environment. http://www.myamericanfarm.org
- Property and Environment Research Center: Resources for improving environmental quality through property rights and markets. http://www.perc.org/
- Student Conservation Association: Discover hands-on conservation service opportunities for students. http://www.thesca.org/
- U.S. Farmers and Ranchers Alliance. Join the conversation, learn about your food and share your knowledge. http://www.fooddialogues.com/
- U.S. Fish and Wildlife Service: Access resources, including information on the Endangered Species Act. http://www.fws.gov/

America's Heartland

America's Heartland is a half-hour television series produced by KVIE, Sacramento. Below is a list of suggested episodes that support learning about agriculture and the environment. Descriptions below are direct excerpts from America's Heartland. Discover more at http://www.americasheartland.org/.

Earth Day Webisode http://www.americasheartland.org/video/earthday_webisode.htm

"In celebration of Earth Day, we thought we'd share some of our favorite stories about people we've met who are true environmental stewards. For them, it's more than just good business-it's what they believe in."

EPISODE 216: "MUSK OXEN AND FUR TRADE"

http://www.americasheartland.org/episodes/episode_216/musk_oxen_farm_and_fur_trade.html

"Throughout the heartland, there are small numbers of dedicated ranchers raising all kinds of exotic livestock. But we've never seen anything exactly like this cottage industry. It's the Arctic's oldest living species-the musk ox. Fifty years ago, one man began an effort to save this endangered animal, while at the same time helping lift some native tribes out of poverty."

EPISODE 601: "CATTLE AND CONSERVATION"

http://www.americasheartland.org/episodes/episode_601/cattle_conservation.htm

"It's not every day that you meet a city kid who wants to grow up to be a farmer. But Virginian Robert Mills decided at the age of 13 that farming was his future. He also decided that his approach to raising cattle and crops would have to involve steps that would also improve the environment."

EPISODE 614: "ANSWERING AN ENVIRONMENTAL CHALLENGE"

http://www.americasheartland.org/episodes/episode_614/environmental_challenge.htm

"North Carolina State University is working with the U.S. Department of Agriculture and a company called Terra Blue to develop a way to transform hog waste into an environmentally friendly solid waste."

EPISODE 615: "FORT BOISE PRODUCE"

http://www.americasheartland.org/episodes/episode_615/fort_boise_produce.htm

"We'll visit one farm in western Idaho that's using modern technology to track their produce every step of the way. Thanks to a traceability program created at Fort Boise Produce, consumers are able to track their food all the way back to the exact field and farmer that grew it."

EPISODE 620: "FARMER SEWER-MAN"

http://www.americasheartland.org/episodes/episode_620/sewer_man.htm

"We hear a lot about 'going green' these days. For farms across the heartland, environmental stewardship is more than just a feel-good exercise. As one Minnesota farmer teaches, it's also a way to ensure future success."

EPISODE 704: ADAMS RANCH

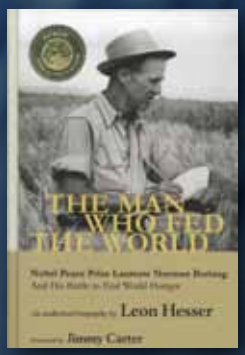
http://www.americasheartland.org/episodes/episode_704/adams_ranch.htm

"When we think of ranches, we immediately picture vast open plains. In central Florida, however, this is cattle ranching among palm trees, swampy wetlands, and thickets of grass and trees."

My Notes

Classroom Resources . . .

Go to www.agfoundation.org and click on Resource Orders for more information. The Foundation's website explains the ordering procedure for the numerous resources we have for educators and volunteers who want to tell the story of agriculture to young people in their schools and communities.



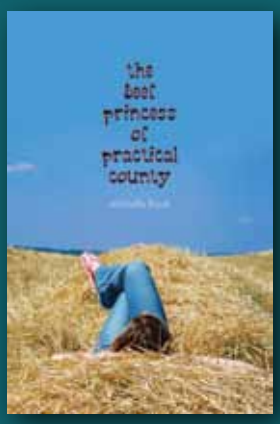
The Man Who Fed the World

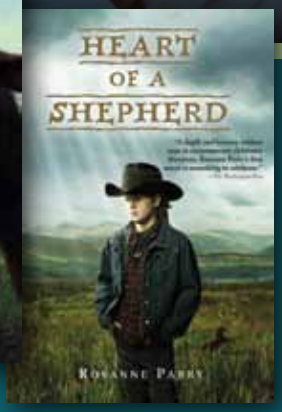
As you will discover, this book brings to life the story of Norman Borlaug —a man who came from a one-room schoolhouse in Iowa and became one of the hundred most influential persons of the twentieth century as he saved hundreds of millions of lives from starvation.

When you purchase a book you receive a free Educator Guide Download

Feeding Minds, Cultivating Growth

This educator's guide can be used with the following title: "The Beef Princess of Practical County" by: Michelle Houts, "Little Joe" by: Sandra Neil Wallace, and "Heart of a Shepherd" by: Rosanne Perry. The lessons support reading in one or all three texts, as students discover how farmers care for others and animals, how to build healthy relationships, how to identify personal values, and how to learn from others. Lesson plans are aligned to national standards, and include take-home enrichment activities, supporting handouts, summarizing information about each text, a suggested implementation plan, and a scoring rubric for a final project.





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