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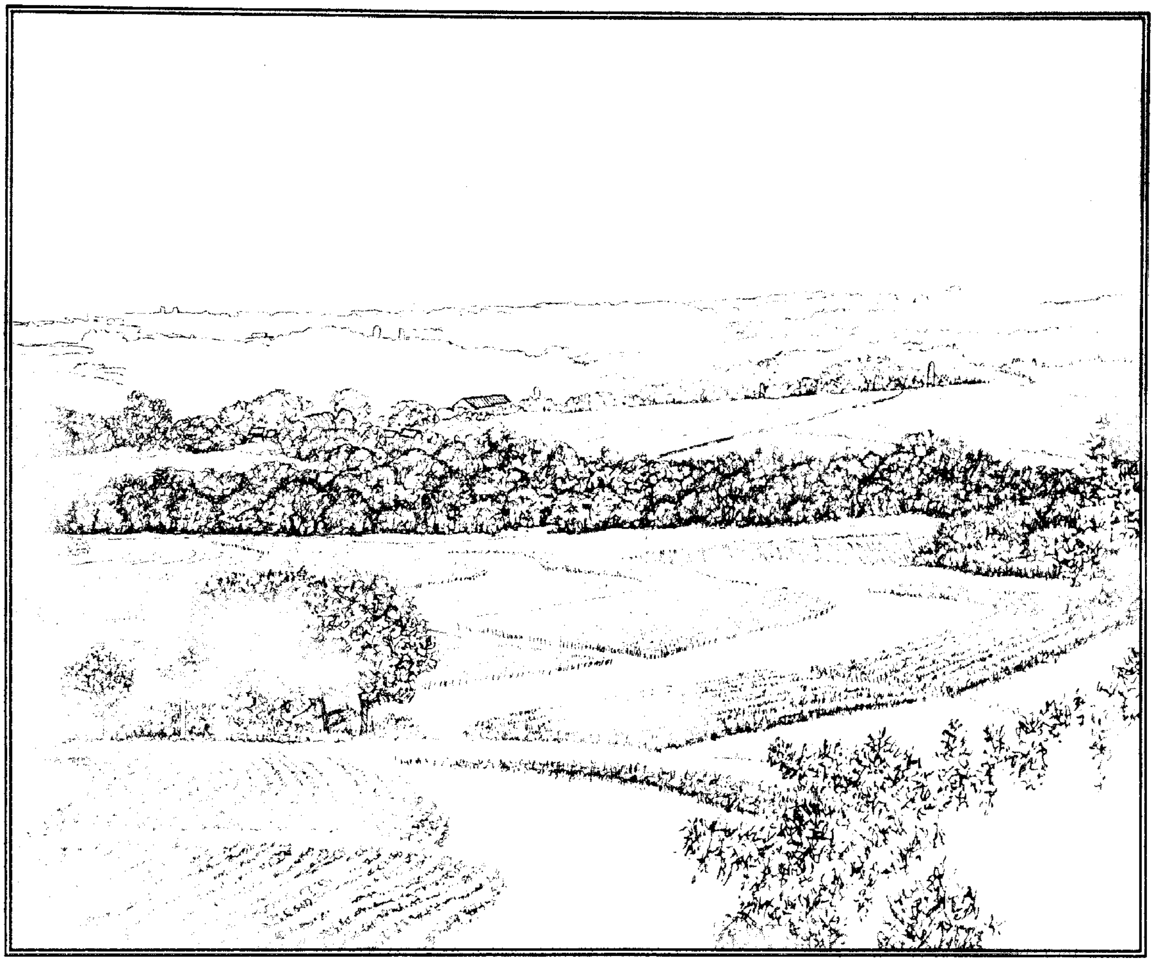

Lessons for Teaching Sustainable Agriculture

Interdisciplinary lessons for hands-on instruction of sustainable agricultural concepts.

Developed by the Wisconsin Rural Development Center through a grant from the Wisconsin Environmental Education Board.

The Sustainable Agriculture Curriculum Project

Lessons for Teaching
Sustainable Agriculture

A Supplement to:
"Toward a Sustainable Agriculture:
A Teacher's Guide"

Sponsored by:
Wisconsin Environmental Education Board
Wisconsin Rural Development Center
and
the Rodefeld Memorial Fund

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Acknowledgments

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Finally, the author gratefully acknowledges the Wisconsin Rural Development Center and the Center for Integrated Agricultural Systems who have listened to the needs expressed by the agriculture teachers in Wisconsin, and have responded with the enthusiasm and expertise to develop the materials which make up the Sustainable Agriculture Curriculum Project.

Introduction

This group of lessons is meant to provide basic knowledge key to the understanding of sustainable agriculture, an economically and environmentally healthy method of growing food and fiber supporting rural communities. We have chosen to present these lessons in an interdisciplinary manner to more closely reflect the true nature of sustainable agriculture. Decisions about farming are considered in context, with due analysis of impacts on the environment, the local economy, neighbors, and other aspects of the farm enterprise. In many cases, it is difficult to remove farming decisions from the community as a whole. For example, a farmer that reduces chemical purchases will affect the bottom line of the chemical salesman, which reduces the amount of income the salesman has to spend at the local grocery, and so on. On the other hand, the farmer that reduces chemicals may have an increase in income, which he or she will in turn spend in the local grocery, or hardware store. Throughout the lessons we have tried to demonstrate these relationships.

These lessons are also supported by the documents **Toward a Sustainable Agriculture: A Teacher's Guide**, and **Resources for Teaching Sustainable Agriculture**, previously developed. The **Teacher's Guide**, sponsored by the Center for Integrated Agricultural Systems and the Wisconsin Rural Development Center, was intended to be a first resource of background information on sustainable agriculture, an instructional unit plan and preliminary learning activities. In response to agriculture teachers' demands, the curriculum project also prepared a **Resource Guide** of classroom-reviewed materials. A lending library of these materials is currently housed at the University of Wisconsin-River Falls Agriculture Education Department. (For a current listing of materials, contact the department at (715) 425-3555.) Recently, the **Resource Guide** has also been placed on the Internet computer system. Contact the Center for Integrated Agricultural Systems, 1450 Linden Drive, Room 146, Madison, WI 53706, or the Wisconsin Rural Development Center, 1406 Business Highway 18/151 East, Mount Horeb, WI 53572 for copies of the **Toward a Sustainable Agriculture: A Teacher's Guide**, or **Resources for Teaching Sustainable Agriculture**.

The five topics used in this group of lessons, Reduced-Chemical Weed Control, Biological Pest Control, Economic Benefits of Reduced Chemical Use, Crops as Alternative Energy Sources, and Environmentally-Sound Alternative Crops were developed to give an overview of some key issues in sustainable agriculture. Within each topic are a series of lessons and activities intended to provide students with an interactive experience with all of these issues. Whether through witnessing the effect of worms on soil health, computing the savings of reduced-chemical weed control on the school's corn test plot, or writing a press-release to publicize their studies, the students will be involved from beginning to end.

When possible, these lessons have been classroom tested. Though it is nearly impossible to predict all of the possible situations that might arise during an experiment, an arrow (▸) has been included to indicate conceivable problems, as well as instructional strategies for salvaging the experiment. It is important to remember and remind students that experiments are designed to test a hypothesis, not to prove a theory. Indeterminate experimental results can be an important learning opportunity, as students consider why the experiment "failed," and how they can try again. As long as everyone learns something, there is no such thing as a "failed experiment." The teacher should feel free to adapt the lessons and activities to fit their individual classrooms. We also hope that the teachers who use these lessons will continue to revise and update these lessons as more research and information on sustainable agriculture becomes available.

Other Sources for Sustainable Agriculture Information

Appropriate Technology Transfer for Rural Areas (ATTRA)
Post Office Box 3657
Fayetteville, AR 72702
800-346-9140

Center for Rural Affairs
Post Office Box 405
Walthill, NE 68067
402-846-5428

The Land Institute
2440 East Water Well Road
Salina, KS 67401
913-823-5373

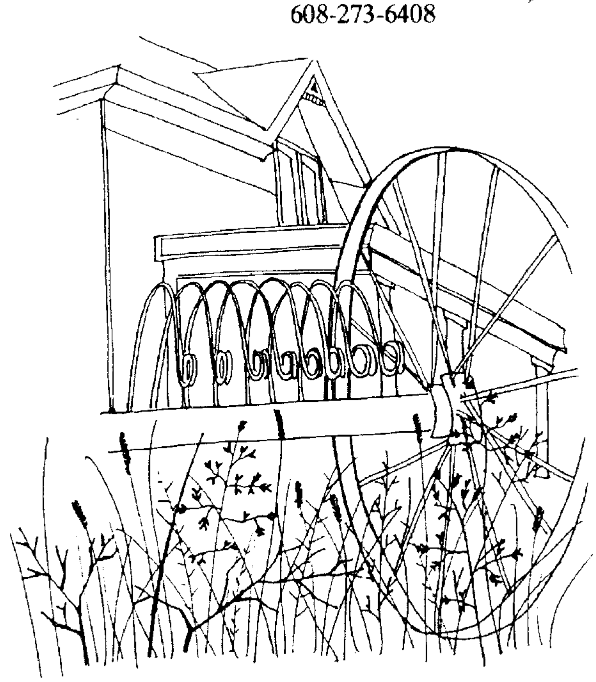
Land Stewardship Project
Post Office Box 815
Lewiston, MN 55952
507-523-3366

Michael Fields Agricultural Institute
3293 Main Street
East Troy, WI 53120
414-642-3303

National Agriculture Library (NAL)
Alt. Farming Systems Info. Center
10301 Baltimore Boulevard
Beltsville, MD 20705
301-504-5724

Rodale Institute
222 Main Street
Emmaus, PA 18098
215-967-8405

WDATCP
Sustainable Agriculture Program
801 West Badger Road
Post Office Box 8911
Madison, WI 53708-8911
608-273-6408



Explanation of Lesson Icons

Agriculture

Lessons designated with a tractor can be taught in most introduction to agriculture courses. These lessons cover plant propagation, pest control, and other agronomic issues.

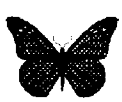
Science

Lessons designated with a magnifying glass can be taught in science classrooms. These lessons include experiments with plant growth, chemical properties, and other science activities.

Social Studies

Lessons designated with a globe are suitable for use in a Social Studies classroom. These lessons include activities on map reading, government policy, and community surveys.

Ecology



Lessons designated with a butterfly can be taught in an ecology or environmental education classroom. These lessons include activities on ecosystem analysis, food chains, and erosion.

Language Arts

Lessons designated with the hand and pen can be used to help students work on their language arts skills. This includes writing press releases, sending letters to elected officials, and presenting findings.

Economics

The lessons designated with a cash register can be used in an economics classroom. This group includes lessons which can be taught in any introduction to agriculture or science classroom, as well as a more advanced agricultural economics course.

Why Reduced-Chemical Weed Control?

Sustainable agriculture's answers to weed control focus on the benefits of sound crop rotations, mechanical and biological weed control, and reduced dependence on purchased, non-renewable, or potentially dangerous inputs. Contained within the organic matter of soil is a mixture of weed seeds. These seeds become a problem for farmers when they germinate and compete with the cultivated crop. Since World War II, farmers have increasingly turned to petro-chemical means to control this non-cultivated crop, reducing the use of other effective methods such as crop rotations, mechanical cultivation and biological controls. In recent years, it has become clear that weed control chemicals are contaminating surface and ground water supplies across the state. Their use has also been linked to increased cancer rates among farmers and rural families. As a result, many farmers are returning to non-chemical methods.

Crop rotations make use of the different characteristics of plants to control weeds either by planting smother crops to compete with young weeds, or by alternately planting fields with row crops and legumes to break the natural reproductive cycles of the weeds. (These rotations also provide farmers with natural, non-purchased sources of nitrogen available for future crops, and also help to control erosion.) Advances in soil nutrient analysis - and the increasing ineffectiveness of some forms of chemical weed control - have prompted renewed interest in crop rotation. Technological advances made in farm implements have also made mechanical control of weeds an increasingly attractive option for farmers. Finally, farmers can use biological control methods, such as planting "allelopathic" cover crops, which biochemically suppress weed pressure.

These lessons are meant to show students that weeds are indeed a problem for farmers, and to introduce students to alternative weed control measures that are environmentally sound and economically viable. In **The Crop that Farmers Never Plant**, students will observe the number of plants that will spontaneously sprout in a given sample of natural soil. Students should be reminded of the factors that will affect seed germination, and that this experiment can only show one specific set. During **Termination Time**, the students will be challenged to devise non-chemical means of ending the life of the weeds, while protecting the "crop." The final lesson of this group, **Ask Your Neighbor**, has the students conducting community surveys to determine attitudes concerning the use of farm and lawn chemicals, or related topics of their choice.

For more detailed information on the effectiveness of reduced-chemical weed control, contact the Cooperative Extension Service in your area. Local sustainable farming networks have contacts of farmers that are currently practicing methods that students could observe and document. Finally, these lessons are not meant to give all the answers, but provide to the students with a set of questions that should enable them to make decisions on their own.

The Crop that Farmers Never Plant

Overview

This lesson will allow students to observe the germination of plants that are not intentionally cultivated in common topsoil.

Objectives

The students will:
- observe and record the effects of sunlight and water on common topsoil.
- identify the plants that germinate in the soil sample.
- describe the organic and inorganic material that is contained in their soil sample.

Teaching Notes

This lesson consists of 4 activities which can be incorporated into a unit on plant biology, soil structure, or plant physiology. They also serve as a lead-in for the second lesson in this unit. **Note:** If the second lesson **"Termination Time"** will be taught, do not let the students remove <u>any</u> of the plants that germinate in their **Bottle Biology TerrAqua Columns**. To keep the "environmental" conditions as similar as possible, all watering and lighting should be controlled by the instructor.

Activities

Soil Collection

Summary: Students will collect soil for experiment.
Materials: shovel, bucket(s), map(if needed.)
Time: one class period.

Have the students collect samples of topsoil (collect only enough for the class from the top 6" of soil) from one area in the community. Spring soil will work best, as many seeds need the freezing conditions of winter to break the seed coat to germinate, or variegate. The past weed control in the field will affect the amount and species of weeds. Students should therefore collect other data such as: the last crop planted in the area, any chemicals that have been used in the past, former tillage types, weed pressure from border strips, and shading. Students should record this information for later use during this lesson. This information is important because certain chemicals (such as atrazine) will carry-over into the next planting season, thereby affecting the experiment.

▸ The following activities rely upon the soil collected. Students might want to collect from several sites to discover the weeds that might be contained in soil from different fields, or areas.

Bottle Construction

See **Appendix A** for materials and time needed for constructing the **Bottle Biology TerrAqua** columns.

Shake and Sprout

Summary: Students will separate soil, and attempt to germinate seeds. Materials: Clear wide-mouth canning jar with lid, water, soil, 5-6 shallow dishes, and clean-up materials. Time: One day for initial experiment, three to five days of short observation.

Using the clear jar, have the students fill three-fourths with water and then add enough soil to raise the water level until it is full. The students should then cap the jar tightly, shake well for at least 30 seconds, and then set the bottle upright to settle. As the soil begins to settle, have the students describe the make-up of the soil and what parts will settle out of the water first, which second, etc. (There usually are four to five distinct layers that will settle out, which can be determined by a change in color, and/or texture.) After the soil settles, the students should drain the cloudy water from the top of the jar through a filter paper. Put the moist filter in a baggie to germinate any seeds that were suspended in the water. (The key to this exercise is warmth. The warmer the conditions, the faster the seeds will germinate. Some weed seeds will germinate with only a strobe flash to start the process.) Students should then carefully remove each layer of soil with a spoon, being careful to not disturb the other layers, and put it into a separate dish and under a grow light. Students should try to determine which layer will contain seeds.

▸ Keep the soil moist and warm for at least 12-16 hours per day. If no seeds germinate students can use the information gathered during the soil collection exercise (such as location, past chemical treatments, etc.) to try to determine the reason for a lack of seeds or lack of viable seeds. Students can attempt to identify the different plants that germinate in the samples.

Planting the "Crop"

Summary: Students will plant various "crops" in their **Bottle Biology** columns. Materials: **Bottle Biology** columns, light source, crop seeds (oats, corn, alfalfa, etc.), and water. Time: One class period to start the lesson, and 2-4 weeks observation time.

Students should place their soil samples in the bottles, and plant one "crop" of their choice in the center (corn, tomato, soybean, etc.). Each student, or small group, will place their bottles either under a grow light or in a southern facing window to initiate the experiment. The students should not be allowed to water the plants individually. The teacher should control the light and water to ensure that all bottles receive constant "environmental" conditions. (In the next lesson, students will have the opportunity to control the environment.) The students should set aside one bottle to act as a control case, for the next activity. Do not let the students remove any of the plants during this lesson.

Students should label each bottle with the following information: sample number, source, depth, control/experiment, crop planted and date. The students should record their observations for a period of two weeks including information such as: time to germination, growth curves for all species growing in the bottle, and effects on water consumption. During this time, lesson activities can be performed on seed physiology, plant reproduction and germination, and plant identification. Students can attempt to determine whether the plants are monocots or dicots, etc.

From Bottles to Acres

Summary: Students will calculate the number of weeds that germinated.
Materials: ruler, **Bottles to Acres Worksheet**, and access to their bottles.
Time: about one hour.

Using the following information, have the students calculate the hypothetical number of weeds that would have sprouted on 1, 5, and 500 acres, using the number of weeds in their **TerrAqua Columns**. Area of a circle=$\pi * r^2$, 1 acre = 160 square rods, 1 rod = 16.5 feet.

IMPORTANT

The students should not be allowed to vary the effects of the weeds at this point. The following lesson will have the students develop alternative weed control mechanisms, without causing damage to the intentional crop they planted. If possible, the students should be encouraged to think of the ways that farmers can control weeds on a large scale.

Extras

As a variation on the **Planting the Crop** activity, students could experiment with different ways of pre-treating the soil for weeds: freezing it, covering it with black plastic and letting the sun heat it up, letting the weeds first and then "plowing" them under, etc.

Bottles to Acres -- Worksheet

Use the following equations to find the number of weeds that would have sprouted if your bottle were one acre in size. {area of a circle=πr^2, π = 3.1413, 1 acre = 160 square rods, 1 rod = 16.5 feet}

1. Determine the area of your bottle in square inches, then convert it to square feet.

2. Find the area of an acre, either in square inches or square feet.

3. Count the number of weeds that germinated in your bottle. Find the proportion, and the number of weeds that would have sprouted if your bottle were 1 acre in size.

4. If your crop was planted 6 inches apart in rows with 24 inches separating the rows, how many plants would you have in one acre?

5. What percentage of the total number of plants are weeds in your acre?

6. Would the percentage change if your bottle were 5 acres in size? ________ Defend your position.

7. Does this percentage pose a threat to the "crop" this year? What factors could change the odds?

Termination Time

Overview

The purpose of this lesson is to have the students learn about how weeds grow and various control methods that do not use of chemicals. Since World War II, the use of chemical herbicides has increased as a method of weed control for food and fiber crops. As concerns increase regarding environmental and human health impacts of herbicide use, farmers will need to become more aware of alternative methods of weed control. The students will be able to try their own hand at weed "termination" in this lesson.

Objectives

The students will:
- observe and record the growth rates of various plant species.
- invent methods of terminating plant growth without chemical herbicides.
- evaluate current farm equipment technology for weed control possibility.

Teaching Notes

This lesson follows the first lesson in this unit **The Crop that Farmers Never Plant**. After the "crops" from the first lesson have sprouted, students will attempt to control the "weeds," run a bioassay, learn from a local weed control expert, and present their findings. Again, the teacher should retain control over the "sun and water" in this lesson to ensure that the plants experience constant environmental conditions.

Activities

Weed Away

Summary: Students will "control" the weeds in their bottles without chemicals.
Materials: Bottles from initial lesson, scissors, plastic spoons, ice cubes, matches, etc.
Time: One hour for initial brainstorm, and weeding. Follow-up observation time (one-week).

Using their initial columns from the lesson entitled, **The Crop that Farmers Never Plant**, the students will use one column as a test case, the other column, they will attempt to "weed" the area around their "crop" without using chemical herbicides. The students should brainstorm possible methods of ending the life of the weeds. For example, they could cut, burn, freeze, pull, bury, plant another competitive plant, or smash the plant. Using a single method, or combination the students should carry out their termination tactics. Students should then record their actions and observe the plant for further growth or other reactions.

Students should keep in mind that the "crop" plant must not be damaged in the process of killing the other plants. The students can have a competition to see which person or group was able to gain the best weed control without damaging the crop plant. Students should discuss which of the termination tactics would be most applicable in an actual farm setting, considering such constraints such as labor, available equipment and machinery, etc. Finally, students should compare the number of crop plants and their vigor in the experimental and control bottles to determine the effects of uncontrolled weeds on the crop.

Bioassay Lesson

Using the **Wisconsin Fast Plants Bioassay** lesson **Appendix B**, have the students study the effects of various substances on plant germination. This information can be related to the effects of other chemical substances such as fertilizers, herbicides, insecticides. (Other fast germinating seeds such as radish can be substituted for **Fast Plant** seeds.)

Local Resource Person

Summary: Students will visit with local resource person to discuss their experiment.
Materials: Student notebooks with results of experiment.
Time: One class period.

A local farmer, implement dealer, or extension agent should be able to visit the class to discuss with them the different technologies available to accomplish their various methods of destruction. Many of the implements, such as rotary hoes and cultivators, have been used for quite some time. Questions to ask include: What are the power and input requirements for each method of operation? Is the technology available now at a low enough cost for most farmers? What amount of time does it take to run the various types of equipment through the field? etc. Possible implements and activities include: rotary hoe, mechanical cultivator, weed burners, and allelopathic plants like rye grass. At the end of the activity, students will discuss the feasibility of the different types of weed control for farmers, keeping in mind probable costs of control, ease of engineering large scale implements, unintended environmental effects, etc.

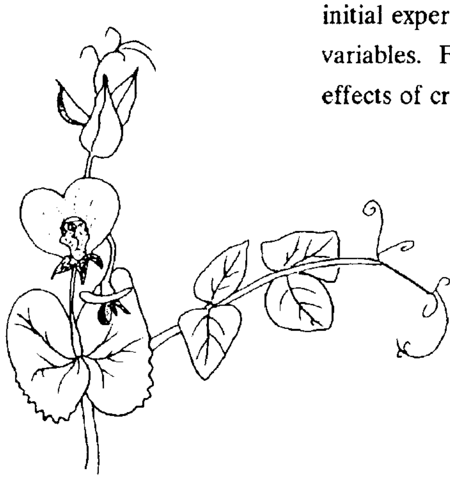
Taking it to the Streets

Summary: Students will summarize their findings with a presentation.
Materials: Student results, poster board, newspaper addresses.
Time: One to two class periods.

As a final exercise, the students will summarize the results of their lessons, and think of some way to publicize their findings (e.g. the local paper, before the FFA Chapter, etc.). Also, evaluations of their findings could be presented in the form of a research paper or a newspaper article. Presentations can consist of examples of their **Bottle Biology TerrAqua Columns**, or a visual display of the results of the various methods of weeding that the class attempted. Students can be evaluated through their understanding of the principles taught and the consistency and accuracy of their record keeping, as shown in their final presentations and journals.

Extensions

The students can, if possible, apply this knowledge to the FFA test plot, local garden, or the school's use of herbicides on the school grounds. Emphasis should be placed on the development of alternatives. Students can expand their initial experiment to include different lengths of experiments, and additional variables. Further study can be performed on the viability of weed seed, and the effects of crop rotations on weed development.



Ask Your Neighbor

Overview

This lesson will have the students conduct a community survey of attitudes toward lawn and agricultural use of chemical treatments. The students can follow through with a community education program to publish the effects of and alternatives to chemical use. This lesson can be adapted to cover a wide range of topics, from opinions about food production to attitudes toward recycling.

Objectives

The students will:

☼ conduct a survey of their community on the topic of chemical use.
☼ evaluate the results of the survey and determine a course of action.
☼ prepare a plan of education based upon the community and state regulations.

Teaching Notes

The students will conduct a survey of community members and business people, concerning chemical use. After analyzing the results of the opinionnaire, the students will present their findings to the school or community.

Activities

Know Your Stuff

> Summary: Students will research issues to be presented in the opinionnaire.
> Materials: Newspaper articles, agri-chemical advertisements, pollution studies.
> Time: One class period for research, or can be done as homework.

Have the students read a variety of articles and advertisements about atrazine and other chemical issues, local public hearings, and state regulatory approaches to herbicides. These articles can be found in agricultural papers such as **the Country Today, Agri-View, the Wisconsin Agriculturist,** local newspapers, and other sources. Students should answer questions such as: What is the main point the article/advertisement is trying to make? Is there an underlying product/service to be sold? Is the chemical controversy a relevant issue in our community? What local businesses are affected by tightening regulations on these chemicals? What problems might a farmer face if the regulations are tighter? What problems might the farmer, the environment or others face if regulations are not instituted? Does the farmer have any alternatives to using chemicals to control weeds? Are there alternatives to regulation - other approaches that might work to reduce pollution problems?

"Popular Opinion"

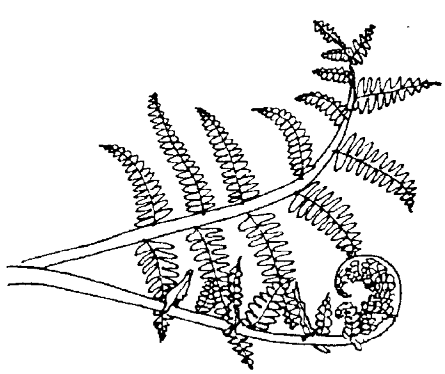
> Summary: Students will present sample opinionnaire, or develop and present their own.
> Materials: Copies of sample (or class) opinionnaire, results from research.
> Time: One class period to create, or practice conducting opinionnaire.

Students will conduct a survey of their community to determine opinions and attitudes toward the use of chemical weed control measures on lawns and farms. Use the opinionnaire provided or develop one that is more appropriate for your community or local situation. If students develop their own questionnaire, be sure that questions are phrased in as neutral a way as possible in order to avoid biasing the respondents' answers. Students should role play several interviews to become familiar with the questions, identify ambiguous terms or problematic questions, and learn courteous interviewing skills. Finally, while the students are conducting the survey, they should be encouraged to write down any answers or remarks that express well a particular point of view or opinion. Before conducting the survey, have the students write down a prediction of how the members of the community will respond.

Analyze the Answers

> Summary: Students will analyze the answers received from the opinionnaire.
> Materials: Completed opinionnaires, calculator.
> Time: One class period.

Have the students compile their results and compare them to their initial predictions. Their summary should include the number of people responding to the survey, percentages of respondents in each category, etc., and some anonymous quotes that could be used to characterize the responses. Questions for the students to answer include, "What percentage of the respondents lived on or near farms? Of those respondents, how many thought farm chemicals presented a danger to water quality? How does this answer compare to the non-farm respondents? Did the non-farm respondents have similar feelings toward lawn and garden chemicals?," etc.



Taking it to the Streets Part II

Summary: Students will compile their results in presentation form. Materials: Results from opinionnaire, newspaper addresses, etc. Time: one to two class periods.

The students can write a press release presenting the survey results to be sent to local and school papers, as well as the Department of Agriculture, Trade and Consumer Protection. The outreach can also consist of community education displays, a field day demonstrating no-chemical weed control, or a petition drive to have the regulations for their area changed. Other possible activities would be to organize an educational meeting where officials and others can come and present their side of the issue. Possible presenters include extension agents, farmers, university researchers, and officials from the Department of Natural Resources, and Department of Agriculture, Trade and Consumer Protection, and representatives of environmental groups.

Summary

As increasing public and government pressure forces farmers and homeowners to evaluate their current weed control practices, all citizens need to be educated about environmentally benign alternatives to chemical-based weed control on farms and in residential areas. Understanding public attitudes about a problem and possible courses of action is a crucial first step in designing appropriate policies and effective public education campaigns.

Sample Opinionnaire

Questions should relate to the activity on *Reduced-Chemical Weed Control*. The following is a possible opinionnaire for the students to use. Questions can be redesigned to fit the needs and interests of your community.

Hello, my name is ______________ and I am student in Mr./Ms. __________________ (science/agriculture/social studies) class at __________________ High School. We are conducting a survey of the opinions of area residents concerning lawn and agricultural chemicals. Could I possibly speak with you for a few minutes.

Person Responding _________ Male _________ Female

1) Do you live on a farm? _____ Near a farm? _____ Neither ____

2) Do you use chemicals on your lawn? ____Yes____No

3) Do you think that agricultural chemicals, such as nitrogen fertilizers and pesticides present a problem for our community? ____Yes____No____Undecided

4) In your opinion, do you think that these chemicals present a danger to the community's water and air quality? ____Yes____No____Undecided

5) In your opinion, do these chemicals present a threat to the safety of our food supply? ____Yes____No____Undecided

6) Is there a problem with the enforcement of the current state regulations concerning agricultural chemicals? ____Yes____No____Undecided

7) Are lawn chemicals hazardous to your health? ____Yes____No

"I will now read two statements, please respond as: strongly disagree, disagree, no opinion, agree, or strongly agree."

8) All agricultural chemicals should be banned, or tightly controlled by the government.

____Strongly Disagree ____Disagree ____Neutral ____Agree ____Strongly Agree

9) All chemicals, both lawn and agricultural, should be regulated by the government.

____Strongly Disagree ____Disagree ____Neutral ____Agree ____Strongly Agree

10) What changes, if any, would you like to see in the way chemicals are used or regulated?

Thank you for your help!

Introduction to Non-Chemical Pest Control

This lesson set will address three different pest control mechanisms: mechanical, cultural, and biological. Mechanical control includes cultivation, trapping or vacuuming insects, and other means of physically removing or killing the pest population. Cultural controls include planting crops in rotations to discourage or inhibit pest growth and reproduction, planting cover crops to smother weeds, adjusting the planting and seed bed preparation, and proper crop selection. All of these cultural practices hope to ensure the crop a healthy start to compete effectively with pests. Finally, biological control entails release of predatory insects or diseases, as well as planting allelopathic plants to suppress the growth of the pest plants.

A question commonly asked might be, "Why should farmers use these biological pest control methods?" The answer lies in both long-term economic and environmental well-being. Economically, these methods can help to reduce farmers' input costs. By taking the focus away from production at all costs, farmers can begin to focus on increasing their returns after costs. This idea does not follow the production theories of the past, nor does it follow policy incentives of the USDA, but it makes more sense for the "bottom line" of the farmers. In some cases, as with organically certified produce, there is even a premium paid for organic products. Environmentally, the benefits are in the form of healthy soil, water and food. Soil has been treated like dirt since the advent of chemically intensive agriculture. Instead of using sound stewardship practices that had been developing for hundreds of years, some farmers have come to rely on the chemical salesman to boost their yields and control their pest problems. This has resulted in soil that has lost water holding capacity and microbial life, and has eroded at unacceptable rates. The water resources of Wisconsin are in jeopardy. Surface and ground water are being contaminated by runoff and leaching of chemical pesticides. Finally, the ecosystem that the farms belong to needs to be protected. This is still as big a concern today as it was when Rachel Carson wrote **Silent Spring** in the 1960s.

Alternatives to chemical pest control exist and these lessons will introduce the students to several of them. Learning about the alternatives is only the first step - the next is to support environmentally sound pest control through family food purchases, farming decisions, etc.

During the first lesson, **Weeds, Worms and Wiggly Things**, students will have the chance to first study the characteristics of the insects, weeds, and invertebrates. They will try to discover what makes them pests, and what beneficial characteristics these organisms have. They will also study the relation of these pests to one another and to crop production. **Nature, Naturally,** will allow the students to further develop their observations of predator/prey relationships, crop rotations, and the timing of their cultivation.

Weeds, Worms and Wiggly Things

Overview

This lesson will assist students in identifying crop pests, their life cycles, and their place in the ecosystem. Biological pest control takes all of these factors into account while making decisions about the use of fertilizers, pesticides, and other chemical inputs.

Objectives

The students will:

- collect and identify farm crop pests -- insect, plant, and invertebrate.
- diagram the effects of crop pests, and removing the pests from the crop.
- design an experiment to test environmentally-sound pest control methods.

Teaching Notes

This lesson consists of four activities. Students will have the opportunity to collect and identify insects, role-play the food chain, study the effect of worms on plant and soil health, and collect and identify weeds. This lesson will provide a guided discovery of various insect, invertebrate and plant species, and their relationships to each other and the farming system.

Activities

Bug Off

Summary: Students will collect and identify insects found in crops.
Materials: Insect Identification Sheet (**Appendix D**), magnifying glasses, collection device, and student notebook.
Time: Two to three class periods.

This activity will allow students to collect and identify insects found in their environment. It also gives them a chance to study the organisms more closely in order to discover more about what makes them a pest or not. Students can attempt to collect insects on their own, or a local county extension agent, university student, or other knowledgeable community member may assist in the collection and euthanasia. If the students are doing the collecting, they should note where the insects are collected (field, forest, etc.) to aid in the identification. Once the insects are collected, the students should examine, and make detailed observations about the insects with their magnifying glasses. Students should pay close attention to the wings and mouthparts of the insects. This information should help them determine which stage of the life cycle the insects are in, and can help in identifying them as crop pests. After listing the species of insects, students should then theorize as to which insects would be most damaging to crops.

Webbing

> Summary: Students will demonstrate the web within an ecosystem.
> Materials: A ball of twine or yarn.
> Time: One class period.

Ask a student to suggest an animal or plant. Hand that student a ball of string, and ask for the name of an organism that eats or is eaten by the first organism. The first student in line should hold one end of the string and pass the ball to the next students who "becomes" the next organism in the chain. Continue asking for organisms that have some relation to each one named, until all the students are connected by the string. Some organisms may have multiple relationships, and the string will pass through their hands several times. Now, ask for one disturbance in this food chain (e.g. poisoning the insects). Have the student(s) representing that organism tug on the string. Ask who felt the tug, and ask them to describe what would happen to them as an indirect result of the initial intervention. Now as the students who felt the first tug, to tug themselves, and see who else is affected. Repeat until the first tug has "reverberated: through the whole food chain, and the students have described the effects. (You might want to keep track of the students and their organism "name" on the board, to help them remember and visualize the effects.)

Predator/prey relationships should be introduced during this activity. Discussion should also cover what would happen if a new, foreign organism were added to the ecosystem. Where would the new organism "fit" and what effect would it have on the surrounding organisms. (e.g. Add some predatory wasps or lady bugs to the web, and determine their influence.)

Inverta-whats?

> Summary: Students will observe the effect of invertebrates on plants.
> Materials: **Bottle Biology Columns**, soil, worms, light source, magnifying glasses, and fast germinating seeds (oats or **Fast Plant** seeds work well).
> Time: One class period for initial set up, and up to six weeks for observations.

In this activity students will grow consecutive "crops" (to a height of five inches) to test the effects of invertebrates on soil health, such as water holding capacity, aeration, and nutrient levels. Have the students set up two **Bottle Biology TerrAqua Columns**. Each of which will have 2" of sand in the bottom, and the rest will be filled with potting soil. Then add 8-12 red worms to one column. (Earthworms prefer 50-60F soil, red worms are smaller and a bit more "heat resistant" and should work better in a classroom. Red worms are available at most bait shops.) Worms prefer dark and moist conditions -- it will be necessary to create a screen of paper to shield the worms while they are in the bottle. This can be done by making a heavy paper cylinder, making sure that it extends above the line of the soil, and fits loosely so that it can easily be removed. After the worms have burrowed into the soil, plant the crop. Have the students hypothesize about the effects of the addition of the red worms to the column. Have them develop a set of questions or criteria for determining the effect of "worms" on the crop and soil characteristics. Comparisons that could be made include: amount of time it takes for the first drops of water to exit the mouth of the bottle, effect on the layer of sand in the bottle, amount of time it takes for seeds to germinate, length of time to reach five inches, color and quality of the leaves, number of plants that make it to "harvest," texture of soil, water-holding capacity of soil, etc. As the experiment proceeds, students should make note of effects the worms seem to have on the soil. Discussion of other soil organisms could follow.

▸ It is important that the worms receive proper handling to stay alive. They breathe through their skin, and too much water in the bottles will drown them. Although students may not see an appreciable difference in the crops under these experimental conditions, the worms should aerate the soil and increase its ability to hold water, as well as to mix the sand from the bottom of the bottle throughout the column. Students might try to figure out what other characteristics the worms have that make them beneficial soil organisms, such as soil "stirring," and nutrient provision (through their castings).

Weed-me Alone

Summary: Students will collect and identify weeds.
Materials: Weed Identification Handbook, paper bag, small shovel, and student notebook.
Time: One day for collection and identification.

This lesson will allow the students to identify different weed species and determine why they are considered pests. Have the students collect weed samples from various areas and fields. They should then attempt to identify them. Helpful resources include: Weeds of the Northcentral States. NCRR Publication Number 281, Bulletin 772 and others available from UWEX (see **Appendix E**) Observations should be made by the students about where the plant was found (type of soil, crop growing in, open or shaded, etc.), the height and width of the plant, root system, reproduction method, seed dispersal method, whether it is an annual or perennial etc. Using these observations, have the students think of the effects of cultivation techniques on the weed. For example, does tilling the field help the weed remain competitive by spreading seed or cutting up rhizomes? Is the life cycle of the weed compatible with the crop?, etc.

Extensions

The students can present the results of their studies in the form of an article for the FFA Newsletter, or they can make a special presentation during a field day at their test plot, using some of the insect and weed identification strategies learned in this lesson.

Nature, Naturally

Overview

This lesson will allow students to discover some "natural" answers to today's pest problems. Students will study the relationships between crops, pests and predators and see how farmers can use those relationships to their advantage.

Objectives

The students will:
☼ identify relationships between field crops and insect and weed pests.
☼ apply information on the life cycle of weeds and insects to develop a crop rotation designed to control pests.
☼ analyze the effects that timing of planting has on weed control.

Teaching Notes

These activities will have the students studying predator/prey relationships, crop rotations, the effect of temperature on tillage and cultivation, observing the relationships between predatory insects, and investigating the differences that crop rotations will make. These activities will require the use of either grow lights, a greenhouse, or some other source of light.

Activities

Good Bug vs. Bad Bug

Summary: Students will observe the relationship between predatory insects and their prey.
Materials: Glass terraria or similar containers, insect "subjects," and student notebooks.
Time: One class period for initial set-up, with additional short observation times.

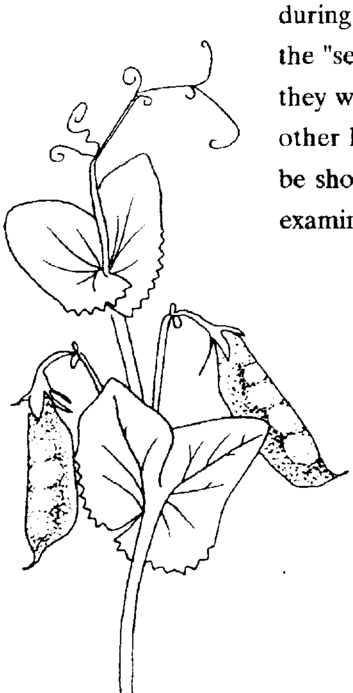
The focus of this lesson is to have the students observe the predator/prey relationships found among insects. Have the students establish a population of prey insects in their containers. Insects to use include aphids, fruit flies and the common housefly. (**Appendix A** has a section from **Bottle Biology** on predator/prey relationships.) Two sets should be established. One will serve as the experiment, the other as a control population. Students should keep records as to how many insects are in their population and basic behaviors exhibited. A predator such as lady bugs, praying mantis, or spiders may now be added to one container with your insect population. Records should be updated daily as to the number of predator and prey organisms remaining in the test container and the control container. Students should try to explain the data. Carrying capacity, population cycles, organism survival techniques, etc. may be discussed, and questions asked such as, "What would happen in nature on a larger scale? What happens when the prey insects are gone? What happens if the prey insects greatly outnumber the predator? Does the predator species increase in relation to an abundant food supply?" etc.

▸ If the insects do not interact, have the students try to determine the reasons for this. (i.e. sufficient food to keep the insect predators fed, different behavioral characteristics -- nocturnal vs. active during the day, etc.) Environmental factors might include temperature, light, or other species that could not be included in the experiment.

Crop Rotations

> Summary: Students will diagram the life cycles of insects, weeds, and crops in a study of crop rotations.
> Materials: Copies of Worksheets on Crop Rotation, data on insect, crop, and weed life cycles.
> Time: One class period.

The object of this activity is to provide the students with a visual comparison of crops and their pests. Using these visual representations, differences and similarities can be identified and weaknesses can be pointed out. Divide students into groups of at least three. Each group will select a "common" Wisconsin field crop as well as an insect and weed that effects that crop. Each group will need to research these organisms in respect to life cycles and cultural practices, and enter the various stages on the worksheet. The students should be as specific as possible about a year in the life of each chosen organism. Any interrelationships among the three organisms should be shown using arrows to designate the effect that is destructive or damaging. For example, the weed might shade the crop during one phase, but the cultivation might be damaging to the weed. During the "second year" of the exercise, half of the class should rotate their crops (i.e. they will use a different crop, but the same set of insects and weeds) and the other half will demonstrate monocropping. Again any interrelationships should be shown. Once the tables are finished they may be hung around the room and examined by other groups.



Timing of planting

Summary: Students will demonstrate the effects of early seed bed preparation on weed growth.
Materials: Three shallow planting trays, crop seeds, small garden fork, access to a refrigerator, soil (spring soil will work best) and a light source.
Time: One class period for the initial set-up and additional observation and work times.

A recent article in the **New Farm Magazine** described the relationship between soil temperature and weed germination and growth. A farmer in Minnesota has found that by waiting until the soil temperature rises to and stays at 50F, he can effectively eliminate weeds that have germinated at a lower temperature during his seed bed preparations. (See the **New Farm**, March/April 1993) This activity will allow the students to experiment with different planting times and observe the effectiveness of these practices in the field. Have the students prepare three "fields" for future use. These fields should consist of topsoil, a container, and nothing else. Place these in the freezer for a day or two to simulate winter conditions. Now, have the students "plow" and "plant" a crop of corn or soybeans using **one** field from the refrigerator. This planting will represent the "early bird" planters - make sure to label the container. The soil is still at a temperature too cool for crop germination. To simulate this, place your crop back into the freezer for 2-3 days. After your early bird crop has been in the refrigerator for three days, remove all "fields" from the refrigerator. Water your fields and keep at room temperature from now on with at least 15 hours of light per day. After two days at room temperature, a second crop should be plowed and planted. After one week, plow and plant the third field. Keep the soil moist in all three containers. The second planting represents the average planting date and the third planting represents a late planting date. Observations should have been noted as to soil and "field" condition at planting times. For example, if thermometers are available, temperature of the soil may be taken and graphed.

- If few weeds germinate, students can study the amount of time that the crop needed to germinate under the different temperatures relative to the health of the crop and its ability to compete successfully with weeds.

Extensions

Students may want to sit and observe food chains in a natural ecosystem. They can walk through an area and note the number and types of organisms found there. They may want to try to establish more elaborate predator/prey relationships, including planting a crop and introducing an pest that feeds on that crop. The experiment could also be continued through the life cycle of the insect.

Crop Rotation Worksheet

Year 1			
	Crop	Insect	Weed
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Show any relationships between your chosen crop and pests. For example, if your insect is in the larval stage in May and feeds on the germinating crop, show this with an arrow pointing from the predator to the prey. (This can work both ways, the crop in late July can shade out the competing weeds.)

Question: Does this system allow the insects and weeds to complete a life cycle? From egg to adult, or seed to seed?

Crop Rotation Worksheet

Year 2			
	Crop	Insect	Weed
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Show any relationships between your chosen crop and pests.

Questions: Did your crop act as a benefit or a detriment to the pests this year?

What effect does crop choice have on the health of pests?

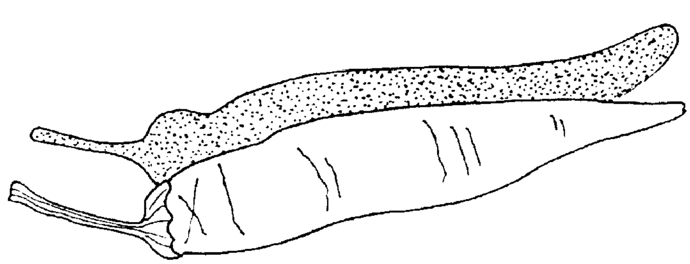
Introduction to Economics Lessons

Profitability is one of the keys to sustainable agriculture. In a conventional system, profitability strategies generally have been to increase production and achieve economies of scale. Sustainable agriculture seeks to increase profitability, while protecting the environment by reducing and recycling inputs. In many cases, this model has proven to be very successful. For example, Wisconsin's Profits through Efficient Production Systems (PEP$) contest, which measures maximum <u>economic</u> yield and not solely production, has been won a number of times by no-chemical farmers practicing sound crop rotations. Wisconsin is not alone in research and success in sustainable agriculture. Programs nationwide have proven the economic and environmental benefits of practicing reduced-input farming.

This group of lessons examines the main economic concepts evident in sustainable agriculture. A copy of the results from a three-year study of Wisconsin farms performed by the WRDC and University of Wisconsin-Madison researchers has been included for your use. The evidence suggests that lowering chemical input costs can increase profitability. Environmentally, the reduced use of petroleum-based (non-renewable) pesticides and purchased fertilizer can make a significant contribution toward a cleaner planet.

During the first lesson, ***Systematically Diverse***, students will analyze the farm system using survey methods and conduct an experiment with enterprise diversity and the related environmental and economic issues. In ***Dollars by the Degree***, the students will discover the use of degree day calculations in Integrated Pest Management; calculate the savings and differences in profitability by banding herbicides and mechanically cultivating; and analyze the current information available to farmers in regards to crop rotations and nutrient cycling. Finally, in ***The BOTTOM Line***, the students will define terminology and basic equations used in agricultural economics. Then, they will practice using these definitions and formulas manipulating real data from the Farm Analysis Project. Finally, students will determine for themselves the economic value or benefits of sustainable agriculture. There is a list of resources at the end of each of the main lesson explanations. In some cases, it may be necessary to order some of the publications or bulletins in advance. Most of the information is available through the Cooperative Extension Service, your county agent, or local library.

It may be necessary to remind students that there are long- and short-term benefits and problems with both sustainable agriculture and conventional systems. Just as conventional techniques do not work on all farms, sustainable agriculture is not a cure for all farm economic hardships. Without more successful pricing and marketing strategies, as well as changes in current agricultural policy, it will be difficult for any type of agriculture to be sustained for the family farmer.



Systematically Diverse

Overview

From farm diversification, to banding or eliminating herbicides, to recycling farm wastes, sustainable agriculture has many environmental and economic benefits. These lessons will allow the students to discover this information through survey analysis, experimentation, and farm design.

Objectives

The students will:
- analyze a farm's systems for economic comparisons of profitability.
- examine enterprise diversity as an economic and environmental benefit.
- interpret data collected in survey and experimental form.

Teaching Notes

This lesson consists of activities designed to allow the students to study farming systems and their crop choices, inputs, and diversity with an eye for both economic and the environmental outcomes. The first activity, ***All Systems Go!***, will have the students conduct a survey of local farmers to study their awareness of a whole system approach to their farming operation. Students should be aware that many of the questions listed on the worksheets will ask the farmer about his/her operation, and in some cases finances. The students should be aware of the sensitivity of some of these questions, and they should fully understand the meaning and the seriousness of confidentiality. The second activity, ***Diversity: Safe or Sorry***, will have the students run a short experiment to simulate the economic implications of monocropping with variable environmental conditions.

Activities

All Systems Go!

> Summary: Students will conduct a survey of local farmers.
> Materials: Copies of survey.
> Time: One class period for preparation, and one to analyze results. The survey will need to be conducted on the students' time.

The purpose of this survey is to determine the nature of farming in your area, and the extent of the knowledge of the local farmers about their own land. This knowledge is important in making economic decisions about the farm operation. After students conduct the survey, they should compile their findings by finding the average number of each answer. For example, with question 1, Part 1: "What percentage of your total farm is in tillable acres? If there were 30 respondents,what percent would have responded to "100%?" If two marked survey to help guide the students' discussion of the survey.

Diversity-Safe or Sorry?

Summary: Students will conduct an experiment to demonstrate the effects of temperature and moisture on crops.
Materials: 30 small **Bottle Biology** columns, plant seeds, grow lights, thermometers, styrofoam or cardboard dividers.
Time: two class periods for initial explanation and set-up, up to three weeks for follow-up observations.

This activity is an experiment for students to test the effects of environmental conditions on a variety of crops, and learn about the economic implications of monocropping. Using small bottle constructions, students will vary environmental factors and observe effects on crop germination, growth, and maturity. It will not be possible to grow crops to harvest in the bottles, but general influences can be observed. The worksheet called **Crop Diversity Observations**, will explain the bottle setup, etc.

It is important to note that adding livestock to a farm operation gives the farmer more choices of which crops to plant. Feed crops as well as cash crops are an option for the livestock farmer. Feed crops may also respond differently than cash crops to a given set of growing conditions, so that having livestock and planting a mix of the two types of crops can help a farmer hedge bets.

In the **Crop Diversity** experiment, students will plant both cash and feed crops and determine the effects of varied growing conditions on each.

▸ Temperature and moisture conditions are key to this experiment. It is important for students to record temperatures and not let them exceed natural conditions. If the growing conditions do not appear to affect crops, students can try to identify modifications that can be made in the experiment design to more closely reflect nature. Making conditions somewhat more extreme may help.

Extensions

Students can develop model farm with the best economic use of farm labor, "wastes," etc. This can also apply the systems inventory to the school. For example, does the school grounds crew purchase fertilizer? Are grass clippings or kitchen waste composted?

Systems Inventory

This inventory is designed to determine the environmental and economic aspects of a real farm system. It is important that the farmers know that their answers are confidential, and no specific financial information is needed. They should also feel free to not respond if they choose.

Part One: Environmental Considerations

1. What percentage of your total farm is in tillable acres?

_____ 100% _____ 75% _____ 50% _____ 25% _____ none _____I don't care to respond.

2. Do you use any conservation tillage practices?

_____ Yes, always _____ Yes, when necessary _____ Sometimes, depends on conditions _____ No

3. What are the slopes represented in the tillable acres? (Check all that apply.)

_____mostly steep ground _____ moderately hilly _____ gently rolling _____ mostly flat

4. What is the predominant soil type in your tillable land?

_____sandy _____ silt _____ loam _____silt-loam _____ sandy-clay _____ mostly clay

5. Of the non-tillable acres, how much would be considered wetland?

_____ 100 - 75% _____ 75 -50% _____ 50 - 25% _____ 25 - 10% _____ Less than 10%

6. Of the non-tillable acres, how much is considered woodland?

_____ 100 - 75% _____ 75 -50% _____ 50 - 25% _____ 25 - 10% _____ Less than 10%

7. How much of your land is used as pasture?

_____ 100 - 75% _____ 75 -50% _____ 50 - 25% _____ 25 - 10% _____ Less than 10%

10. What are the on-farm sources of crop nutrients? (Check all that apply.)

_____ manure _____ green manure _____ other, please list______________________________

Part Two: Personal and Economic Considerations

11. How much full-time family labor is available? (e.g. 2.5 if one person works full-time and three half-time)

_____ 5+ _____ 4 - 5 _____ 3 - 4 _____ 2 - 3 _____ 1 - 2 _____ 1 _____ Other

12. Why do you work on the farm? (Check all that apply.)

_____ enjoy the life _____ I grew up on a farm. _____ What I know how to do best _____ other

13. What aspect of the farm operation do you enjoy most(mark with X), ... which least (mark with O)

_____working with the livestock _____ growing the crops _____ fixing the machinery

_____ management/planning/bookkeeping _____ marketing __________________other (fill in)

14. How do you handle periods of increased labor? (i.e. harvest, or lambing)

_____ hire custom work _____ work long hours by myself _____ have family help

15. Does the farm support itself? (Is it profitable without off-farm income.)

_____Yes, _____ No, _____ do not care to respond

16. If the farm is self-sufficient, which enterprise generates the most earnings.?

_____ cash crop _____ livestock _____ dairy ______________________other (fill in)

17. What percentage of the farm income goes toward paying loans (retiring debt)?

_____ > 75% _____ between 50 and 75% _____ between 25 and 50% _____ < 25% _____ paid

18. What percentage of the farm income is needed to cover expenses? (i.e. fertilizer, seed)

_____ > 75% _____ between 50 and 75% _____ between 25 and 50% _____ < 25% _____ paid

19. Do you work off the farm?

_____ No _____ Part-time or occasionally _____ Full-time

20. Does anyone else in the family work off the farm?

_____ No _____ Part-time or occasionally _____ Full-time

21. Do you hire labor?

______ Custom/occasional _______ Full-time equivalent _____ No

22. If you don't hire labor, why?

______ Don't need help. ______ Can't afford help. ______ Can't find help.

23. How many farm enterprises are there? (e.g. individual crops, livestock, custom services)

_____ one _____ two _____ three _____ four _____ five _____ more than 5

24. Do you pay yourself an hourly wage?

_____ No _____ Yes, amount (optional) _______________

25. What percentage of farm income comes from government payments?

_____ > 75% _____ between 50 and 75% _____ between 25 and 50% _____ < 25% _____ none

26. Are there constraints that keep you from trying new practices?

_____ yes, economic _____ yes, time _____ yes, lack of information/ideas _____ no

27. Will you be able to pass your farm on when you retire?

______ Yes ______ No, no one can afford to take it. ______ No, no one wants to take it.

Survey Discussion Questions

Using the results from your class survey, answer the following questions.

1. Describe the average farm in your survey in terms of size, terrain, soil makeup, and enterprises.

2. What are the environmental implications of farming in your area? Do farmers report tilling hilly land? Do they use conservation practices? Are enterprises well matched to soil and terrain? What limitations do soil and terrain impose upon farmers? What opportunities do they provide?

3. Economically speaking, from your survey, how stable are the farms in your area? (low debt load, high profitability) In what ways do farmers seem economically vulnerable? In what ways are they in a strong position?

4. List some possible changes that farmers could make to increase their profitability, and decrease their debt and dependence on subsidy payments. Analyze their responses to question 26 and discuss how this might limit or provide opportunities for enterprise diversification. Discuss which obstacles could be overcome and how.

Diversity Experiment

Rationale: The point of this experiment is determine the effects of different environmental factors on a series of four crops. Seasonal temperature and rainfall will be the two characteristics to be studied. Economically, you will be asked to determine the effect of the various conditions if you were a farmer with different crops planted. It is important to use natural soil rather than potting soil to determine the effect of the changing environmental conditions on weed germination and growth.

Materials Needed: 30 small plastic soda bottles(one-liter maximum), seeds, - Plant two from each category: cash crops (corn, soybeans, peas, wheat, tomatoes, other); feed crops (alfalfa, oats, clover, corn, other), 3-4 5-gallon buckets of soil (preferably from a field without chemical usage - atrazine carryover will affect the experiment), grow light bank, cardboard for building separations, heat source, fan.

Setup: See the enclosed instructions for preparing Bottle Biology columns. Make sure that you save all the caps, and remember to punch holes for drainage. Design a grid that will allow you to place 4 of the bottles in a box at a time. See enclosed diagram. You may want to use some 1/2" or 1" styrofoam for stiffening between the sections. By separating the bottles into the different grids, it will be easier to control the environmental characteristics. The heat source, either heat lamp or incandescent bulb array should be placed at the far end of the grid. (You could also create a mini-greenhouse environment by placing the bottom of a bottle over your column. See the **Insect Habitats Part II,...** in the Bottle Biology Appendix for bottle greenhouse constructions tips. Mix the soil thoroughly, and add equal amounts to all of the bottles. When planting the seeds, make sure they are not planted too deeply. Make sure that each section of the grid and each bottle is accurately labeled. The watering should be done by one person to ensure a constant rate. Make sure that there are six sets of bottles set up in a grid similar to the **Diversity Experiment Observations** worksheet. One side of the grid will be watered every 2 - 3 days, to keep the soil moist. The other side will simulate drought conditions and should be lightly watered every 10 - 14 days.

☼ Make sure that the conditions you create (i.e. temperature, rainfall do not exceed natural conditions.

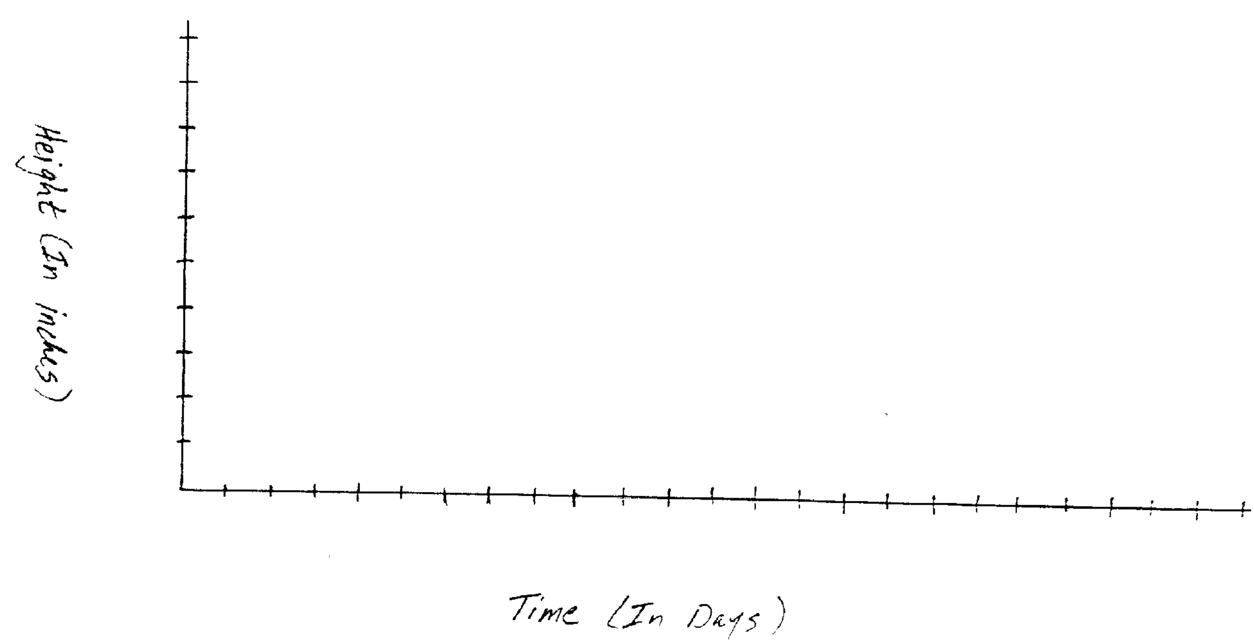
Observations: At the beginning of each class, write down your observations of the bottles. Make sure that you record observations for each section of the grid. Record emergence, signs of the first leaves, temperature, soil condition (dry, moist, cracked, soggy), any activity of plant growth, etc. Measurements of the height of plants in each grid will be useful too. These will be made into a graph depicting the growth rates of the different crops over time. Also make note of the species and the growth rate of any weeds that might germinate.

Diversity Experiment Observations

Time to Plant Emergence (in days)

	Temperature: Hot		Temperature: Warm		Temperature: Cold	
Rainfall Normal						
Rainfall Drought						

While making daily observations of plants, you should also record temperature in each grid, plant height, weed species and growth rate, and color and condition of "crops." Graph the growth rates of the different crops in relation to one another. This can be done by making a line graph with different colors or symbols for each grid situation (hot, dry = red: cold, wet = green: etc.) Remember to put a key on the graph so that others can read the information easily.



Diversity Experiment Questions

Answer the following questions after you have finished the diversity experiment. You will need your notes on the experiment, as well as the graphs and other information that you generated.

1. Briefly explain the effect of the variable conditions on the crops that you planted. What would have happened to your farm during cold, dry conditions?

2. How would a rotation help in a bad year? ... and how might it hurt your operation?

3. How would a cash crop farmer and a crop and livestock farmer fare differently under different weather conditions?

4. What effect would adverse conditions have on a dairy farmer? Are there any farm operations that are not affected by these weather differences?

5. What are the economic and environmental benefits of practicing crop rotations and diversity with respect to adverse weather conditions?

Dollars by the Degree

Overview

The second group of lesson activities will allow the students to study the economic benefits of determining the economic damage threshold for insect pests, banding herbicides, and taking nitrogen credits for legumes and manure.

Objectives

The student will:

☼ calculate the savings incurred by using integrated pest management, herbicide banding, and credit for nitrogen.

☼ describe the economic benefits of sustainable agricultural systems.

☼ analyze the usefulness of sustainable agriculture practices for small and large farm systems.

Teaching Notes

In the following lessons, the students will be required to determine cost savings for farmers associated with certain alternative practices. In order to use integrated pest management, herbicide banding, and nitrogen credits, the farmer must become more aware of the farm as a whole system.

The first lesson will have the students learning about integrated pest management (IPM) from University of Wisconsin-Extension publications and by trying their own hand at field scouting and predicting infestations through the use of degree day calculations. Banding herbicides and the use of herbicides at less than the recommended label rate will be covered in the second lesson. The third lesson will address the crediting of nitrogen through legume plowdown and manure credits.

Activities

Degree Day Calculations

Summary: Students will calculate degree days for European Corn Borer.
Materials: Copies of the degree day worksheets, UWEX and WDATCP IPM bulletins.
Time: One day for the explanation of the principles, and one day for the calculations.

The "degree days" measurement of insect development is an important tool for farmers to better time the spraying of insecticides and other growing and harvesting activities, like cutting hay. This timing can result in direct monetary savings by predicting the most efficient time to spray, as well as a possible reduction or elimination of spraying altogether. See **Appendix F - Prediction of Infestations** from document **A3466 Nutrient and Pesticide Best Management**

Practices for Wisconsin Farms. Your Wisconsin County Extension Office can provide full copies of this document. The following criteria must be met for degree day calculations to work: first, the pest must overwinter locally, and second, the pest must have clear and distinct generations that do not overlap. You might have your students research the characteristics of pests that they think might fit these criteria. Two of the pests that meet these criteria are alfalfa weevil and european corn borer.

Students will use the following equation to figure the degree day totals for each day: [(high T + low T)/2] - threshold = degree days for one day. The threshold for an insect is the lowest temperature that will allow for development. With alfalfa weevil the threshold is 48F, and for european corn borer 50F. If the low temperature falls below this threshold, then the total number of degree days figured could actually be smaller since the decreased temperature will retard the growth of the insect. After explaining the principles behind degree day calculations, have the students complete the attached worksheet to determine the best dates for finding the first moth, eggs, peak months, and the best time for treatment of the first generation of european corn borer. Economically, this information can potentially save a farmer hundreds of dollars through a more timely or reduced use of pesticides. **Part B - Optional** Have the students calculate the best time for first crop alfalfa based on their information. The temperature information can be obtained through observation, or from the National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC 28801, or the Wisconsin Department of Agriculture.

Band-It!

Summary: Students will calculate savings of reduced herbicide rates.

Materials: Copies of worksheets, copies of UWEX Bulletin **A3563 - Reduced Herbicide Rates: Aspects to Consider**, calculators optional.

Time: One class period.

Recent studies have indicated that by using mechanical cultivation in combination with herbicides, farmers can significantly reduced their herbicide applications. (When herbicides are tested to determine the application rate, mechanical cultivation is not used.) By taking this into account, farmers can significantly reduce their input costs through employing these strategies. Banding, spraying the herbicide in a band that only covers the crop row, can further reduce input costs since mechanical cultivation will control the weeds between the rows. Students in this lesson will calculate the different cost savings for four hypothetical farmers. For the sake of this activity, the farmers will all have farms of equal size and environmental conditions. Each of the four farms will use different methods of spraying their herbicides, running from full-rate broadcast spray of the entire field to a banded application of one-half the recommended application rate combined with mechanical cultivation. The yields and approximate costs are based upon Extension Publication **A3563 - Reduced Herbicide Rates: Some Aspects to Consider**. Once the students have performed the necessary calculations, they should discuss the labor, management, and environmental implications of what they have found. They should consider what kinds of farms are most likely to successfully adopt banding, cultivating, etc.

▸ When the students have finished the worksheets, remind them that other costs such as labor, machinery repairs, loan payments, seed costs, and fertilizer will all subtract from the returns they calculated.

Nitrogen: Grow it, Spread it, or Inject it?

Summary: Students will design a system for, and calculate savings of using non-purchased nitrogen fertilizer.
Materials: Calculators, copies of **Nitrogen...Tables to Use**, and worksheet.
Time: One class period.

Using the farm examples from the **Band-it!** lesson, the students will design a non-chemical method of providing sufficient nitrogen (N) for the corn crop and calculate the savings compared to anhydrous ammonia applications. The following tables and worksheet will provide students with the needed information. Documents: **A3566 The Bottom Line**; **A3557 Nutrient Management**; **A3537 Nitrogen Credits for Manure Applications**; **A3517 Using Legumes as a Nitrogen Source**. Discussion questions to include with this activity include: "What are some of the environmental benefits of using legume and manure credits? What are some of the problems of using manure to fertilize fields? How can run-off problems from applying manure be addressed?"

Extensions

Ask your county extension agent to perform a pre-plant soil nitrate test, crop scouting seminar, or other integrated pest management strategy. Students can also perform a survey of local use of the studied methods, as well as develop a scenario for what might happen if there were a mandated 50% reduction in farm chemical use in their area.

Worksheet -- Degree Days

Degree Days and European Corn Borer	
First Generation (Spring)	**Degree Days**
First Moth	374
First Eggs	450
Peak Moths	631
Treatment Period	800-1000
Second Generation (Summer)	**Degree Days**
First Moth	1400
First Eggs	1450
Peak Moths	1733
Treatment Period	1550-2100

*See also **Appendix F** or, ***Nutrient and Pesticide Best Management Practices for Wisconsin Farms*** Publication A3466.

The equation needed to determine degree days is: [(high T + low T)/2] - threshold = degree days

For use with the European corn borer, the threshold T = 50F.

Questions: Show your work on a separate sheet of paper.

1. What dates would be best to scout for the first moths of the first generation and the second generation?

2. On what date would you find the first eggs during the first generation and the second generation?

3. What are the best dates for treatment during the two generations?

4. Explain the economic benefits of employing degree days when treating for pests?

5. What are the problems associated with this method of determining when to treat for pests?

Temperature Record -- Stevens Point, Wisconsin -- 1991

Date	High T	Low T	DegDay	Date	High T	Low T	DegDay	Date	High T	Low T	DegDay
5-1	52	41		6-1	71	63		7-1	70	61	
5-2	46	38		6-2	77	65		7-2	82	62	
5-3	50	29		6-3	80	64		7-3	84	62	
5-4	51	39		6-4	80	50		7-4	74	59	
5-5	61	40		6-5	71	49		7-5	74	60	
5-6	45	35		6-6	73	49		7-6	81	68	
5-7	47	38		6-7	77	52		7-7	85	60	
5-8	55	41		6-8	78	53		7-8	83	58	
5-9	52	42		6-9	81	61		7-9	76	53	
5-10	74	49		6-10	81	67		7-10	77	54	
5-11	78	49		6-11	77	55		7-11	82	61	
5-12	85	58		6-12	79	55		7-12	85	63	
5-13	85	62		6-13	79	55		7-13	70	61	
5-14	85	51		6-14	87	66		7-14	75	50	
5-15	87	55		6-15	83	65		7-15	80	54	
5-16	84	62		6-16	75	56		7-16	82	66	
5-17	75	47		6-17	79	55		7-17	88	65	
5-18	49	41		6-18	82	60		7-18	88	65	
5-19	58	41		6-19	84	64		7-19	90	68	
5-20	71	43		6-20	84	64		7-20	87	69	
5-21	78	56		6-21	84	59		7-21	81	72	
5-22	77	66		6-22	64	51		7-22	80	70	
5-23	80	67		6-23	70	47		7-23	87	58	
5-24	79	66		6-24	74	54		7-24	76	56	
5-25	79	61		6-25	80	62		7-25	78	51	
5-26	74	61		6-26	84	66		7-26	70	47	
5-27	78	59		6-27	90	75		7-27	72	53	
5-28	85	64		6-28	91	75		7-28	73	57	
5-29	87	63		6-29	91	70		7-29	66	58	
5-30	89	62		6-30	91	64		7-30	70	55	
5-31	79	63						7-31	76	61	

Temperature Record -- Stevens Point, Wisconsin -- 1991

Date	High T	Low T	DegDay	Date	High T	Low T	DegDay	Date	High T	Low T	DegDay
8-1	82	53		9-1	71	48		10-1	62	40	
8-2	84	64		9-2	74	49		10-2	63	48	
8-3	66	60		9-3	81	66		10-3	72	37	
8-4	72	53		9-4	78	46		10-4	57	37	
8-5	74	51		9-5	74	47		10-5	57	40	
8-6	74	50		9-6	69	48		10-6	47	35	
8-7	73	59		9-7	81	63		10-7	48	27	
8-8	75	58		9-8	81	66		10-8	58	40	
8-9	73	54		9-9	78	63		10-9	70	40	
8-10	79	55		9-10	84	59		10-10	64	33	
8-11	82	55		9-11	71	52		10-11	56	36	
8-12	83	57		9-12	60	56		10-12	63	42	
8-13	81	57		9-13	68	60		10-13	54	34	
8-14	83	63		9-14	72	63		10-14	54	43	
8-15	85	63		9-15	76	68		10-15	43	30	
8-16	81	64		9-16	80	56		10-16	57	27	
8-17	77	66		9-17	65	45		10-17	68	51	
8-18	80	59		9-18	69	42		10-18	72	35	
8-19	69	51		9-19	49	33		10-19	39	19	
8-20	71	49		9-20	49	30		10-20	45	35	
8-21	75	55		9-21	55	35		10-21	58	43	
8-22	82	61		9-22	63	39		10-22	65	39	
8-23	81	61		9-23	59	40		10-23	71	51	
8-24	78	58		9-24	55	39		10-24	73	60	
8-25	83	58		9-25	51	41		10-25	67	41	
8-26	88	71		9-26	60	36		10-26	67	38	
8-27	90	65		9-27	51	28		10-27	42	37	
8-28	90	65		9-28	53	28		10-28	46	41	
8-29	90	70		9-29	61	33		10-29	59	45	
8-30	90	70		9-30	61	47		10-30	62	28	
8-31	90	58						10-31	40	28	

Band-it! -- Worksheet #1

☼ Farmer Joe has been broadcast spraying his corn field at the recommended label rate for weed control for as long as he can remember. If his field is exactly 100 acres, calculate the costs and profits from his corn field for the season. (For this assignment, the herbicide Nuke-Em will be used. The cost of Nuke-Em is $39.50/gallon, and the recommended application rate is 5 pints/acre. 2 pints = 1 quart. 1 acre = 160 square rods. 1 rod = 16.5 feet.)

1. Part 1 -- How much must Farmer Joe have to buy to cover his field and how much will it cost? Part 2 -- If the application costs $5.75 per hour using a contract sprayer, and his field will take 6.5 hours to spray, how much will it cost? Part 3 -- What are Farmer Joe's <u>total</u> costs for spraying his entire field with Nuke-Em at the recommended rate?

2. Part 1 -- Farmer Joe's corn field produces 183 bushels to the acre. How many bushels of corn does his field produce? Part 2 -- If corn is worth $2.15 per bushel, how much is Farmer Joe's return for his corn? (Remember to subtract the costs* from the question above.) *This is not his total cost, he must still pay for land, taxes, fuel, machinery, repairs, and other costs.

3. List some possible problems (labor, environmental, cost, etc.) that Farmer Joe might find using his current weed control methods.

Band-it! -- Worksheet #2

☼ Farmer Joe has a sister named Farmer Jill, who farms the 100 acres right next to him. After reading a newspaper article, she thinks that the recommended label rate is too much. For environmental and economic reasons this season she will try to use one-half the recommended rate. Assuming she pays the same for seed corn, find the amount of herbicide, cost, and production for her field of corn. (For this assignment, the herbicide Nuke-Em will be used. The cost of Nuke-Em is $39.50/gallon, and the recommended application rate is 5 pints/acre. 2 pints = 1 quart. 1 acre = 160 square rods. 1 rod = 16.5 feet.)

1. Part 1 -- How much must Farmer Jill buy to cover her field and how much will it cost? (Remember that she is using one-half the recommended rate.) Part 2 -- If the application costs $5.75 per hour, and her field will take 6.5 hours to spray, how much will it cost? Part 3 -- What are Farmer Jill's <u>total</u> costs for spraying her entire field with Nuke-Em at one-half the recommended rate?

2. Part 1 -- Farmer Jill's corn field produces 176 bushels to the acre. How many bushels of corn is her field produce? Part 2 -- If corn is worth $2.15 per bushel, how much is Farmer Jill's return for her corn? (Remember to subtract the costs* from the question above.) *This is not her total cost, she must still pay for land, taxes, fuel, machinery, repairs, and other costs.

3. List some possible problems and benefits (labor, environmental, cost, etc.) that Farmer Jill might find using her weed control methods for this season.

Band-it! -- Worksheet #3

☼ Farmers Joe and Jill have a neighbor named Farmer Bill, who farms the 100 acres right across the road. After reading an article in a sustainable farming magazine, he thinks that spraying in a 15" band over the row and mechanically cultivating will reduce his costs. For environmental and economic reasons this season he will try this strategy. Assuming he pays the same for seed corn as Farmers Joe and Jill, find the amounts, costs, and production for his field of corn. The herbicide Nuke-Em will be used. The cost of Nuke-Em is $39.50/gallon, and the recommended application rate is 5 pints/acre. 2 pints = 1 quart. 1 acre = 160 square rods. 1 rod = 16.5 feet.

1. Part 1 -- How much must Farmer Bill buy to cover his field and how much will it cost? (Remember that he is using the recommended rate in 15" bands. This will involve finding out how large his field is, and finding out the area that would be sprayed. Assume that the rows of corn are 30" apart) Part 2 -- If the application costs $6.25 per hour, and his field will take 6.5 hours to spray, how much will it cost? Part 3 -- What are Farmer Bill's <u>total</u> costs for spraying his field with Nuke-Em in 15" bands at the recommended rate?

2. Part 1 -- Farmer Bill's corn field produces 182 bushels to the acre. How many bushels of corn does his field produce? Part 2 -- If corn is worth $2.15 per bushel, how much is Farmer Bill's return for his corn? (Remember to subtract the costs* from the question above.) *This is not his total cost, he must still pay for land, taxes, fuel, machinery, repairs, and other costs.

3. List some possible problems and benefits (labor, environmental, cost, etc.) that Farmer Bill might find using his weed control methods for this season.

Band-it! -- Worksheet #4

☼ Farmer Bill has a neighbor Farmer Betty, who farms the 100 acres right next to Farmer Bill. After reading the article Farmer Bill loaned her, and talking with her neighbor Farmer Jill, she thinks that spraying in a 15" band over the row at half the recommended rate and mechanically cultivating will reduce her costs. For environmental and economic reasons this season she will try to use this strategy. Assuming he pays the same for seed corn as her neighbors, find the amounts, costs, and production for his field of corn. The herbicide Nuke-Em will be used. The cost of Nuke-Em is $39.50/gallon, and the recommended application rate is 5 pints/acre. 2 pints = 1 quart. 1 acre = 160 square rods. 1 rod = 16.5 feet.

1. Part 1 -- How much must Farmer Betty buy to cover her field and how much will it cost? (Remember that she is using the one-half the recommended rate in 15" bands. This will involve finding out how large her field is, and finding out the area that would be sprayed. Assume that the rows of corn are 30" apart) Part 2 -- If the application costs $6.25 per hour, and her field will take 6.5 hours to spray, how much will it cost? Part 3 -- What are Farmer Betty's <u>total</u> costs for spraying her field with Nuke-Em in 15" bands at one-half the recommended rate?

2. Part 1 -- Farmer Betty's corn field produces 181 bushels to the acre. How many bushels of corn does her field produce? Part 2 -- If corn is worth $2.15 per bushel, how much is Farmer Betty's return for her corn? (Remember to subtract the costs* from the question above.) *This is not her total cost, she must still pay for land, taxes, fuel, machinery, repairs, and other costs.

3. List some possible problems and benefits (labor, environmental, cost, etc.) that Farmer Betty might find using her weed control methods for this season.

Questions for the Band-it! Worksheet

The following questions can be used for a discussion format, or can be assigned to the students.

1. What are the possible time and labor constraints that farmers might have when they consider reducing their chemical usage?

2. Would the low-chemical banding, and cultivation techniques work on very large and very small farms? Why and/or why not?

3. What are the management questions that a farmer must consider when switching to a new technique of pest control?

4. In the examples given, did low-chemical methods reduce production? Did they reduce profitability?

5. What effect would fines on groundwater pollution have on the outcome of question #4?

6. What are some costs, both direct and indirect, of contaminated ground and surface water? (Consider lost use of the resource, clean-up costs, etc.) Discuss who currently "pays" these costs. Who should?

7. What effect might widespread use of low-chemical methods have on the supply of grains? ... the price of grain?

8. Economically, would a change to a low-chemical form of production be good or bad for farmers in the long run? Why?

9. Generally, do you think that reduced use of chemicals is good or bad for the farmer, consumer, government, agribusiness, environment?

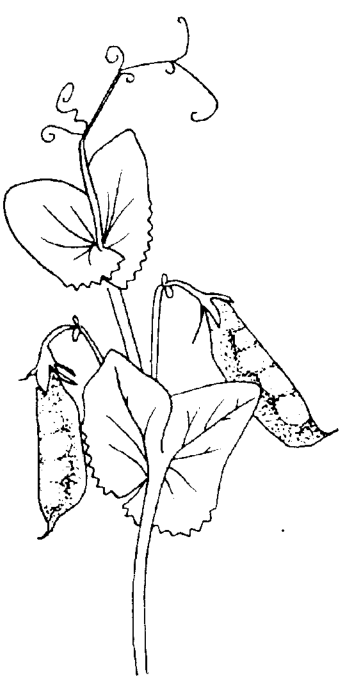
10. How can consumers influence the system to conform to their taste preferences? What are their constraints?

Nitrogen -- Grow it, Spread it, or Inject It -- Tables to Use

The four farmers from the **Band-it!** lesson attended a field day on reducing nitrogen run-off by crediting legume stands and manure applications. Using the figures in the tables below, answer questions 1-3.

Table 1 -- Nitrogen Values for Legume Crops

- Alfalfa
  - Full Stand (100%) = 190 lbs N/Acre
  - Fair Stand (60%) = 160 lbs N/Acre
  - Poor Stand (30%) = 130 lbs N/Acre
- Red Clover and Birdsfoot Trefoil (80% of Alfalfa Credit)
  - Full Stand (100%) = 150 lb N/Acre
  - Fair Stand (60%) = 125 lb N/Acre
  - Poor Stand (30%) = 100 lb N/Acre
- Green Manure Crops
  - Sweet Clover 80 - 120 lb N/Acre
  - Alfalfa 60 - 100 lb N/Acre
  - Red Clover 50 - 80 lbs N/Acre



Nitrogen Content of Various Manures

First Year Available N (lb/ton)

Nitrogen	Dairy	Beef	Swine	Poultry
solid				
- surface applied	3	4	4	13
- incorporated	4	4	5	15
liquid				
- surface applied	8	10	12	35
- incorporated	10	12	15	41

Table 3 -- Manure Area and Weight

1 bushel of manure = 77 pounds
1 cubic foot of manure = 62 pounds
1 gallon of manure = 8.3 pounds

*** Source: UWEX Bulletins A3557 - Nutrient Management, and A3537 Nitrogen Credits for Manure Applications*

Grow It, Spread It, or Inject It -- Worksheet

Our farmers decide to apply the information learned at the field day to reduce their input costs. For all four farmers, the recommended application rate for their yield and soil type has been figured at 160 lb N/Acre. Answer the following questions to determine their savings.

1. Find the amount of N available for each farmer's legume credit.

☼ Farmer Joe -- 75% stand of alfalfa.

☼ Farmer Jill -- 100% stand of alfalfa

☼ Farmer Bill -- 50% stand of red clover

☼ Farmer Betty -- 75% stand of birdsfoot trefoil

2. Determine the amount of manure our farmers will need to apply to reach the recommended Nitrogen application rate. Put all your answers in tons/acre and, if possible, how many bushels of what would be needed by each farmer.

☼ Farmer Joe -- Raises beef cattle.

☼ Farmer Jill -- Operates a dairy.

☼ Farmer Bill -- Raises swine.

☼ Farmer Betty -- Raises poultry.

3. What non-manure forms of N are also available for our farmers?

4. If anhydrous ammonia costs $6.83 per acre including application, calculate the savings for our farmers of using notrogen credits instead of purchasing 160 lb N/acre.

The BOTTOM Line

Overview

The manipulation of numbers generated during a three-year study of the economics of conventional, low-chemical, and no-chemical farming methods comprise the core of this lesson. Economic principles of crop value, cash costs, and net return per acre will be covered.

Objectives

The student will:
- define economic terminology related to agricultural economics.
- compute gross and net cash returns on a given crop.
- analyze the economic and environmental benefits of low- and no-chemical farming practices.

Teaching Notes

The results from this study suggest that the economic efficiencies associated with large operations and increased production might be overstated. In fact, agricultural economist Marty Strange of the Center for Rural Affairs (in Nebraska) authored a report which notes that, "that peak efficiency is achieved by medium-sized farmers, those selling around $133,000 in crops annually, employing one or two people, and using up-to-date technologies."

Profitability is the key to successful farming. For the sustainable family farm, this may mean incorporating the ideas learned in this group of lessons, such as reduced-chemical weed control, low-input farm start-up, alternative enterprises, and farm diversification. For the most part, those ideas run against the policies and farm practices being promoted and taught today. However, with increasing public concern over the environment -- and farmer concern over their bottom line -- these practices are receiving renewed attention.

Activities

Terms, terms, terms?

> Summary: Students will define the concepts and terms used in agricultural economics.
> Materials: Copies of Terms Worksheet.
> Time: One class period.

Students will determine as a class the best definition for a group of agricultural economic terms. Standard economic analysis uses concepts like capital recovery cost and depreciation. Farmers, on the other hand, may not see these as actual costs. Other terms have variable use when it comes to "real world" application. For example, for some farmers, fixed costs equal all the annual costs that the farmer will incur no matter what the crop or enterprise. For others, this will include repair and depreciation costs for machinery and buildings. Have the students select and justify one of these methods of accounting, and then define the terms listed on the Terms Worksheet.

Gross! Computations

Summary: Students will perform calculations using the Farm Analysis Project data.
Materials: Copies of worksheets, calculators or computers for Option B.
Time: One class period.

This lesson will have the students working with the numbers from the Farm Analysis Project. Each worksheet will list farms from one category (conventional, low-chemical, and no-chemical). Divide the students into three groups. Each group will be responsible for computing the gross and net cash return for the farms on their worksheet and answering the questions following each section. **(Part B - Optional)** This part will depend upon the level of the students as well as the equipment available at the school. Have the students write a program for their personal computer that will solicit the needed information and compute the final numbers. With this type of information, students can then attempt to "cash flow" hypothetical farms.

Analyze the Analysis

Summary: The students will analyze results from the Farm Analysis Project in terms of economic and environmental criteria.
Materials: Results from the **Gross!** lesson, and copies of discussion questions.
Time: One class period.

In the minds of most people, economics is usually the study of supply and demand, gross and net returns, and profits. Students will discuss possible methods of including environmental costs in the economic model. Using the enclosed list of discussion questions, have the students discuss the results from the earlier activity. When possible, try to relate the terms and concepts to activities and examples from the students' lives.

Extensions

Students could calculate the return and other numbers for their corn test plot, or a family farm operation. They could also compare the numbers and environmental consequences for confinement facilities versus a pasture-based system.

Terms Worksheet

Define the terms indicated with an * and list items that might fall under each heading. (e.g. under veterinary, list vet costs, medications, etc.)

1. Cash or "Variable" Costs*
    - A. Crop
        1. seed
        2. fertilizer
        3. insecticide
        4. biological control
        5. custom spraying
        6. other custom work
    - B. livestock
        1. veterinary
        2. purchased feed
        3. breeding
2. Fixed Costs*
    - a. crop
    - b. capital recovery*
    - c. labor
    - d. land
        1. loan (interest and principal)
        2. taxes
    - e. overhead*
3. Total Crop Costs*
4. Net Return*
5. Net Cash Return*
6. Total Gross Revenue*
7. Total Cash Costs*
8. Net Return*
9. Net Return per Labor Hour*
10. Net Return per Acre*

Worksheet Group 1

Farm Analysis Project -- Corn after Alfalfa -- Conventional Group								
Acres	**Yield**	**Gross**	**Seed/A**	**Insect/A**	**Herb/A**	**Fert/A**	**Total**	**Net**
19	120		22	0	18	37		
22	145		23	0	6	28		
16	193		26	0	17	28		
54	150		12	0	37	19		
91	156		17	0	9	22		
20	140		22	0	8	52		
20	170		19	0	5	12		
12	144		18	0	12	14		
115	175		22	0	8	23		
20	75		19	0	0	46		
40	160		19	0	0	26		
51	100		21	0	19	17		
50	140		22	0	13	27		
Ave:								

Step 1: Find the current price of corn per bushel. ________________ (This can be found in a local or agriculture newspaper, television or radio agriculture report.)

Step 2: Each row represents one farm. Figure the Gross Return for each farm. (Yield * Acres * Price = Gross)

Step 3: Find the total cost of inputs for each farm. Add seed, insecticide, herbicide, and fertilizer -- multiply this total by the number of acres and write that number in the column marked Total.

Step 4: Find the net cash return for each farm. (Gross - Total Costs = Net).

Step 5: Compute the averages for each column. (Add the numbers in each farm, and divide by the number of farms.)

Step 6: Find the average net return per acre. ________________________(average net/average # acres) Calculate the average cost/acre. ________________________

Worksheet Group 2

Farm Analysis Project -- Corn after Alfalfa -- Transition/Low Chemical Group								
Acres	**Yield**	**Gross**	**Seed/A**	**Insect/A**	**Herb/A**	**Fert/A**	**Total**	**Net**
30	165		21	0	0	14		
29	175		19	0	0	13		
20	110		19	0	6	20		
21	200		20	0	40	22		
55	130		19	0	0	15		
35	120		15	0	0	6		
16	120		16	0	0	26		
32	55		16	0	2	20		
30	126		20	0	0	0		
23	205		16	0	0	18		
55	77		13	0	0	0		
15	140		17	0	0	20		
Ave:								

Step 1: Find the current price of corn per bushel. ________________ (This can be found in a local or agriculture newspaper, television or radio agriculture report.)

Step 2: Each row represents one farm. Figure the Gross Return for each farm. (Yield * Acres * Price = Gross)

Step 3: Find the total cost of inputs for each farm. Add seed, insecticide, herbicide, and fertilizer -- multiply this total by the number of acres and write that number in the column marked Total.

Step 4: Find the net cash return for each farm. (Gross - Total Costs = Net).

Step 5: Compute the averages for each column. (Add the numbers in each farm, and divide by the number of farms.)

Step 6: Find the average net return per acre. ________________________(average net/average # acres) Calculate the average cost/acre. ______________________

Worksheet Group 3

Farm Analysis Project -- Corn after Alfalfa -- No-Chemical Group								
Acres	**Yield**	**Gross**	**Seed/A**	**Insect/A**	**Herb/A**	**Fert/A**	**Total**	**Net**
42	130		14	0	4	35		
34	123		30	0	0	0		
47	85		17	0	0	13		
50	70		20	0	0	28		
32	80		15	0	0	0		
52	95		25	0	0	21		
41	120		21	0	0	0		
34	106		22	0	0	25		
27	115		19	0	0	35		
Ave:								

Step 1: Find the current price of corn per bushel. ________________ (This can be found in a local or agriculture newspaper, television or radio agriculture report.)

Step 2: Each row represents one farm. Figure the Gross Return for each farm. (Yield * Acres * Price = Gross)

Step 3: Find the total cost of inputs for each farm. Add seed, insecticide, herbicide, and fertilizer -- multiply this total by the number of acres and write that number in the column marked Total.

Step 4: Find the net cash return for each farm. (Gross - Total Costs = Net).

Step 5: Compute the averages for each column. (Add the numbers in each farm, and divide by the number of farms.)

Step 6: Find the average net return per acre. ______________________(average net/average # acres) Calculate the average cost/acre. ______________________

Analysis of the Numbers -- A Discussion

Questions to be answered include:

1. Compare the three groups of farms. Which group appears to have the highest production? Which has the best highest revenues? Which has the highest net cash returns?

2. Why might one group of farms have higher production? Does one farm stand out as having the highest net cash return? What might account for the one farm with the high numbers?

3. Does an increase in production offset the increased costs of farming with more chemical inputs? Why?

4. What other cash costs besides fertilizers and pesticides do farmers have to pay to produce crops? (Examples: fuel, custom costs, repairs, land rents, etc.)

5. What are some of the external costs of farming with chemical inputs? (ground and surface water contamination, soil erosion, loss of soil tilth, etc.)

6. Do farmers consider repair costs to be an out-of-pocket expense or a fixed cost that has to be paid each year? How will this affect their perceptions of the economic models used to determine the economic well-being of a farm?

7. Where do family living expenses fall: fixed cost or cash cost?

8. What will a high capital recovery cost tell you about the debt load of the farm?

9. Where could each group of farmers possibly save money?

10. What effect will prices of commodities have on the net return? For example, drop the price of corn by 50 cents and calculate the new values. What about premiums for organic or no-chemical products? (raise the price paid to the no-chemical group by 50 cents per bushel and recalculate.

11. How can farmers increase the value of their crops before it leaves the farm?

12. What would happen if stiff fines were placed on farms that polluted ground or surface water?

13. What would happen if the price of fuel rose by 50%? ....by 75%?

14. Which farms are best able to handle low prices in one commodity?

15. Which way of farming would be the easiest to enter for a beginning farmer?

Production of Crops as Energy Sources

Environmental and political concerns have in recent years spurred the search for alternative fuels. Air pollution, "greenhouse gases," and the threat of global warming all encourage experimentation with renewable energy sources. Political instability in many of the countries with the largest petroleum reserves provides further impetus to develop alternatives. One alternative with real potential for farmers is biomass, which can be converted to ethanol and biodiesels. Rapeseed, soy, switchgrass, big bluestem, and safflower have all been explored for their energy potential.

Rapeseed derived biodiesel is currently being used in Europe and in test vehicles around the United States. It has the essential fatty acids that make it an acceptable alternative for high speed diesel engines (used in tractors and cars). According to one report, an Italian company producing methyl ester from rapeseed sold the entire production quota, even before ground had broken on the production facility. European tax and policy incentives played an important role in making the biofuel attractive. Soydiesel on the other hand, has a makeup that favors its use in lower speed diesels, such as those used for locomotives and stationary engines. Biodiesels' almost non-existent sulfur levels, cleaner burning properties, and generally high performance, make them very attractive energy alternatives. In addition, biofuels emit significantly less carbon into the atmosphere than petroleum-based fossil fuels. Finally, there are no major modifications needed to allow current diesel engines to run on vegetable-based fuels. The only modification is to change any rubber-based fuel lines to synthetic ones.

Given the increasing problems with our use of petroleum-based fuels and the clear potential of some biofuels, many United States agricultural and energy leaders are exploring ways to develop and promote the use of biofuels. These lessons provide an opportunity for students to learn about these exciting new developments, and explore their potential for farmers.

During the course of these lessons, the students will have the opportunity to grow their own biofuels, see them in action, and design a future with the use of more renewable energy. In the first lesson, **Ethanol the Easy Way**, students will ferment and distill their own ethanol from a molasses mixture for use in a comparison activity with kerosene. During **Grow Your Own Fuel**, students will cultivate a common alternative crop to study its characteristics and similarity to commonly cultivated field crops in terms of cultural practices and machinery needed. Using **Bottle Biology TerrAqua** columns (see the instructions listed in the first group of lessons), students will attempt to grow as much biomass as possible in only three weeks. Finally, the students will turn an eye to the future during **Design a Future with Renewable Energy**. Students will work on solving problems associated with the current policies and practices.

Alternative Crops as Energy Sources

Overview

This lesson will examine the use of farm commodities as energy substitutes. The lesson will address the following questions: Is it possible to convert feed and forage crops to energy; Is it practical to convert them to energy; and, What are the long-term costs/benefits of substituting plants for petroleum?

Objectives

The students will:

- cite three examples of crops grown and used for alternative energy.
- outline three reasons for and three reasons against using a particular crop for an energy source.
- evaluate a crop as a potential energy source in terms of economic benefit.

Teaching Notes

The United States suffers from dual problems of over dependence on foreign oil and over supply of agricultural commodities. Many people are interested in using excess farm commodities as energy substitutes. This lesson will show that this is possible, and can be better for the environment in terms of emissions and erosion. Ethanol from corn is not considered to be an effective or economical alternative due to its high cost of production, erosive characteristics, and low energy budget (amount of usable energy, compared to the amount of energy to produce and refine the product.) However, ethanol can be derived from any plant sugar, starch, and cellulose matter. The easiest and oldest has been by fermentation of the plant sugars into ethanol. During this lesson students will ferment and distill their own ethanol and compare it to kerosene.

Activities

Ethanol On Our Own

Summary: Students will ferment and distill ethanol from molasses, water and yeast.
Materials: Copies of laboratory set-up sheet, flasks, stoppers, tubing, collection jars, (see lab sheet).
Time: One class period for fermentation set-up, one for distillation.

Ethanol is one of the potential biofuels that can be made from crops and crop residue. Henry Ford designed one of his early vehicles to run on ethanol. However, petroleum proved to be a lower cost fuel with advances in extraction and refinement. Currently, ethanol is again being considered for fuel due to its cleaner burning properties. This activity will ask the students to ferment and distill their own ethanol for use in the following comparison lab. (See the enclosed laboratory sheet for more details.)

▸ During the fermentation stage, the molasses mixture will release carbon dioxide - remind the students to use a cotton plug to cover the mixture. Remember to remind students that ethanol is very dangerous and should not be ingested.

Burn Baby Burn

Summary: Students burn ethanol and kerosene to compare the energy and pollutants produced.
Materials: Copies of Laboratory Sheets, thermometers, timer, beakers, burners, kerosene, and ethanol from the distillation exercise.
Time: One class period.

In this activity the students will burn the ethanol produced in the **Ethanol On Our Own** activity and kerosene to test the levels of energy and pollutants. It is essential that the students use exactly the same set-up for each fuel. The height of the wick in the burner, the beaker's distance from the flame, and the amount and temperature of the water at the start of the experiment should all be held constant. Have the students record the starting time and temperature. (It will be easier for later calculations to use a celsius thermometer.) Light the burners and record any observations such as: smoke, color of flame, time needed to raise the temperature, etc. ***Caution:** Ethanol burns with an almost invisible flame.

▸ Do NOT use gasoline as a comparison fuel, it is very volatile and will explode. Only conduct this experiment in a well-ventilated laboratory or under a vented hood. Improperly trimmed wicks can result in excessive smoking which is not due to the nature of the fuel being burned. Ethanol, when prepared wrong, can cause severe illness, blindness, or death when ingested in any quantity. It is possible to denature, or render unfit to drink, the ethanol by adding a few ml. of kerosene or methanol.

Fossil or Food Fuel

Summary: Students will compare the fuels used in the previous activity.
Materials: Results from experiment and discussion sheet.
Time: One class period.

Using data collected from the **Burn Baby Burn** activity, the students will compare the two fuels burned. The students should be prepared with data on the amount of energy produced in BTUs and calories, pollutants emitted from each, and source of each fuel. By dividing a sheet of paper in quarters, each student will create one column for ethanol and one for kerosene (or fossil fuels). On the top half of the paper have the students write three positive characteristics of each fuel, and on the bottom, three negative characteristics.

Extensions

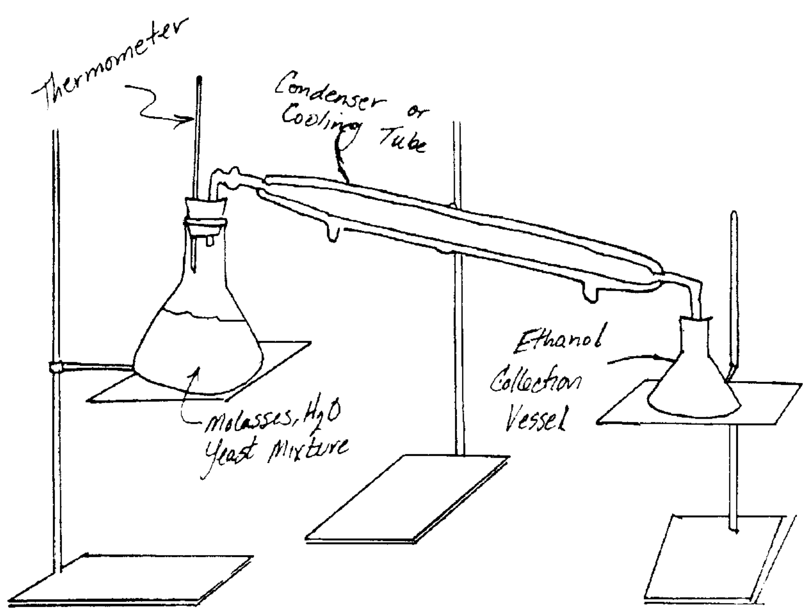
Have the students brainstorm as a class to identify as many sources of non-fossil fuels as possible. The list might include: wood, vegetable oils (sunflower, canola, soybean), garbage, crop residues (corncobs, spoiled corn, hay, straw, etc.) From the list generated in the previous activity, assign 2-3 students to a potential fuel and have them research it. Suggested sources of information include: libraries, county extension personnel, local government agencies, farmers, and local businesspeople. Information can also be obtained through the National Appropriate Technology Assistance Service (NATAS). Each group should outline at least three advantages and three disadvantages of their fuel. Have the students make special note of the estimated cost of production figures, and the energy budget.

Additional Info

The Wisconsin Corn and Soybean Grower's Association has information on Soydiesel. Contact Mr. Robert Karls, 2976 Triverton Pike, Madison, WI 53711.

NATAS, PO Box 2525, Butte, Montana 59702-2525. 1-800-428-2525.

The Yearbook of Agriculture -- 1992.



Fermentation Experiment

Fermentation is one of the oldest known and simplest methods of producing energy. In this experiment molasses, water and yeast will be combined to create ethanol and carbon dioxide ($C_{12}H_{22}O_{11}$ + H_2O + (yeast as a catalyst) → 4 CO_2 + C_2H_5OH (ethanol). ◻ Since carbon dioxide is a gas, do not seal the fermentation beaker!!

Materials needed for each lab group: 1 500 ml. Erlenmeyer flask, 1 graduated cylinder, distilled water (100 ml.), yeast (5-6 grains), molasses (20 ml.), cotton gauze.

Make sure all lab equipment is clean and ready for use (no cracked or broken glassware). Begin by adding the distilled water to the flask, then add the molasses and yeast. Stir. Plug the beaker with the cotton gauze. Let the mixture sit in a warm (80-90F) room for at least 24 - 30 hours. Record any observations concerning the mixture.

Distillation of the Ethanol

Distillation is a process by which a liquid mixture, (your molasses/water/yeast mixture), can be separated from the water by means of a simple boiling, cooling and collecting device, due to the fact that ethanol has a lower boiling point than water. By heating your mixture to 78C and collecting and condensing the vapor at that temperature, you can "refine" your own fuel.

Materials needed: Erlenmeyer flask from fermentation exercise, rubber stopper with two holes, thermometer, glass tube bent at 90 degrees, rubber tubing, (or a condenser), a bunsen burner and a collection vessel (preferably a beaker that can be stoppered to hold the ethanol.

Set-up: Place the thermometer and the glass tubing into the rubber stopper. *Be careful thermometers are thin and break easily. Set up a beaker stand for the Erlenmeyer flask (secure the flask by the neck and support it underneath with a ring stand.) Connect the rubber tubing or the condenser to the glass tubing, and place the stopper on the flask (make sure you secure the tubing or condenser with another beaker stand. Place the collection vessel under the outlet of the condenser. Light the burner and monitor the effects on your mixture. When you have about 30-40 ml. of liquid in the collection vessel, stop. Let the ethanol cool down and stopper the collection vessel for use in the next activity.

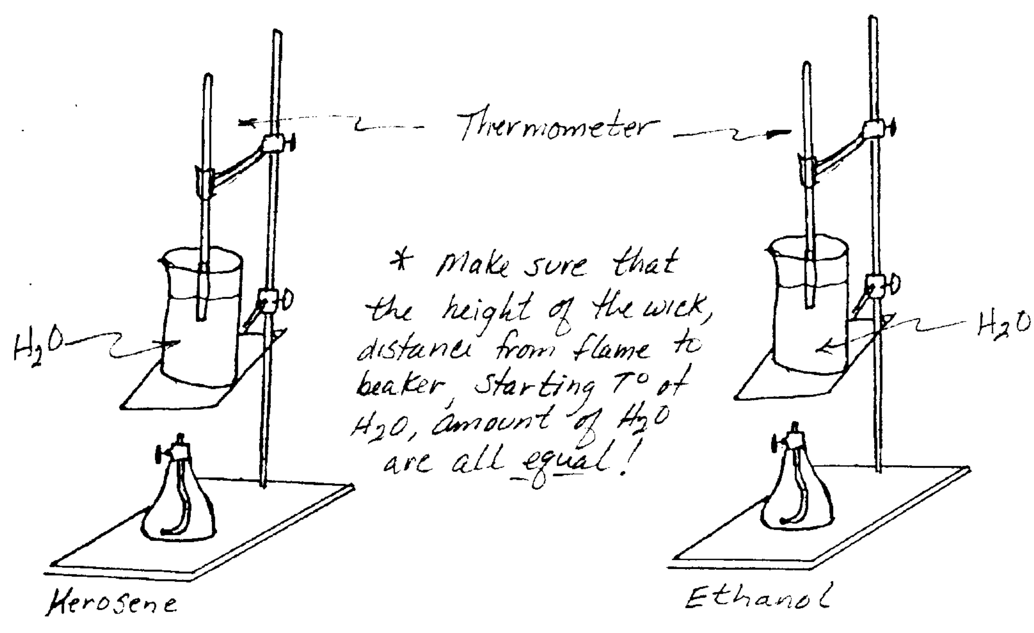
▸ Remember that the ethanol has a boiling point of 78C, and if you heat the mixture to too high a temperature, you will distill the water in the mixture as well.)

Burn Baby Burn

In this activity you will be comparing the ethanol you made to kerosene (a fossil fuel). You will need to make sure that the two measuring apparatuses are exactly the same to ensure that your results are as accurate as possible. Only perform this experiment in a well-ventilated laboratory or under a hood.

Set-up: You will need two of the following: 750 ml. beaker, beaker stand, distilled water (about 1 liter), thermometer (Celsius), thermometer holder, ring stand, and small wick-type kerosene lamps (burners). Make sure that everything is clean and in working order. You will also need a good watch or timer for recording temperature, and a graduated cylinder.

Procedure: Following the diagram below, set up the two systems in exactly the same fashion. This includes the height of the wick, and the distance of the wick from the beaker. Light both burners at the same time and record the temperature at 30 second time intervals. (This is a vital step when determining the amount of energy produced.) Run the experiment until each burner is out of fuel. Be prepared to answer the questions on the back of this sheet.



Comparison Experiment

Analysis of the Fuels

Now it is time to find out how much energy each fuel produced. Energy can be measured in calories and BTUs (British Thermal Units). First, a few equations to help your calculations of the number of calories each fuel produced. One calorie = amount of heat it takes to raise 1 gram of water 1 degree Celsius at 1 atmosphere of pressure. 1 gram of water = 1 cm^3. 1 BTU = 251.996 calories.

1. What was the total number of grams of water used? ____________

2. What was the rise in temperature of the ethanol?___________ ... the kerosene?__________

3. Find the number of calories contained in each.

4. Now find the number of BTU's in the ethanol. ______________________

   ... and in the kerosene. ________________________

5. List some of the differences in the two reactions. (amount of smoke, heat, energy)

6. What might account for the differences?

7. Which would appear to make the best fuel based upon energy produced?

8. Fossil fuels are decayed plant matter. Strictly speaking, they too are "biofuels." Why is the carbon they release a problem, when the carbon released by the modern biofuels is not?

Grow Your Own Fuel

Overview

This lesson will allow students to further investigate those crops that have demonstrated the most potential for use as energy crops. Students will also have an opportunity to experiment with various other crops to determine their potential as biofuel.

Objectives

The student will:
- cite three examples of crops grown and used for alternative energy.
- outline three reasons for, and against using a particular crop for an energy source.
- evaluate the economic value of a crop as a potential energy source.

Teaching Notes

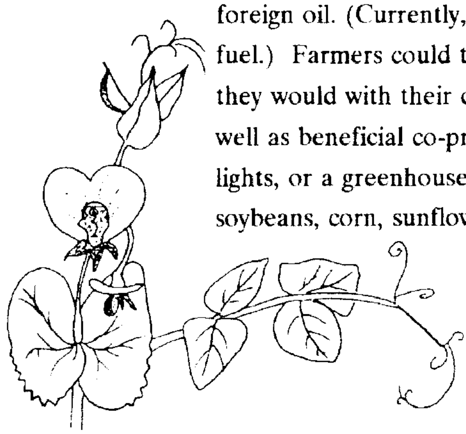
These two activities have students grow their own biofuels. The first lesson will use the information learned in the previous activity and apply it to commercial production. This includes comparing a crop to others currently being produced and analyzing the environmental and economic properties. The second lesson will have the students try to grow as much biomass as possible in three weeks time. By using **Bottle Biology TerrAqua** columns, students can analyze the effects of their production practices on the soil and the groundwater.

Activities

Growing Fuel

Summary: Students will grow and make observations concerning an alternative energy crop.
Materials: Crop seed, access to a greenhouse or grow lights.
Time: One class period for seed bed preparation and planting, several weeks of short observation time.

Studies have indicated that a small change (>10%) of America's farmland were planted in rapeseed for biofuel production, it could eliminate the need for foreign oil. (Currently, 5% of a farmer's total production costs are incurred for fuel.) Farmers could take their seed to a cooperative for processing much as they would with their cattle feed, and receive usable, renewable fuel in return, as well as beneficial co-products (high protein feed, and glycerin). Using grow lights, or a greenhouse (if available), have each student plant some rapeseed, soybeans, corn, sunflower, switchgrass, or other alternative fuel crop. Observe



the germination and development characteristics of each crop over a period of several weeks. Questions the students should ask include, "What would the cultivation practices be of this crop? Would this crop be grown in rotation or as a monocrop? Are there any foreseeable problems with this?" (e.g. erosion, chemical intensive cultivation, excessive water needs, weedy relatives that might crossbreed, etc.) Finally, the students should decide whether the crop is suitable for farmers to produce given the following criteria (using rapeseed as an example here): Is rapeseed similar in cultivation techniques and physical properties to any that are currently being cultivated in our area? Do farmers have enough experience with similar crops to successfully raise rapeseed? What are the barriers to convincing farmers across the Midwest to grow rapeseed for biofuel? What can the USDA do to overcome these barriers? As the plant matures, have the students list specific aspects plant breeders should work on to improve the amount of fuel the plant can produce (e.g. more seeds per plant, better frost tolerance, greater amount of important acids, etc.)

Biomass Production

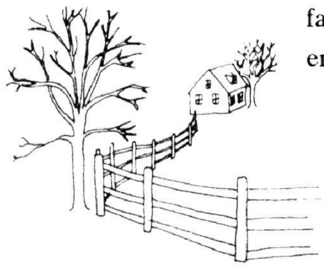
Summary: Students will attempt to grow the largest amount of biomass in three weeks, using **Bottle Biology Columns**.
Materials: **Bottle Biology Columns**, soil, light source, plant seeds, water, fertilizer, and a LaMotte test kit.
Time: Two class periods for initial set-up, three weeks of short care and observation time. One class period for wrap-up.

Each year thousands of tons of agricultural crop residue are simply plowed down. However, acres of corn stalks, corncobs, wheat straw, and other crop residues can be burned for their energy value. Some farmers burn the corncobs and/or cornstalks from their field to dry shelled corn for storage. Some people burn corncobs in their furnace, just as others burn wood. Currently, biomass combustion only accounts for about 5% of the energy used in the United States, estimates are that this figure will grow to over 15% by the year 2000. Challenge the students to grow the most biomass possible in a **Bottle Biology** column. They may plant any crop, weed, etc. at any density level they wish. They may also use fertilizer, and should record the amount they use, if any.

At the end of three weeks, "harvest" the above-ground portion of the crop. All students should test the water at the bottom of their column for nitrate levels by using a LaMotte Test Kit. Have the students compare the level of nitrate in their "groundwater" to tap or local surface water. A "penalty" can be placed on the producers with the highest level of nitrate in their water. Place the crops in a 200F oven to dry them. Weigh the crops to determine who raised the most biomass. Samples of the various crops can be sent to a local laboratory at a university campus to compare the energy present in each crop. By multiplying the weight of the crop produced by the heat value, the biomass energy may be calculated. Note that the student who produced the most biomass didn't necessarily produce the most biomass energy.

Questions to consider are, "Could the system producing the most biomass be used indefinitely? What inputs would be needed? What possible environmental problems might arise? Are there ways to grow this crop sustainably? Is there a difference in combustible energy between crops? Have the students compare their results. How might farmers use this information when deciding to install a biomass furnace? Which "crop" lost the most weight during drying? What might this tell you about the water requirements of the plant? How would this crop work in a more arid climate?"

Extensions



Take the students to visit a local farmer that is using a biomass furnace on his farm. Study the other possible methods that farmers can use to increase their energy independence, including solar and wind power.

Worksheet -- Growing Fuel

The following questions relate to the crop that you are currently cultivating. You will be asked to determine whether or not you would recommend this crop to area farmers as a beneficial alternative fuel crop.

1. What are/would be the cultivation practices of this crop?

2. Are there any foreseeable economic or environmental problems with its cultivation? (For example, will the crop require heavy doses of chemical inputs to grow, or will it contribute to erosion?)

3. Will there be any problems with this new crop? (Can it become a weed? Will it breed with local weed species?)

4. Is this crop similar to any others currently being cultivated by local farmers? What information or equipment can be easily modified for production? Can it be grown in rotation with other crops?

5. Do farmers have enough successful experience with similar crops to begin cultivating your crop for fuel production?

6. What are the barriers that would keep midwestern farmers from producing of your crop?

7. What properties of your crop could be improved through plant breeding?

8. Would you recommend your crop for widespread cultivation? Why or Why not? How does it compare with other biofuel crops?

Design a Future with Renewable Energy

Overview

This lesson will assume the federal government proceeds with an aggressive policy toward the production of biofuels. How will American agriculture need to change?

Teaching Notes

While American agriculture produces an abundance of food, it relies heavily on a policy of cheap energy for production, processing and transportation. This lesson assumes that the price of energy will rise in the future. Students will be asked how American agriculture can adapt and what changes society will face.

Objectives

The students will:

- identify three effects of cutting production of traditional crops to grow biofuels.
- evaluate the feasibility of growing a mass quantity of a biofuel.
- identify three environmental concerns raised by growing the crop.

Activities

The Air That We Breathe

Summary: Students will choose a plan of action for improving air quality through the use of biofuels, and defend this choice in a debate.
Materials: Information from the earlier lessons.
Time: One class period.

Assume the government decides that as part of an air quality program, it will encourage the use of biofuels. What are some ways they could do this? Consider taxes on fossil and other fuels, tax subsidies for research and development in biofuels, low-interest loans for planting biofuels, mandating a certain amount of acreage planted to biofuels, increasing demand for biofuels by converting all government vehicle fleets to biofuels, giving block grants to states to develop biofuels programs, etc. Students should discuss the pros and cons of as many ideas as they can think of. Then have the students choose one measure or combination of measures and determine what impact this could have on agriculture. Under what circumstances could the results include greater/less environmental impact; higher/lower government commodity program costs; shortages of some crops; more/fewer people employed in agriculture; greater/lesser role for small and medium size family farmers; etc. Hold a mock public hearing with officials prepared to explain and defend the policy, and the citizens/farmers ready to support or challenge it depending on their self-interest. Finally, refine or fine-tune the policy as needed.

Other Sources of Biofuels

> Summary: Students will consider a scenario with imported fuel restrictions.
> Materials: Student notebooks with information learned during this unit.
> Time: One class period.

Assume the Middle East is in the middle of a regional war and no oil can or will be shipped out. The President of the United States has appointed your class to be a special committee to locate alternative sources of energy for the Midwest. Oil is in short supply and VERY expensive. Nuclear power is considered too problematic and dangerous to consider further expansion. Coal violates air quality standards. Design as comprehensive a plan as possible to convert vehicles, power plants, industry and homes to burning biofuels. Where will your energy come from? Are some types of energy worth more than others? For example, liquid ethanol may be more valuable than oak firewood because cars can run on ethanol. Ask the students to identify activities that can be eliminated or re-structured to use less energy. Daylight savings time was originally proposed by Benjamin Franklin to save candles. Can the students identify sources of potential fuel that we currently do not use such as crop residues, methane from garbage landfills, etc.? How will the students' proposed energy changes affect our environment? (more air pollution, fewer oil spills, more unemployment, less solid waste disposal problems, etc.) As a class, identify the major obstacles to implementing these changes in real life.

Extensions

Students could develop a survey to determine the use of, and opinions toward alternative fuels in their community. Some students may want to design a small scale biomass furnace to heat a greenhouse or shop.

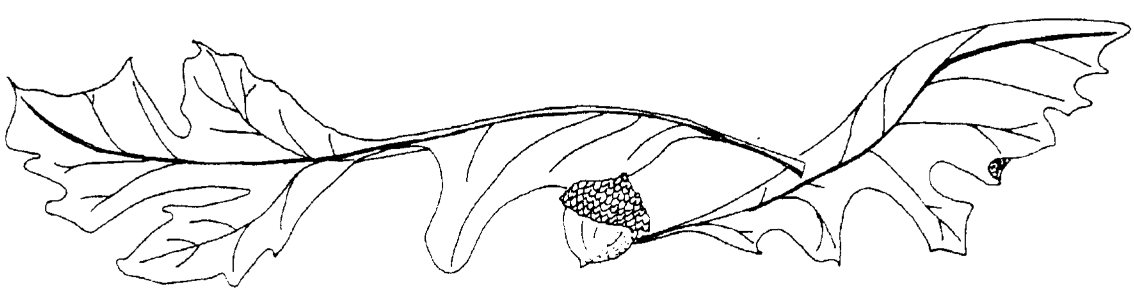
Environmentally-Sound Alternative Crops

As consumer preferences change and environmental concerns become more prominent, the benefits and disadvantages of the current food system will come under increasing scrutiny. Pressure to change will be felt by farmers - and other players in the food system.

This set of lessons helps students to identify some of the problems with the food system, and to explore some of the alternatives. Students will learn not only what farmers can do to diversify their operations and protect their pocketbooks and the environment, but what they themselves can do, as consumers, to support positive changes in agriculture.

During the first lesson, **Take a Walk on the Wild Side**, the students will try their hand at finding alternative crops and activities that farmers may be able to use to diversify their operation. They will examine the environmental impact of their proposed actions and the place of their product or activity in the ecosystem. In the **What Will Grow Where** lesson, the students will study maps of the United States, and the growing conditions of the major food crops. This information will then be used to study the current system and help to "drive" home the fact that the average morsel of food travels 1300 miles between the farm and the table. This "travel time" will be further studied as students' trace their breakfast meal back with the, **Pop-Tarts, Cornflakes, and Orange Juice...** lesson. By studying the food system, its producers, wholesalers, retailers, and consumers, the students will gain a better understanding of their food choices, and the related impact on the environment. They will to learn about the increases in cost as the product becomes more refined. For example, there is less than 5 cents worth of wheat in a loaf of bread. This amount has changed little in over 20 years, but the costs incurred by the farmers have gone up. In **Wisconsin's Other Crops**, students will have the opportunity to research and learn about the environmental impacts of the other crops grown in America's Dairyland. For many non-farm students, this lesson can act as a beneficial introduction to Wisconsin agriculture.

As extension activities, your students may want to study the story of CornHusker Corn Flakes in Nebraska, or a local food processor such as a specialty cheese maker, or Community-Supported Agriculture (CSA) marketing cooperative.



Take a Walk on the Wild Side

Overview

This lesson will enable students to explore their local wild areas with an eye for potential environmentally sound alternative crops and activities. This lesson is meant to take students out of the classroom and into the areas to be studied. Different seasons can stimulate different ideas. Students should be encouraged to use all of their senses and imagination in this project. It should be noted that this is not the only manner of generating ideas for environmentally-sound alternative crops or diversification ideas.

Objectives

The students will:

- discover local wild areas as possible income sources for farmers and landowners.
- identify local plants and animals in the wild.
- evaluate plants for possible market value and in terms of environmental soundness.
- identify risks of overpopulation of a given species.
- identify potential negative impacts of exploiting natural resources.

Teaching Notes

These activities can be incorporated into a unit on wildlife studies, ecosystem analysis, wild plant identification, and alternative marketing strategies. Students will have the opportunity to use various areas in their community that could provide inspiration for possible income for farmers and landowners. Local plant identification strategies will be covered as well as the possible environmental effects or agronomic difficulties (such as disease) of intentionally cultivating a wild species. Examples of products and services include: walnuts, cattails for dried flower arrangements, ginseng, mushrooms, firewood, hiking/nature path, and private hunting or fishing rights.

Activities

Woods Walk

> Summary: Students will walk in the woods to look for possible products.
> Materials: Student notebooks, identification sheet for local plants and animals.
> Time: One class period.

The initial activity will consist of the students taking a walk through a local area of "wilderness." Local forest, wetland area, county park, or state and national parks are examples of possible places to visit. Before the activity, handouts on species identification should be presented to students. Handouts should cover local tree and plant species, as well as animal habitats. Throughout the walk, the students should be asking themselves about possible product or source ideas, and the effects of developing these ideas economically. Will plants, seeds or animals be added or subtracted from the ecosystem? Will the action cause pollution? Is heavy machinery needed? Will the changing of a habitat cause environmental problems? What effect will the idea have on the area? Is this a project that could be passed along to my children? ...grandchildren?

Income Identification

Summary: Students will identify their new product idea, and check its economic feasibility.
Materials: Copies of **Worksheet #1**.
Time: One class period.

This lesson can be done by groups or individuals. The students will develop the ideas discovered during the natural areas into possible alternative enterprises/activities for farmers and landowners. This activity will include the selection of the product, such as reproducing ferns from spores gathered in a woodlot, raising seedlings from seeds gathered in the woodlot, etc. Also, students will work on the marketing of the product, estimating numbers to be sold, price, packaging, and transportation of the product. Using the fern example, students should determine the number available per acre, method of handling, (e.g. bare root stock versus containers), price per plant, (this can be figured by researching at a local nursery or seed catalog), method of selling (direct, through a nursery, or by order), and transportation. While students are considering their options, they should try to keep a simple balance sheet identifying incomes and expenses. If expenses outweigh the incomes, students should be encouraged to search for alternatives. For example, if the transportation costs are too high, they might consider a mail-order operation. (the attached worksheet may help the students to solidify their product decisions)

Environmental Impact Statement

Summary: Students will diagram the effect of their actions on the ecosystem.
Materials: Student notes from hike, copies of **Worksheet #2 - Ecosystem Web**.
Time: One class period.

The first part of this activity is to have the students design an ecosystem web inclusive of their new products. With the above example, the students should include all of the plants and animals that either rely on, or contribute to the ferns. (students can fill in web #1) After studying the ecosystem, each student should then evaluate the product in terms of its environmental soundness. Questions to be asked are included on the back of the web. The final part of this activity is to have the students determine the impact of their product on the woods involved in the first activity by asking the question, "Now that you are aware of the environmental impact of your product, will you continue with its marketing? Will you make changes to affect the impact of your product?"

Defending the Final Product

Summary: Students will defend the environmental soundness of their product.
Materials: Student information from earlier activities, and copies of **Developing Your Defense** worksheet.
Time: One class period, or can be assigned as homework with classroom follow-up.

A final activity for the lesson will have the students "defend" their product. The initial premise is that the students' activities involving their product have been questioned by state agencies and a local wildlife protection group. The main point in this lesson is to have the students develop a working relationship with the involved agencies. Their ability to defend will depend most heavily on the environmental costs of their actions. In some cases, their actions will not be environmentally sound. For example, if the fern project from above were to remove all ferns and leave none for future regrowth or animal habitat, then the production would have to be scaled back to meet compliance with the state agencies and possibly the wildlife protection group.

Summary

The student activities can be expanded in each section to complement the rest of the unit currently being studied, whether ecosystem analysis, alternative enterprise development, marketing, or environmental education. The students should be evaluated on their ability to identify species and their relation to the ecosystem. Students will learn to incorporate environmental constraints and opportunities into their economic development plans.

Extensions

Students could actually follow through with one of their products, complete with the initial idea development, environmental impact analysis, and market studies, development of the product, marketing, sales, and promotion of their product line. Students may want to research the "experts" ideas for diversification in their area. One such resource is the Appropriate Technology Transfer for Rural Areas (ATTRA) program. The toll free number for information requests is 1-800-346-9140. State Departments of Agriculture and Development may also prove helpful.

Worksheet #1 -- Alternative Product Balance Sheet

Product or Service:____

Your Snazzy Name for it: ____

Source of your product or service: ____

____

____

____

This table should help you keep track of the total costs and revenues from your new product or service. Use the top box to fill in the product name. Under each of the two middle bars, fill in the approximate costs and projected revenues from your project. Examples include: Income Generated = money generated from sales of products or services, or secondary products sold and Costs = products or tools needed to produce or package the product, and transportation costs.

Income Generated	Costs Incurred
Total Income:	Total Cost:

If the total costs for your product are greater than your income, then you will need to search for ways to reduce your total costs. Reducing your packaging or transportation costs may be necessary to make your balance sheet - and your idea - work out.

Ecosystem Web -- Worksheet #2

Place your product or service at the center of the web. Then identify all of the other living and non-living things that are reliant on your product or actions. In some cases, an entity that you identify may be reliant on another and your product. Can you think of any examples?

Developing your Defense

Answer the following questions as if you were defending your new-found product/enterprise. Remember the work that you have done previously to determine the environmental impact of your product/enterprise, and the ecosystem web that you designed to find the relation of your product/enterprise to the surrounding area. Remember that the environmental soundness of your answers will help to convince the concerned groups that your product/enterprise is acceptable and should continue.

1. A member of a state agency dealing with proper land use asks you to defend your actions and describe the impacts that you will be having on the long-term environmental health of the area. How would you respond?

2. Your city's local hunting group has always used the land adjacent to yours to hunt each year, and they are concerned about the effect that your product/enterprise will have on their activities. How will you respond to their concerns?

3. How would you respond if it were found that your area is a prime habitat for an endangered species?

What Will Grow Where?

Overview

This lesson will introduce students to climatic and environmental constraints to food and fiber production and will help them examine how certain technologies have allowed agriculture to bypass those constraints. Finally, students will analyze the environmental soundness of current patterns of crop production in the United States.

Objectives

The students will:

- analyze maps of the United States in terms of crop production potential.
- learn how various regions have used various inputs and technologies to grow crops not favored by the local environment.
- assess the environmental impact of current crop production patterns.

Teaching Notes

There are many reasons why certain crops are grown in seemingly unsuitable locations. For example, a large, cheap labor pool and mild climate in the West has led to California's becoming a national leader in the production of many fresh fruits and vegetables despite the fact that rainfall is scarce and irrigation a necessity. For this lesson, the students will examining the climatic constraints to food production and how they have been overcome -- and at what cost socially, environmentally, and economically. Some student research may be necessary. Most of the required information can be found in a plant biology text, an encyclopedia set, or an atlas. Basic information about the needs of different crops may also be obtained from the Cooperative Extension service.

Activities

Map Lessons

> Summary: Students will study maps of the United States to discover optimum conditions for crop growth.
> Materials: US History or Geography text, rulers, and copies of outline map.
> Time: One to two class periods.

Have the students use rainfall, temperature, and other geographic and climatic maps to create a master map of the United States. This map can be enlarged by the students to be used for a bulletin board or as a wall map. By dividing a smaller map into a given number of grids and having the students reproduce each grid at a ratio of 1:4, the smaller map can be enlarged to be used for a wall or bulletin board. The students should then use different colors or symbols to outline the different regions found. For example, the Southwest has a mild climate, but low precipitation and poor soil. Different regions and/or states should be labeled with a list of important climatic and geographic factors that will limit crop production under natural conditions.

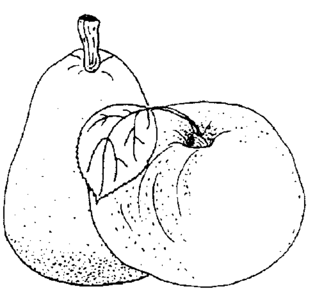
Ideal Conditions

Summary: Students will research the climatic and geographic needs of some common crops, and determine where they might best grow under natural conditions.
Materials: Copies of **Table of Common Crop Needs**, information from seed catalogs and grower's associations, and the final map from the map activity.
Time: Two class periods. One for research, and one for map work.

Individually, or in groups, students will research the requirements of different crops. Students will then decide which regions of the country fulfill the needs of each crop chosen. Have the students fill in the crop needs on the enclosed worksheet. Important crops such as corn, wheat, rice, beans, potatoes, tomatoes, citrus and apples are listed along with extra spaces for student choices. Students should "place" these products on the outline maps for reference. Different colors of pens or symbols can be used to demonstrate the placement of the crops in their "ideal" locations.

Reality Check

Summary: Students will compare their ideal crop condition map to reality.
Materials: Map from earlier activities, information on crop production.
Time: One class period.



After the map is complete, it can be compared to a map showing actual, current agricultural production. Crops will be grown in some areas which had been deemed unsuitable given natural conditions. In such cases, students should try to discover the type of input or change permitting the crop's production in the area. For example, corn requires more water than is available in the Great Plains region, thus the prevalence of center-pivot irrigation systems. Another example might be Southern Texas whose temperature and growing season may be ideal for growing citrus, but where annual rainfall may be a problem. They should speculate on environmental and social consequences of these changes. For example, the Central Valley of California is capable of producing lettuce, but at the cost of importing large quantities of irrigated water. Where does that water come from, and what are some of the issues, environmental and social, surrounding its use? Related issues are groundwater depletion, salinization (the build up of salts due to irrigation), construction of dams and reservoirs to hold water, and the conflicts which arise between competing industries or communities over the use of water resources.

Extensions

An additional point of discussion should be the costs and logistics of transporting crops from where they are grown to where they are consumed. For example, what are the environmental implications of potatoes grown in Florida being eaten in Chicago? Using the master map, is there a closer source of potatoes for Chicago? Another important factor to study is the effect of the type of system used to raise livestock. A comparative study of rotational grazing versus feedlot/factory farm systems - and regional circumstances that contribute to selecting one system over another - would make an interesting study project for students.

Outline Map of the United States

Table for Common Crop Needs

Common Crops and Their Needs						
	max/min temperature	season length	rainfall needed	labor requirement	shelf life	soil type
corn						
wheat						
rice						
potatoes						
citrus						
tomatoes						
apples						
lettuce						
beans						

Use this chart to fill in the common characteristics that are usually associated with these crops during their production. Feel free to substitute for any other product that you wish. Remember that some of these products are actually produced more for animal feed, and vegetable oil production rather than actual human consumption.

Pop-Tarts, Cornflakes, and Orange Juice: Where does my breakfast come from?

Overview

In this lesson, students will learn more about the food system by tracing some of the foods they eat back to the regions that produce them. What happens to harvested crops after they leave the farm and before they reach our tables? How far do the foods we eat travel?

Objectives

The students will learn about the structure and geography of the food system by:

- investigating the geographic origins of the foods they eat.
- tracing and mapping the route foods take through the food system.
- developing an awareness of the energy used in getting food from the farm to table.

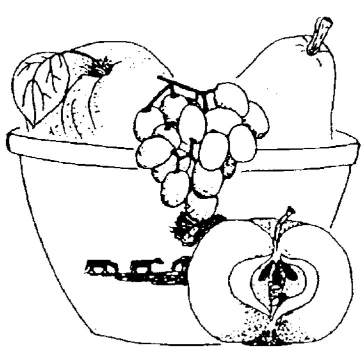
Teaching Notes

This lesson follows from a previous lesson in which students learned about where, geographically, different crops are grown. Only a few generations ago, Americans had a firm understanding of the origins of their food. Discovering the origins of specific foods that students eat will entail investigative research. The necessary information should be available from either grocery store managers or food wholesale companies. Exact information and precise origins may be difficult for some foods. It will be impossible in most cases to trace the foods back to specific farms and farmers. This reality is one aspect of the food system which should be impressed upon students. It is more important that the students gain an appreciation of the general distances and extent of energy use than precise figures.

Activities

Breakfast Menu

> Summary: Students will investigate the distance their breakfast traveled.
> Materials: Students will need access to research materials.
> Time: Will vary.



Have the students break into groups of three to five. Have the students develop a typical breakfast menu. If the item is a breakfast cereal, the students should investigate the various main ingredients (wheat, raisins, and sugar for example) in addition to the milk poured on top. The students should select a local supermarket as their starting point and trace the product back to its source. This could potentially take the student through warehouse distributors, food processors, food brokers, (companies which buy from farmers and sell to wholesalers and processors), transportation industries, and ultimately to the farm (or agricultural region) where the products were grown. Encourage the class to investigate a variety of foods: include fruits, eggs, milk, cereals, and breakfast meats. Some products, like milk, will have much different production, processing, and transportation history than items like cornflakes and bacon. This activity can be made more or less complex depending on the nature of the class. A trip to the supermarket produce aisle, or research from an encyclopedia set may be sufficient to gather data on the geographic origin of fresh fruits. (See also, **Appendix I -- Where does our food come from.**) Highly processed foods have a much more complex history, which may be difficult to uncover.

Go With the Flow

Summary: Students will design a flow chart that simulates the food system.
Materials: Information from the previous lesson, maps of the United States, and **Appendix J**.
Time: One to two class periods.

Farmers must produce 104 pounds of corn to afford one box of Corn Flakes, or 93 pounds of potatoes to buy one 3 ounce serving of fried potato skins with cheese. This lesson will have students draw a flow chart to demonstrate the current food system in the United States. Starting at their home, have the students draw a flow chart that follows the food back through the system, past the farmer and ending with the inputs farmers purchase to produce the crop. This system will include the grocery, warehouse distributors, manufacturers, commodity wholesalers, food brokers, farmers, fertilizer and insecticide suppliers, oil refineries, and oil wells. (The last part could be one possible branch of the chart which can include seed, fuel, and implement dealers.) One important aspect for students to consider is the increasing vertical integration of the food system. Companies like ConAgra sell farm inputs, purchase crop commodities, feed animals to market weight, slaughter, and sell to supermarkets. Another implication of the distances and processing common in the food system is the nutritional quality of food. In many instances, even the "fresh" foods found in supermarkets have traveled many hundreds or thousands of miles.

Visual Results

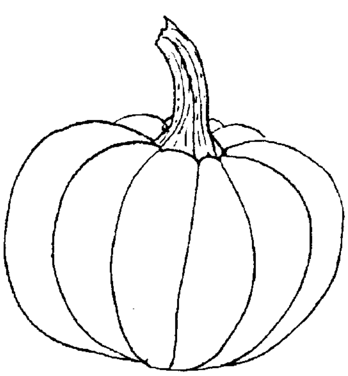
> Summary: Students will generate a map documenting the distance their breakfast traveled.
> Materials: Information from the previous lesson, blank outline maps of the United States.
> Time: One class period.

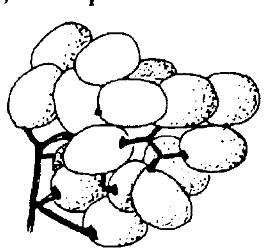
As a final product, have the students place their flow chart on a map of the world. Which foods come the farthest and which are produced closest to home? Why? Do any items come from foreign countries? This activity could also result in tabulations of the total miles traveled, or a list of all the industries ("middlemen") involved in the food system (from input industries like fertilizers, to processors, to consumers), or an account of the various energy inputs (planting, fertilization, cultivating, harvesting, processing, packaging, transportation, refrigeration, etc.) An interesting discussion question is, "Are all the environmental costs of producing and transporting foods accounted for in the supermarket price? What would happen to the price of food is consumers paid the costs of cleaning up contaminated water, un-silting dams, and other costs to society of other environmental degradation that some agricultural practices incur? What would happen to the price of food if the cost of fossil fuels increased? How can the consumers affect the system?"

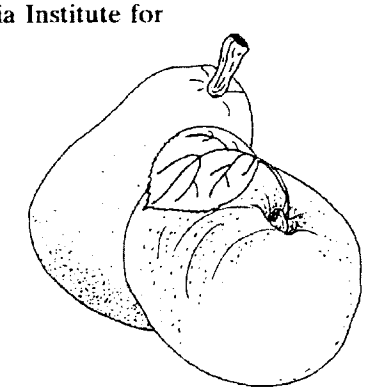
Resources

Farm to Market Review, Winter 1993. from the Western Organization of Resource Councils Education Project, 412 Stapleton Building, Billings, MT 59101

"Food, Farm and Consumer Forum," the Northeast Taskforce for Food, Farm and Consumer Policy, in cooperation with the Pennsylvania Institute for Community Services.







Wisconsin's Other Crops

Overview

This final activity will introduce the students to Wisconsin's secondary crops, in terms of the total income generated. Many people are unaware of the importance of these "secondary" crops in America's Dairyland. Introductions to cranberry, lumber, ginseng, and Christmas tree production will allow the students to gain an understanding of environmental impacts of certain crops and assess the environmental "friendliness" of Wisconsin's other crops.

Objectives

The students will:

☼ demonstrate an understanding of the origins and uses of secondary crops in Wisconsin.

☼ assess the environmental soundness of cultivation of these secondary crops.

☼ propose sustainable solutions to the common production problems of secondary crops.

Overview

Wisconsin produces 95% of the nation's ginseng, and almost 40% of its cranberries. Its the nation's second largest producer of Christmas trees.* This group of activities will have the students research the background and the origins of these secondary crops, as well as their cultivation, processing, and transportation characteristics. Additionally, students will propose environmentally sound solutions to some of the common problems associated with their cultivation. Some initial contact with the local growers and producers associations may need to be made some weeks in advance to prepare the lessons for use. Substitutions may be used to more closely reflect regional differences and student interest.

*From "*This Business Called Agriculture*."

Teaching Notes

Origins of Alternatives

Summary: Students will research the origins of Wisconsin's secondary crops. Materials: Information from grower's associations, and other student research. Time: One to two class periods for compilation of the information.

The students will research the origins of Wisconsin's alternative crops. This can be done by dividing the class into a number of groups equal to the number of alternative crops. Each group will be responsible for writing to the state growers associations of the different crops. Outside and early research may be required. (This step is vital to the following activities. Students will need as much information as possible.) Using the table provided, students will list the origin of the crop studied, its dates of earliest cultivation, uses in the past and present, current value of Wisconsin's annual crop, and some common problems associated with its production.

Environmental Impacts of Alternatives

Summary: Students will determine the environmental impact of Wisconsin's secondary crops.
Materials: Copies of environmental impact assessment from the first lesson.
Time: One class period.

This activity consists of the students using a similar environmental impact statement as with the **Take a Walk on the Wild Side** lesson. In this case, it is necessary for the students to understand all of the inputs, and transportation expenses incurred with these products. For example, Christmas trees grow well in Wisconsin soil. However, in an intensive monocropped system, it may be necessary to apply many pesticides to protect the young trees from weed competition and rodent damage. There are also questions of biodiversity that must be answered for some of the larger tree farms. Discussion can be initiated with a question like: "What if a disease like Dutch Elm disease attacked the Christmas tree varieties?" Each group can prepare a presentation on the impacts that are related to the production of their crop.

Marketing other-than Dairyland Products

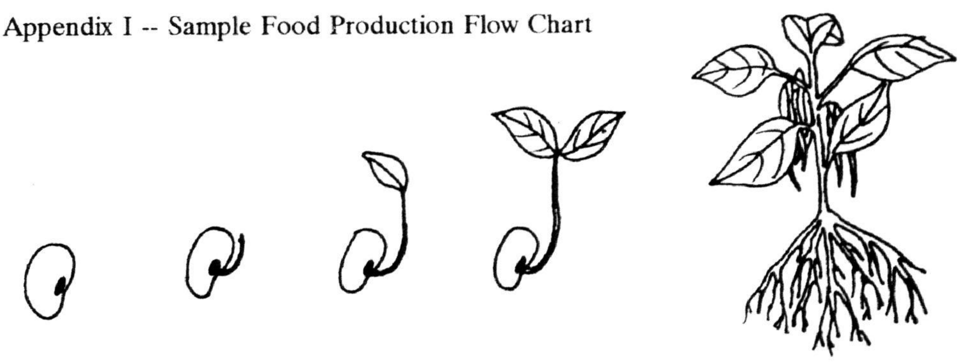
Summary: Students will develop an advertising campaign for Wisconsin secondary products.
Materials: Copies of successful food advertisements, posterboard, and markers.
Time: One class period for design and one for presentation of ideas.

This activity can stand alone, or can act as a supplement to a unit on advertising. Have the students imagine they are the marketing directors for the growers of these alternative crops. They should design a marketing strategy for the crop that emphasizes the environmental benefits of the products, the Wisconsin pride in its production, and the merits of these products. This marketing strategy can take many forms. Students could produce a commercial, draw posters, or develop a radio campaign. The strategy should consider: primary and secondary audiences, product merits, obstacles to consumer acceptance of the product, and other issues about which the students may brainstorm.

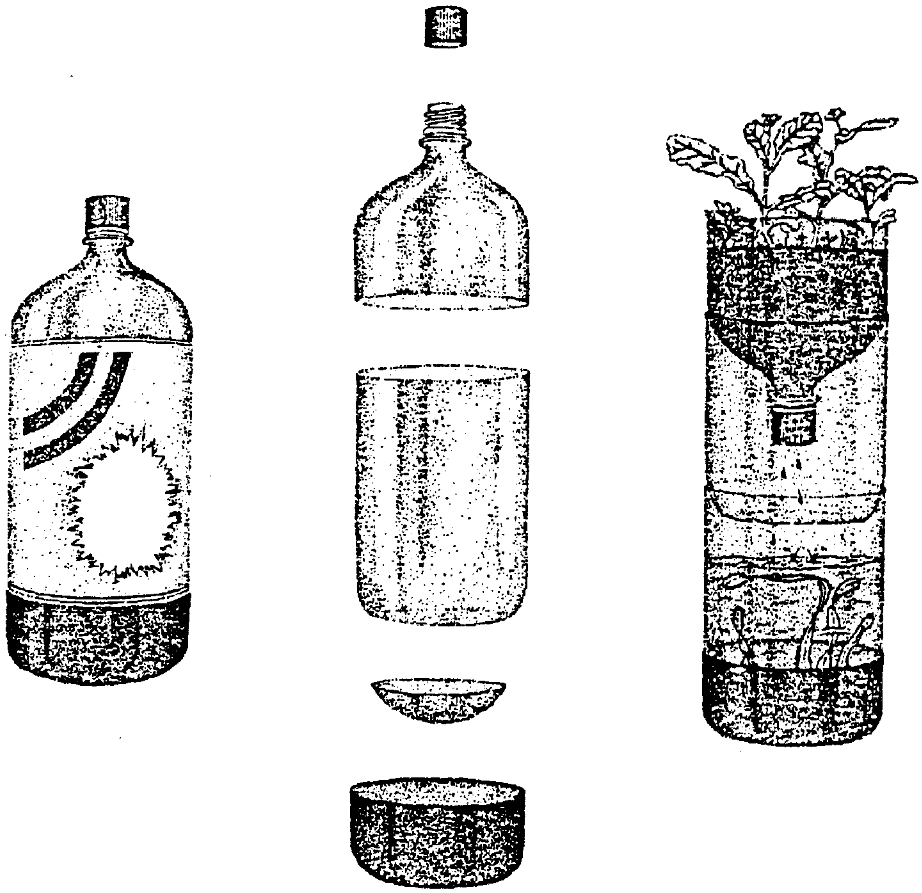
Extensions

As an extended study, students could attempt to grow some of these alternative crops on their own. Adaptations of the **Bottle Biology** columns can be used if the students are going to try to work with these plants indoors. Students could research and write reports on the alternative crops and enterprises in their locality and alternative ways of producing more traditional products: rotational grazing of dairy cattle, and the pasturing of poultry, swine and other animals commonly associated with confinement production. Field days and information provided by the Sustainable Agriculture Networks in your region may provide an interesting opportunity to view some of these practices.

List of Appendices



Bottle Biology



Exploring:

- Ecosystem Interactions
- Population Dynamics
- Biodegradation
- Microbial Fermentation
- Experimental Design

Hands-on Biology with Plastic Containers

Bottle Biology Program, University of Wisconsin-Madison, Department of Plant Pathology
1630 Linden Drive, Madison, WI 53706, 608-263-5645

BOTTLE BIOLOGY

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Bottle Biology is a classroom-tested approach to hands-on biology which allows students on all levels to become engaged in the actual process and activity of doing science: asking questions, creating experiments, testing hypotheses and generating "answers." Teachers and students working with Bottle Biology use throw-away containers to explore many areas of the life sciences leading to a better understanding of ecosystems, local environments, and biotic interactions. Our activities present a low-cost and accessible scientific world, which includes microbes, plants, insects, and environmental interactions as the ground from which to pose their questions and launch their investigations. Explorations include composting, making Korean *kimchee* and sauerkraut fermenters, stacking eco-habitats, creating insect environments, and modelling environmental interactions such as nutrient runoff and groundwater contamination.

We are currently in our third and final year of funding by the National Science Foundation. These pages represent our continuing efforts to put Bottle Biology concepts and theories into practical resource formats. We are also producing a comprehensive manual for Bottle Biology, which will be published by Kendall/Hunt Publishing Co. in August, 1993, the official ending date for the Bottle Biology Program. The manual is a compilation of bottle ideas and extensions generated by our project and associates thus far. Many of our ideas have come from teachers, students and others who do science in throw-away containers and shared their creations with us. We aim to provide the kinds of materials that promise easy and exciting integration into the classroom. We know that Bottle Biology will continue to thrive in classrooms long after this program has officially ended.

If you have any bottle frustrations or inspirations, please write or call. We will be here until August 1st and would love to hear from you. Enjoy your bottle work!

EcoColumn

Bottle Biology is an instructional materials development program funded by a grant from the National Sciences Foundation administered by the University of Wisconsin-Madison
Bottle Biology Program, Dept. of Plant Pathology, UW-Madison,
1630 Linden Drive, Madison, WI 53706 (608)263-5645

Bottle Basics

Create hands-on scientific explorations using throw-away containers

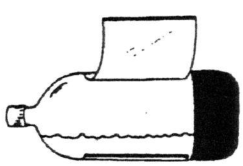
Plastic beverage bottles provide the primary material for Bottle Biology explorations. They are readily available — millions are produced and discarded daily — and they are easy to cut and combine in a wide variety of ways for science projects. These Bottle Basics are meant to get you started, showing how plastic bottles can be taken apart, cut, and connected. Once these basic techniques are mastered, you can use your imagination to combine bottles and parts of bottles (as well as other disposable containers) into the apparatus needed to try out any number of ideas for fascinating projects in the life sciences..

Removing the Label and Base

Both the bottle label and base may be readily removed, but for some projects or parts of projects it might be best to leave the base glued firmly to the bottle. Aquariums and compost columns, for example, will be more stable if the lowest unit has the base attached. In almost all projects the label should be removed. The label and base are held in place with a heat-sensitive glue. To remove them, the glue must be softened with heat.

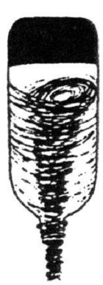
A) Fill the bottle about 1/4 full with very hot (120° - 150° F) water. If the water is too hot (170° - 212° F) the plastic will soften, warp, and may permanently crumple. Screw the cap back on firmly. This will retain pressure inside the bottle allowing you to hold the bottle tightly without crushing or denting it.

B) Tip the bottle on its side so the water warms the area where the label is attached to the bottle — this will soften the glue. Catch a corner of the label with your fingernail and gently peel it from the bottle. If there is resistance, you may need hotter water.



C) To remove the base, tip the bottle upright so the hot water warms the glue holding the bottle bottom to the base. Hold the bottle tightly and slowly twist off the base.

D) Remove the cap and pour the water out slowly. You might try swirling the bottle around as it begins to empty, causing the water to form a vortex resembling a tornado funnel. This lets the water to swirl slowly out of the bottle mouth without buckling the sides.



E) Usually most of the glue from the label and base is left on the bottle. It can be removed by scraping with a sharp-edged piece of metal or plastic while the glue is still warm. It can also be chemically softened and removed with a solvent such as cleaning fluid. Put a small amount on a paper towel and rub. This works best if most of the glue has been removed by scraping. Be sure there is adequate ventilation.

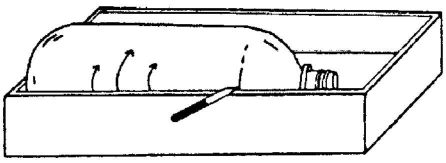
F) Save all parts, bottle, cap, and base. You now have the raw materials to begin fascinating explorations!

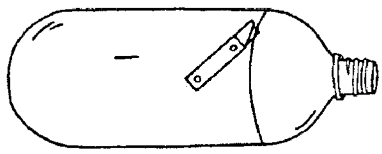
Department of Plant Pathology, University of Wisconsin, 1630 Linden Dr., Madison, WI 53706
Bottle Biology is an NSF funded instructional materials development project in the biological sciences

BB 1-21-91

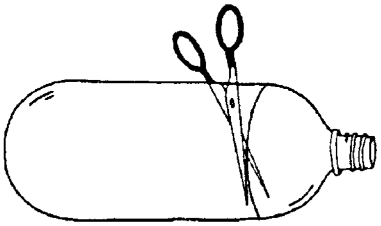
Bottle Basics - Cutting Techniques

Plastic bottles can be cut and modified in a great variety of ways — but before you begin cutting, plan carefully. Remember that some bottles are wider than others, some have larger bases, and some have more tapered shoulders. The bottle shape and location of the cuts affect how your pieces fit together.





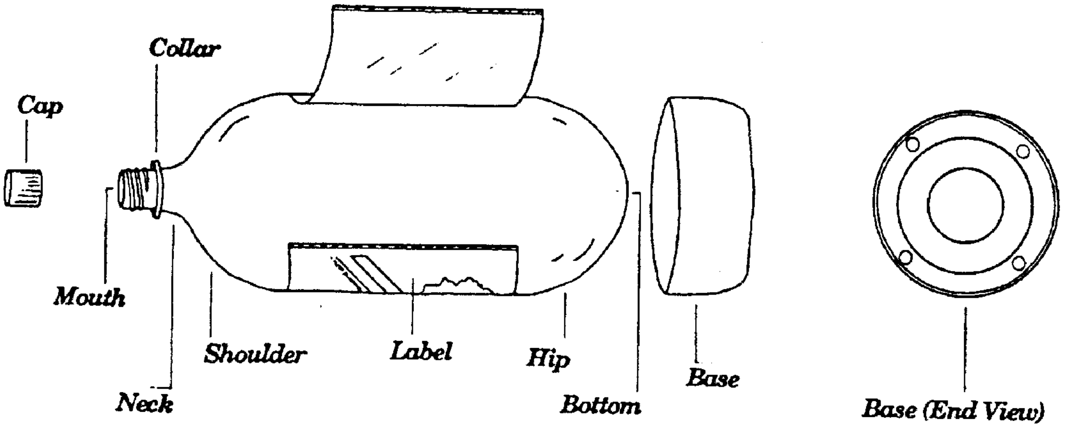
1) Place bottles on their sides in an empty drawer, tray, or box — shallow cardboard flats and computer paper boxtops work well. Hold the bottle up against the side and corner of the box to stabilize it while rotating. Brace a felt-tip pen against the box with the tip just touching the bottle and roll the bottle slowly around. This will leave an even line encircling the bottle. Sometimes it's easier to do this cooperatively. One person holds the bottle and rotates, while the other keeps the pen tip touching the bottle.



2) Use a single-sided razor blade or utility knife to begin the cut, slicing along the cutting line about two inches. Insert the tip of the scissors and snip your way around the rest of the cutting line. Because the scissor blades tend to catch in the plastic, it may be easier to snip along with just the tips.

Trim away rough edges and irregularities with the scissors. Once the bottle is cut open, you can snip more from the shoulder, hip or side if you decide shorter lengths are needed. When in doubt about how project pieces may fit, cut them a little too long — you can always remove the extra length. Because it is more difficult to draw lines once a bottle has been cut, draw all intended lines before cutting.

Basic Bottle Anatomy



BOTTLE BIOLOGY
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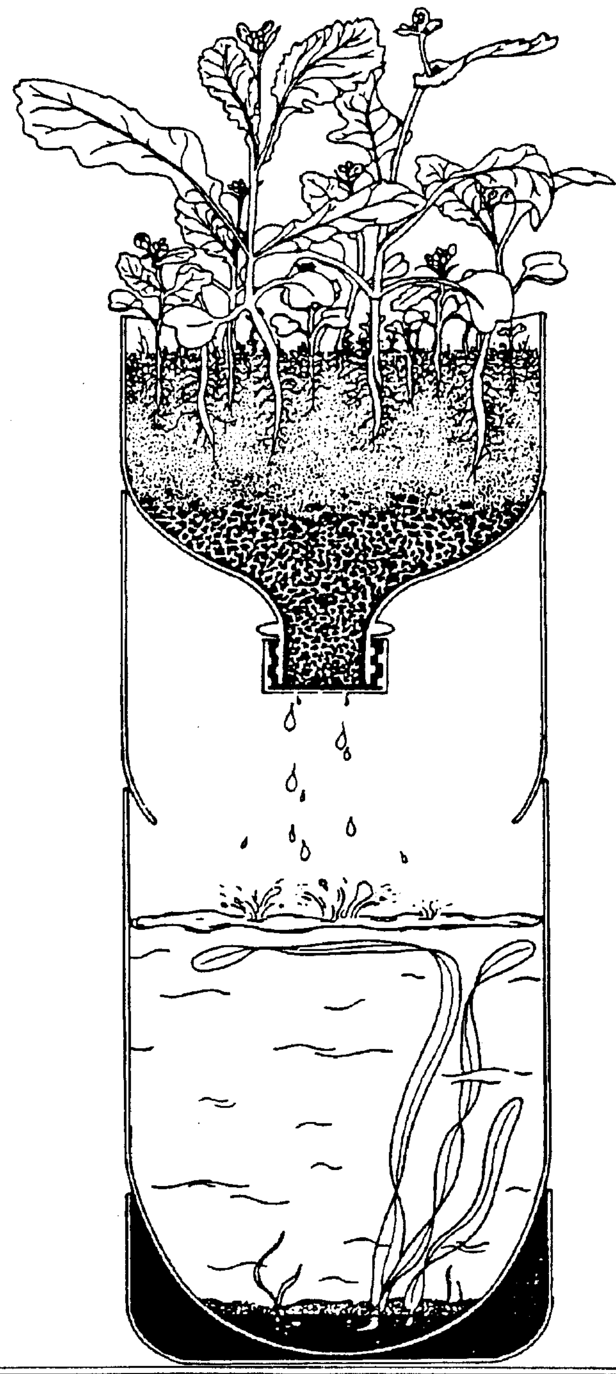
TerrAqua Column

Explore interactions between terrestrial and aquatic systems

Terrestrial and aquatic ecosystems are frequently viewed as two separate and independent entities. However, land and water systems are connected in many ways. One of the major links between terrestrial and aquatic ecosystems is water.

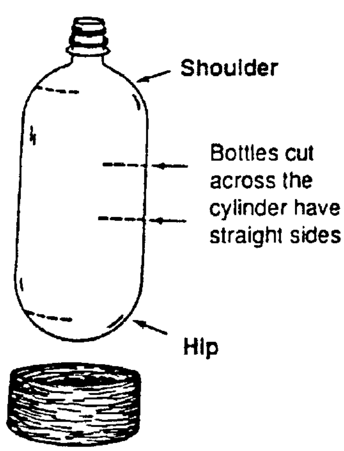
Water is the life blood for the terrestrial community and usually finds its way to wetlands, rivers, lakes and oceans. Passing through the soils of fields and forests, the water picks up compounds such as nutrients and agricultural chemicals. As this solution enters an aquatic community it then modifies biological, physical and chemical aspects of that community.

Construction of a TerrAqua Column can allow you to model and explore relationships between land and water ecosystems.

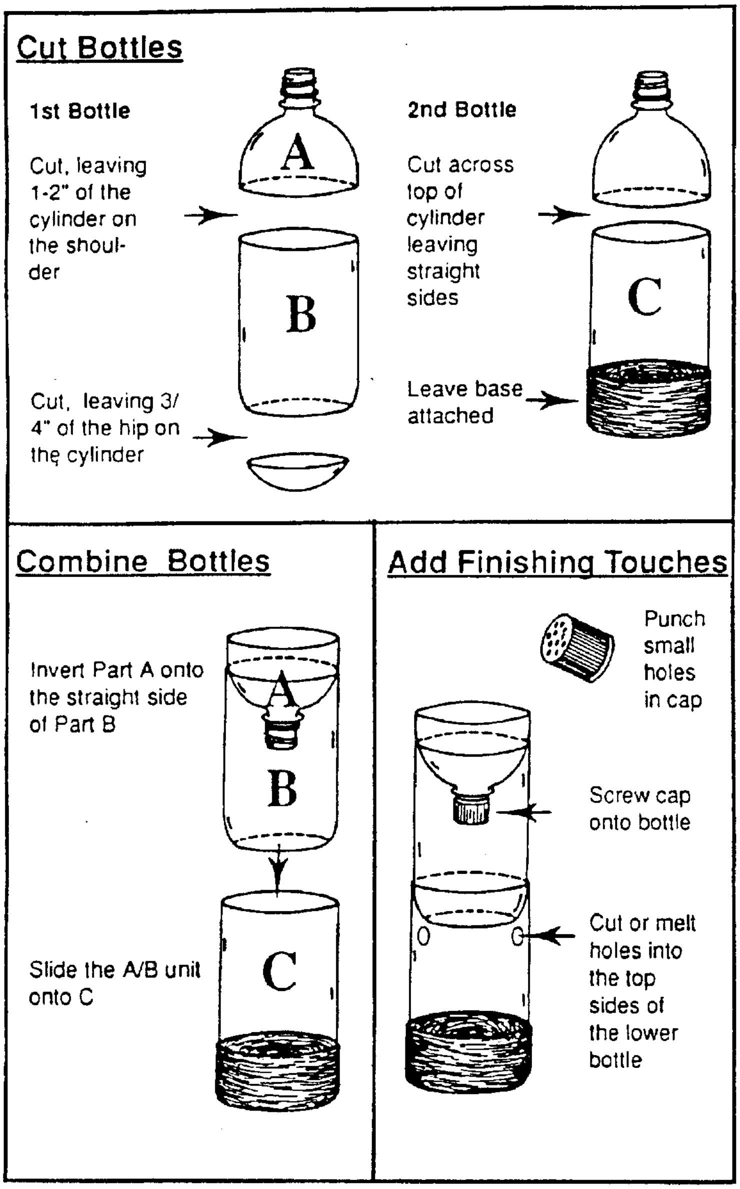


Bottle Anatomy

Bottles cut across the shoulder or hip have tapered sides



Department of Plant Pathology, University of Wisconsin, 1630 Linden Dr., Madison, WI 53706
Wisconsin Fast Plants and Bottle Biology are NSF funded instructional materials development projects in the biological sciences



Column Construction

This column is composed of two units. The upper, terrestrial unit is made by cutting a bottle to make pieces A and B as shown in the illustration. These two pieces can be held together by a wide transparent tape such as bookbinding or mailing tape. The lower, aquatic unit is made by cutting a second bottle to produce piece C. Biological materials for the aquatic system can come from a pond, lake, puddle or fish tank and can include algae, phytoplankton, zooplankton, aquatic plants and insects. A variety of plants can be used in the terrestrial system. Because of their rapid life cycle, Fast Plants work well.

Studying the Flow of Agricultural Chemicals

Recent concerns about the interaction between land use and water quality have led to the study of nutrient and chemical flow from terrestrial to aquatic ecosystems. Fertilizers and pesticides used for lawn care and agriculture readily make their way into aquatic systems causing water quality problems ranging from algal growth to the build-up of toxins in drinking water.

The TerrAqua Column allows for the study of various aspects of land-water interactions such as the effects of:

1. Nutrient sources for the terrestrial system
2. Nutrient concentration
3. Type and amount of soil in the terrestrial system
4. Type(s) of plants in the terrestrial system
5. Physical factors such as temperature and light
6. Effect of various pesticides
7. Frequency of fertilizer or pesticide application.

Various aspects of the terrestrial and aquatic systems can be monitored such as the growth of plants and algae. For plants in the terrestrial system, percent germination, height, weight, leaf size, length of life cycle, and seed production can all be measures of plant health. Populations of algae, aquatic plants and animals can be monitored in aquatic systems. Changes in the soil microorganism populations and soil structure can also be monitored. Finally, the solution flowing from the terrestrial to the aquatic system can be examined with a Fast Plant bioassay (*Fast Plant Notes*, Spring, 1990).

BOTTLE BIOLOGY

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Compost Columns

Where do things go when they die?
Explore the process of decomposition.

Composting is based on the biological process of decomposition. What turns plants and animals into compost? Microscopic bacteria and fungi, which feed on dead tissue, are the chief agents.

What affects the composting process? The amount of moisture and air, temperature, light, sources of bacteria and fungi, and the nature of the decomposing material are all critical. The presence or absence of air (oxygen) is one of the most important factors in composting. The practice of composting allows air and moisture to speed the natural process of biodegradation. Making a compost column lets you see and experiment with this process, and witness nature's world of recycling.

Materials Needed:

- Three 2-liter plastic beverage bottles
- Hot tap water, knife or razor blade, scissors, marking pen, sharp needles for poking holes, clear tape, netting or mesh fabric, rubber bands.
- Organic materials for composting, such as kitchen scraps, leaves, newspapers, animal manure, and grass clippings.

Procedure:

Remove the bases from two bottles, and the labels from all three, by pouring about two cups of hot tap water into the bottles. (Columns can also be made from bottles that don't have removable bases.) Replace the cap, tilt the bottle so the water softens the heat-sensitive glue, peel off the label and twist off the base. Pour out the water, draw cutting lines around the bottle, make incisions with the knife and cut with scissors and assemble as illustrated.

Most columns will require air holes for ventilation, and these can be poked into the plastic with a sharp cold needle or with a needle or paper clip heated in a candle flame. Alternatively, larger holes can be cut into the sides with the knife and covered with fine mesh fabric held in place with tape. A piece of mesh fabric over the lower end allows for drainage. Refer to the illustrations. Add ingredients for composting through the top of the column.

Explorations:

The possibilities for compost column explorations and discoveries are endless. There is no limit to what can be put inside, or the conditions under which the column can be kept. In addition to simply observing changes, you can design experiments which explore the effects of variables on you column.

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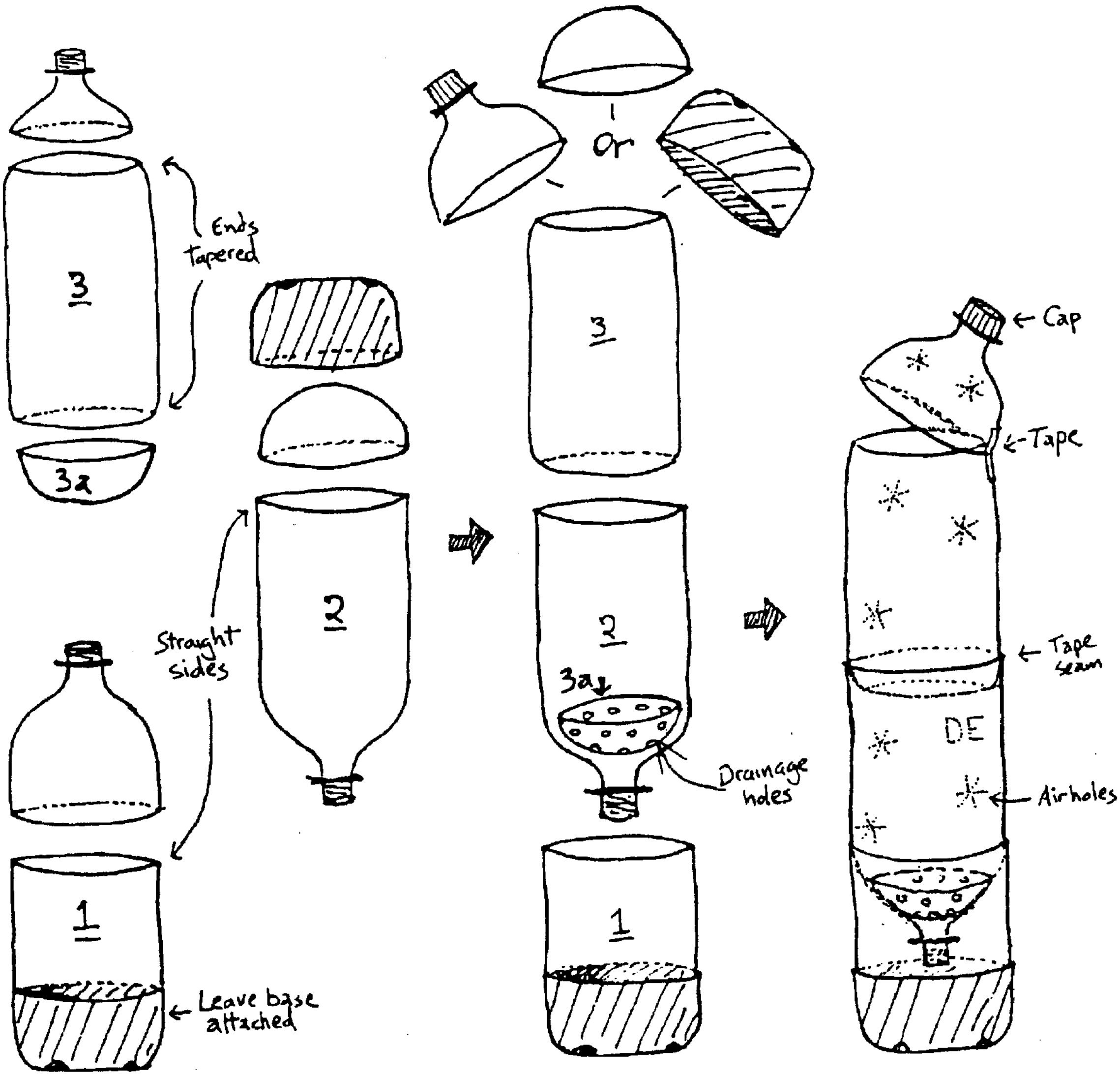
Compost Column Construction



Two Possible Explorations:

• **Leaf Digester.** Make two columns, and use a balance or postal scale to weigh out two equal quantities of leaves. Loosely pack one column with leaves only. Mix about a half cup of garden soil to the other batch of leaves and loosely pack the second column. Pour equal amounts of pond or rainwater into each column, and wait several hours for it to percolate through. If none comes out the bottom, add more in equal amounts until about a half cup drips into the reservior. Schedule a rainstorm to occur in the column every few days, pouring the drippings back through the column. Which column decomposes faster and why?

• **Compost Tea.** Compost columns can be used to generate a liquid fertilizer called "compost tea". Try making several columns using different ingredients, whose drippings will differ in color and chemistry. Use this liquid to water and fertilize identical sets of seedlings to see how different brands of "tea" affect plant growth. Some drippings, such as those from a column filled with leaves from a black walnut tree, may even inhibit growth.

EcoColumns

Creating miniature systems that can be interconnected to explore natural systems

This advanced Bottle Biology activity makes possible a fascinating variety of dynamic life sciences explorations. EcoColumns can be designed to model many kinds of aquatic and terrestrial environments, with habitats and niches for insects, spiders and small vertebrates. Individual modules can be used alone or stacked into a stable, free-standing column. Modules can be kept isolated from one another or be interconnected to stimulate interactions between systems.

The tapered sides of the Eco-Column chambers allow a closeup view of organisms from aquatic environments. Roots of plants are also made visible, and the module can be viewed from underneath as well. Studies of ecology, population dynamics, water chemistry and many other sciences can be conducted in an Eco-Column. Columns can also simply be constructed and observed, noting changes over time. There is no limit to the number of ways that the modules can be designed and put together. What kind of biological question could you try to answer in an EcoColumn?

Materials:

• Several one or two liter beverage bottles

• Bottle Basics tools for marking and cutting bottles, plus equipment for making ventilation and port holes

• Clear waterproof tape (Most postal and bookbinding tapes are waterproof.)

• Silicone sealant (Available at most hardware stores, for chambers that will need to hold water.)

Explorations

• Consider the different types of habitats you might expect to find in an ecosystem such as a tropical rain forest. How many of these habitats can you include in one EcoColumn construction?

• Put a fruit fly module below a chamber containing a hungry spider or praying mantis. Connect them with a narrow tube which will allow flies to wander upward but which prevents the spider or mantis from descending into the fruit fly chamber. Fruit flies will live off of banana peels and other rotting fruits.

• Plant seeds or small plants in a chamber filled with soil (or filled up to the bottle mouth). In time, root growth will be visible along the clear sides, and from underneath as well. Patterns of root response to crowding, overwatering, and other variables could be compared among different species of plants.

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EcoColumn units are modules made from soda bottle pieces which can stacked to make numerous different models of ecological systems.

Tips

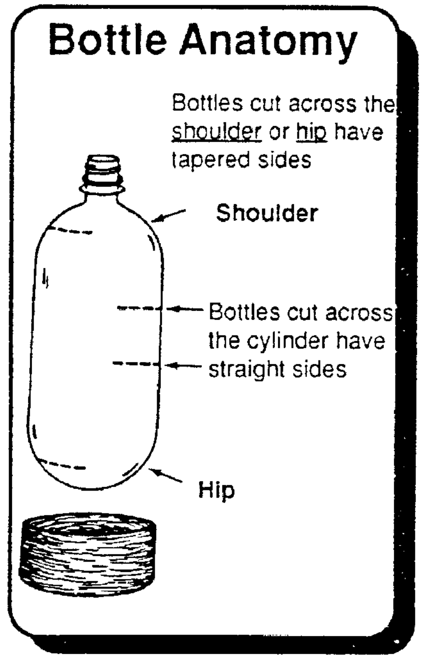
Use the same brand of bottle for all of the EcoColumn units which will make up a final construction. Different brands of bottles can have slightly different diameters or shapes and this can lead to complications. Also, some bottles have bulges at the top of the hip which can make it difficult to stack units. These bottles should be avoided.

Use a waterproof tape to fix bottle part A to part B. Some clear tapes are waterproof, but check first by taping a test strip to a scrap piece of bottle and leaving it under water overnight.

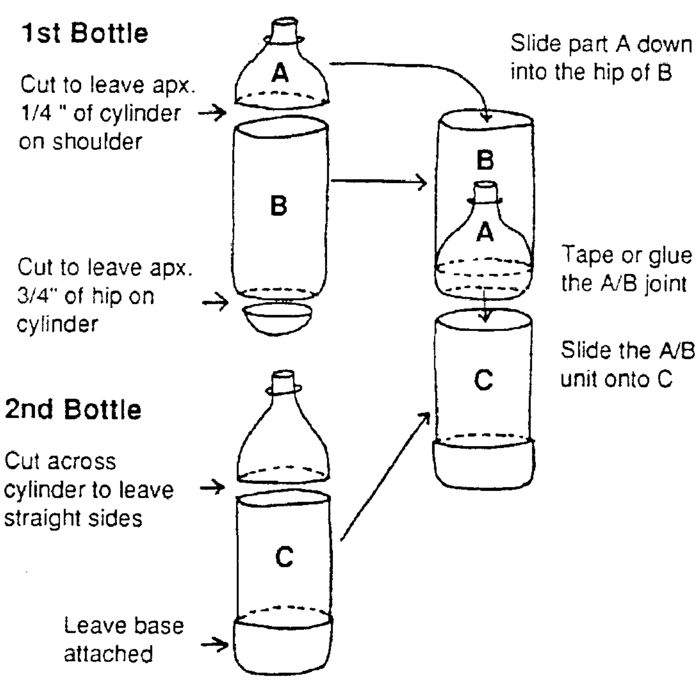
If the unit is going to contain a terrestrial system be sure to add drip holes in piece A. Units with drip holes high up part A will hold some water and can be used to make a unit which is bog-like in character.

If the EcoColumn unit is going to hold water, seal the A/B joint with a silicone sealant after taping. The sealant also acts as a glue to make a strong joint

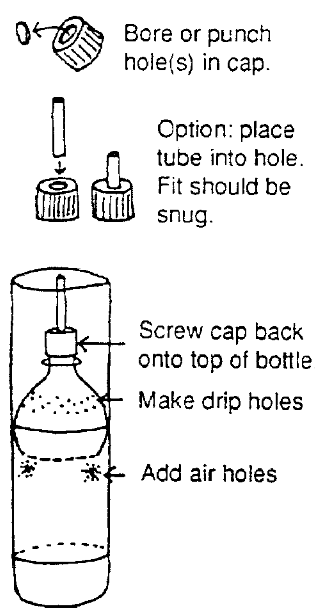
Bottle Anatomy



Cut and Combine Bottles

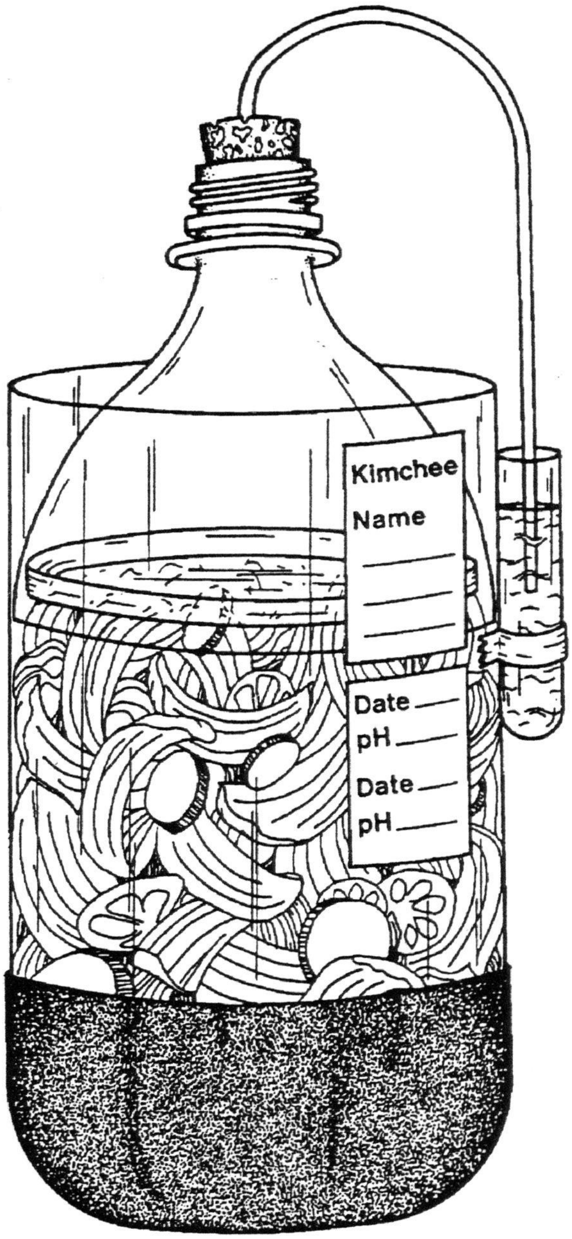


Add Finishing Touches



Kimchee: Korean Delight

Fermentation Experiments with Bottle Biology



Pickling is one of the most ancient forms of preserving food. It involves the microbial conversion of sugars into lactic acid through the growth and activity of acid-forming bacteria known as *lactobacilli*. As *lactobacilli* grow, they convert the natural sugars in plant juices into lactic acid. Under the high acidity (= low pH) created by the *lactobacilli* other food spoiling organisms cannot grow. *Lactobacilli* are found almost everywhere in our environment and are known as anaerobes because they grow under conditions in which oxygen is lacking. Many foods can be preserved through natural pickling. Some common ones are sauerkraut, yogurt, dill pickles, and silage for livestock. The ancient Chinese cabbage product known as kimchee is a major part of the Korean diet.

You and your students can make kimchee and study lactic acid fermentation in a two liter bottle by using the following recipe and procedure.

Ingredients:

- 1-1$^1/_2$ kg head of Chinese cabbage (*Brassica rapa*; also called napa or petsai), cut leaves into 5-7 cm chunks.
- 1 red hot chili pepper, chopped (or hot chili powder)
- 2 cloves garlic, thinly sliced
- 3 tsp. non-iodized (pickling) salt

Materials:

- one 2 liter soda bottle
- large plastic lid (approximately 9 cm in diameter) from jar or petri plate
- pH indicator paper (litmus paper, obtainable in small vials from lab suppliers)
- small plastic pipette

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Kimchee...

TRY IT, YOU'LL LIKE IT!

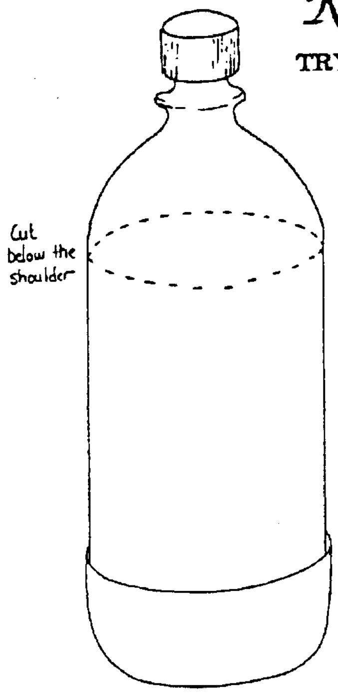


Figure 1

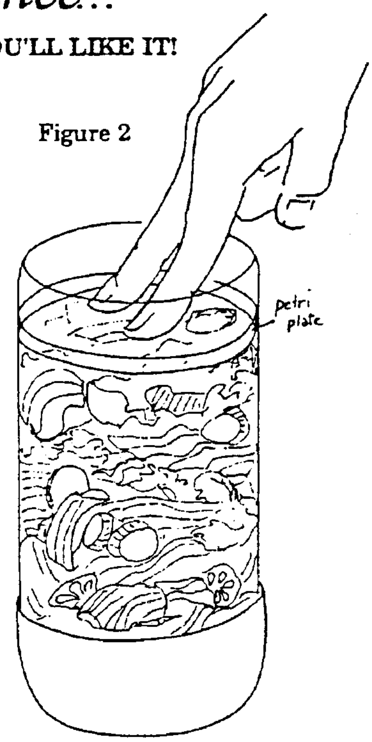


Figure 2

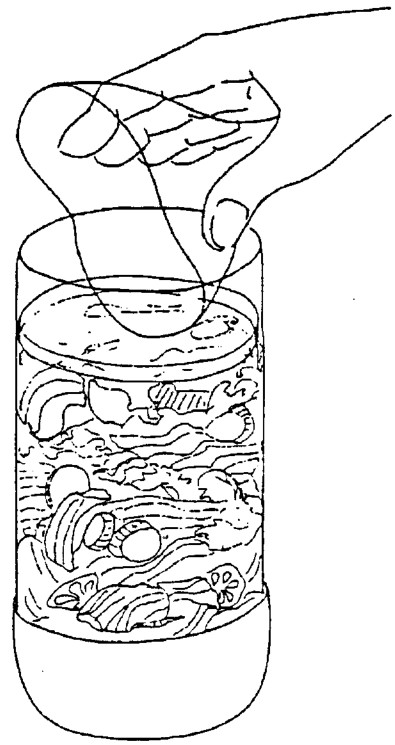


Figure 3

Procedure:

1. Cut the bottle just below the shoulder as shown in the illustration.

2. Alternate layers of cabbage, garlic, pepper and a sprinkling of salt in the soda bottle, pressing each layer down firmly until the bottle is packed full. **Caution: when working with chili pepper, take care not to touch eyes or mouth. Wash hands thoroughly when finished.**

3. Place the lid, rim side up, on top of ingredients and press down again. NOTE: within a few minutes liquid begins to appear in bottom of bottle as salt draws liquid from the cells of the Chinese cabbage.

4. Press down occasionally for an hour or two. After that there should be sufficient space to fit the bottle top inside the bottle bottom, forming a sliding seal.

5. Upon pressing firmly with sliding seal, cabbage juice will rise above the petri plate and air will bubble out around the edge of the petri plate.

6. The Chinese cabbage will pack to 2/3 or 1/2 the volume of the bottle. Press daily on the sliding seal to keep the cabbage covered by a layer of juice at all times.

7. Notice bubbles of gas escape each day when pressed. The gas is produced as bacteria grow on the sugary contents of the Chinese cabbage juice in the salty solution.

8. Measure and record the acidity of the fresh juice on top each day with pH indicator paper. Tape the indicator paper on the bottle and write the pH (acidity level) above it.

9. Note the increase in turbidity and change in acidity together with the continued production of gas as the pickling proceeds.

Did you notice the aroma of the garlic and pepper? These ingredients flavor the product. After a few days to a week or more (depending on the temperature), the pH will have dropped from 6.5 to about 3.5 and you will have kimchee!

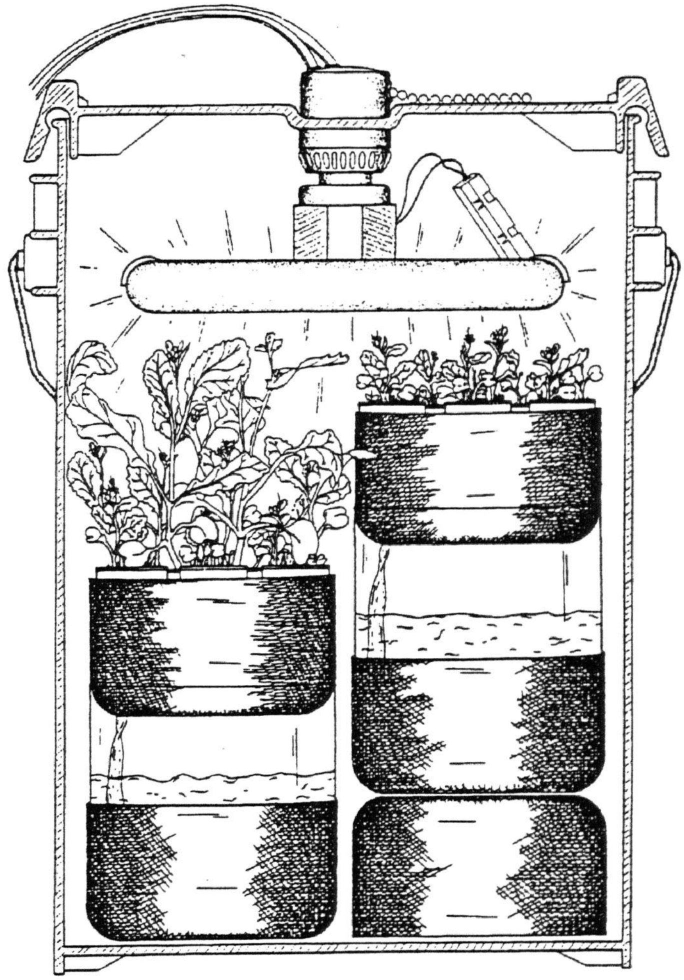
WISCONSIN FAST PLANTS

GrowBuckets and Bottle Reservoirs

BOTTLE BIOLOGY WISCONSIN

Plant Growth Systems Made from Recycled Materials

Much of the fun in science comes from creating, designing and running experiments. Over the past year, the Bottle Biology Project and Wisconsin Fast Plants teams have been collaborating in the playful and serious task of designing growing systems for small plants (especially Fast Plants) made out of materials from the trash can. This article presents some of our latest ideas for you to consider and improve upon. What we describe below are working prototypes. We hope that you and your students will modify and improve upon the ideas presented. P.S. Let us know what your ideas and successful designs are!



GrowBuckets

Finding the right light conditions for optimum plant growth can be tricky. Plant researchers sometimes rely on expensive growth chambers to get the right conditions for their experiments. We have recently discovered that the new energy saver circular fluorescent light bulbs fit nicely into five gallon plastic buckets. These bulbs produce, on average, the same amount of light as a 75 watt incandescent bulb, but with less heat production. With several holes cut for ventilation and a door for access, we have been able to grow Fast Plants in these buckets in much the same way we have grown plants under banks of regular 4' florescent bulbs.

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GrowBucket Construction Tips

Cutting Buckets: Five gallon plastic buckets can be cut a number of different ways. If you are making only a few buckets, they can be cut with a heavy duty **utility knife or a key hole saw**. It is frequently easier to start a cut by drilling a hole with either a hand or electric **drill** at the beginning of the line you are going to cut. For production of a many bucket constructions you may prefer to use a small electric hand saw such as a jig or saber saw.

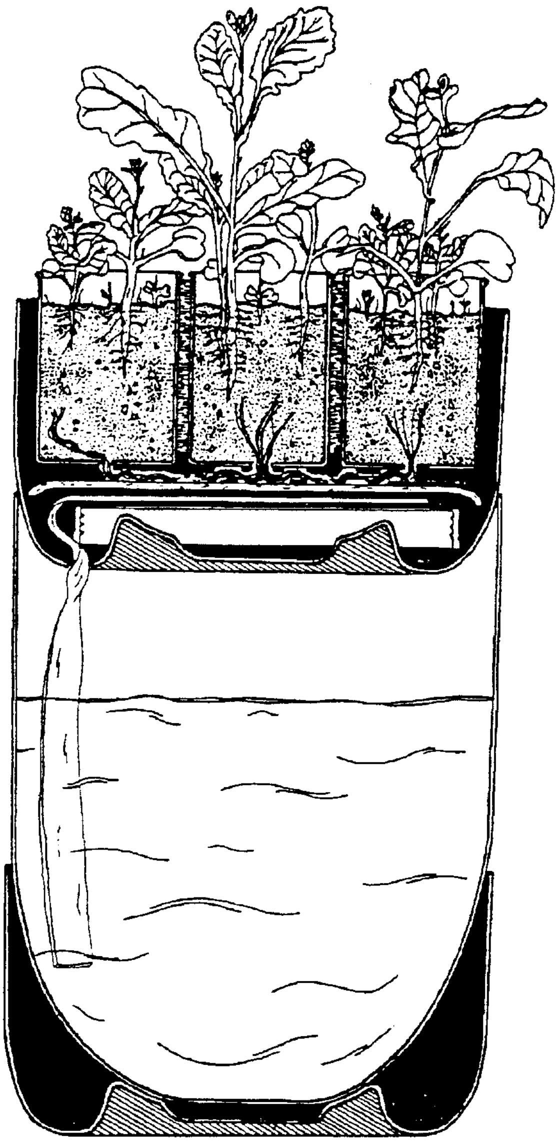
Ventilation: It is critical that the air temperature in the bucket be as close to room temperature (18° to 24° C) as possible. Cut two 7.5 cm diameter holes opposite each other on the bottom of the side of the bucket. Cut another pair of holes opposite each other on either side of the lid. Leave as much space as possible between the ventilation holes on the lid to allow room for mounting the light-bulb.

Mounting the bulb: The **circular fluorescent bulb** is mounted to the lid of the bucket. Cut a hole into the center of the lid which is just big enough to accept the metal shaft of a two piece porcelain utility **light bulb socket**. Connect a light-weight **electrical wire** (lamp cord) with **plug** to the socket. Screw the socket together with the plastic lid sandwiched between the two porcelain pieces. Screw the bulb into the socket. To date we have worked mainly with LIGHTS OF AMERICA 22 watt circular energy saver bulbs. We are in the process of testing similar GE bulbs which are rated at 27 watts.

Making a door: It is possible to access plants in a bucket by removing the bucket lid. However, it is easier to make a door on the side of the bucket. Our doors measure 20 cm wide by 26 cm tall and go to the bottom of the bucket. A hinge can be made from **duct tape** or small metal hinges can be screwed into the plastic bucket wall. Similarly, duct tape can be used to keep the door closed, or a small hook-and-eye can be installed. To allow for the maximum amount of reflected light it is best to keep the door closed when plants are not being moved or viewed.

Positioning plants: When plants are placed in the bucket it is critical that they get as much light as possible. This is especially true for Fast Plants. We recommend that plant containers be propped up until the tops of the plants are two to four centimeters from the bulb.

Bottle Reservoirs



Small plants (such as Fast Plants) can be grown in small containers as long as they are watered regularly. This task can be made easier using a continuous water wicking system. In the sample design presented above, empty 35 mm film cans are used as pots and parts from plastic soda bottles serve as water reservoirs. We have found that Fast Plants can be left unattended for two to four days with this system.

Bottle Reservoir Tips

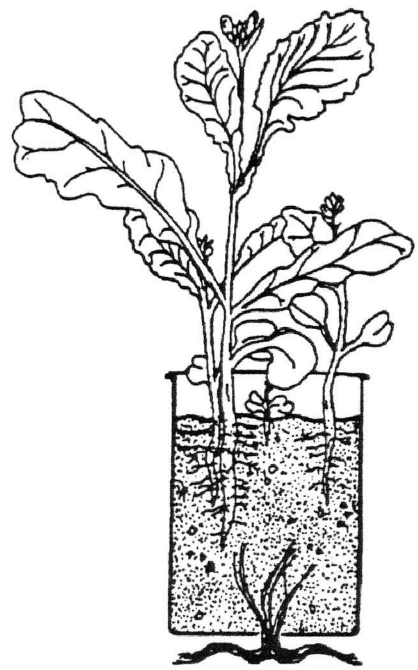
Bottle Preparation: The labels and bases on **plastic soda bottles** can be removed by filling the bottle with hot (50° - 65°C) water. After several seconds the heat sensitive glue will soften allowing the label to be peeled off, and/or the base twisted off. For this construction you will need one bottle with the label removed. Cut the top off of this delabeled bottle. For use in GrowBuckets we usually leave only 4 cm of the side attached to the bottom of the bottle. This makes the reservoir short enough to keep plants in the reservoir from hitting the lid of the bucket. Green bottles, as compared to clear bottles, work well for these reservoirs because they reduce the growth of algae.

You will also need the base from a second bottle. It is possible to substitute certain plastic containers (such as small cottage or cream cheese cups) for soda bottle bases. Place this base, bottom down, into the top opening of the first bottle. Into the base place a **plastic jar lid** (the ones from peanut butter containers are great) or petri dish to act as a platform for the plant pots.

Wicks: **Pellon™**, a fabric interfacing material, functions well as a wick for water. Before being used as a wick, pellon must first be washed on delicate cycle with soap and bleach to remove flame retardants, then line dry. Cut two pieces of pellon wick. The first is a strip 1 cm wide which runs from the bottom of the reservoir through a hole in the upper bottle base and well over the lid platform. The second wick is cut as a disk or square to fit the platform, and is placed over the strip wick on top of the lid. Presaturate the wicks before use by repeatedly squeezing them underwater. Water will move along a wick only if it is presaturated!

Film Can Plant Pots: Empty **35 mm film cans** make wonderful pots for Fast Plants and other small plants (mosses, babies tears, and miniature african violets.). Camera and film development stores discard large quantities of film cans. Ask to have them saved for you! For drainage and wicking, drill or cut a small hole (5 mm) in the center of the bottom of the can.

Thick unpolished **cotton string** (butcher's string for example) cut to about 4 cm in length works well as a wick for these film can pots. Presaturate the string by squeezing it under water. Frequently, a small amount of soap added to the water will facilitate wetting. Push a loop string half way through the hole in the bottom of the can. When the can is placed in the reservoir this cotton string wick should make solid contact with the pellon disk wick on top of the lid/dish.



Fast Plants in Film Cans: A film can has about four times the volume of a single cell in a Fast Plant quad. From this fact it is possible to extrapolate from a Fast Plant manual how to grow Fast Plants in film cans. Four plants can be grown in a film can. N-P-K slow release **fertilizer pellets** can be used at a rate of 12 pellets per can. Fertilization can also be achieved by adding a few milliliters of a one tablespoon/gallon solution of **Peter's fertilizer**, 20-20-20 (N-P-K), to the top of each film can at three, seven, and fourteen days. **Jiffy Mix**, a commercial potting mix, has worked well for us with Fast Plants.

A Word of Wisdom: Through the use of recyclable materials it is possible to make many inexpensive educational materials but, variations in local materials may cause problems. We have found that it is always best to do a test run with any new construction before you use in the classroom or other such situation when first-time success can make-or-break an activity!

BOTTLE BIOLOGY
WISCONSIN

Insect Habitats Part I: Fruit Fly Trap and Breeder

Introduction

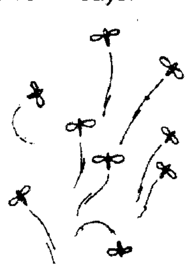
Insects make up 99% of the animal species on the planet. However, most of us understand little about the needs or life cycles of insects. The Fruit Fly Trap and Breeder allows students to observe fruit fly development and reproduction in the classroom in a practical and manageable way. Further, it serves to trap and breed fruit flies as a source of food for carnivorous insects and plants.

Construction

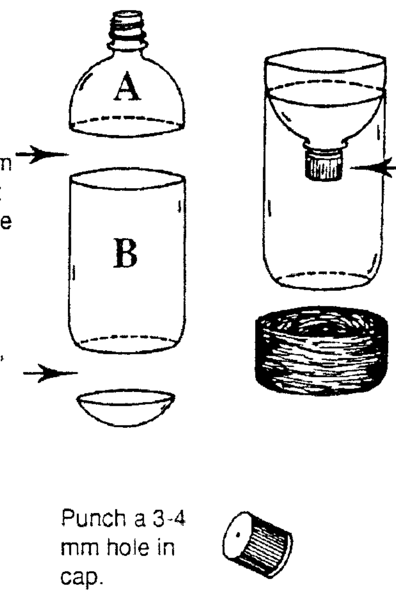
Cut a 2-liter bottle as illustrated. Place a piece of fruit (banana works well) in each of 3-5 film cans and place in the bottle bottom. Let the breeder sit inside or outside (if warm) and eventually wild fruit flies will be attracted to the fruit and will fly in through the hole in the cap. In summer, you will see flies in a few days but it might take weeks to trap flies in the winter.

When disturbed, fruit flies will fly upwards and lodge in the sides of the trap. You can then access the film cans through the bottom minimizing the escape of the flies.

Flies will lay eggs in the fruit meat and in a short time larvae will hatch. Soon these larvae will become adults and will then be able to fly. At 24-27°C the fruit fly life cycle takes 10-14 days.



Construction



Tips

- Make sure the hole in the cap is large enough only to allow a single fly through—no larger!
- Setting the film cans on a plastic jar lid in the bottle bottom provides a stable platform for the film cans.
- TAPE THE TOP JOINT. Dislodging the top lid will free the flies!
- This construction can be used as a way to trap fruit flies from an unwanted area (such as near a compost column!)

Uses and Extensions

- Discuss what fruit flies eat. We suspect that the flies are not actually eating the banana but are spreading yeast on it. The yeast, which the flies carry on the pads of their feet and in their gut, then grows on the banana meat and the flies come back later and feed on the yeast. In this way fruit flies are really yeast farmers! Begin to test this by covering half of the cans with mesh which excludes the flies. Compare the contents over the next few of weeks.
- Do fruit flies have fruit preferences? Explore which factors influence preferences such as color, odor, amount and pH.
- Once you have a film can with fruit fly larvae in it, transfer it into other bottle habitats and the emerging flies can provide a food source.
- For carnivorous animals and plants, a single film can continues hatching new flies which will, in turn, lay more eggs in fresh fruit. By removing old film cans and replacing them with cans containing fresh fruit, the fruit fly colony can be kept alive for a long time.

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BOTTLE BIOLOGY
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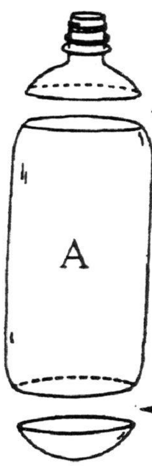
Insect Habitats Part II: Predator-Prey Bottle Column

Introduction

The fascinating world of predation and predator-prey relationships can be captured in the classroom. Using preying mantises, spiders or carnivorous plants as predators and fruit flies as prey, the behaviors, life cycles and interactions of the organisms can be easily observed. A predator-prey bottle column provides a relatively simple set-up for such complex interactions.

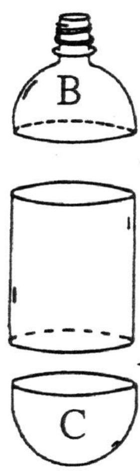
Construction

Cut Bottles



Cut about 2 cm above shoulder leaving 2 cm of curve on Piece A

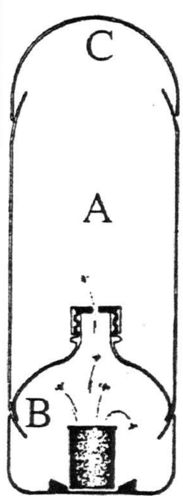
Cut 1-1.5 cm below the hip leaving 1-1.5 cm of the curve on the straight side



Cut .3-.4 cm below shoulder leaving .3-.4 cm of straight side on piece B

Cut 5-8 cm above the hip leaving 5-8 cm of straight side on Piece C

Combine Bottles



Piece C serves as a top. Access the predator chamber from here

Slide Piece B into the hip of Piece A.

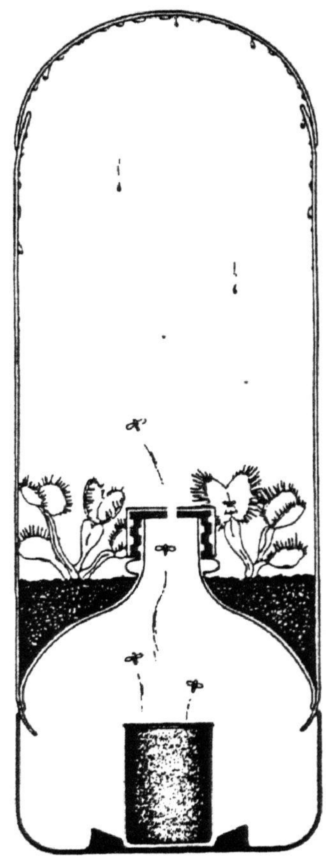
Set construction in Bottle Bottom. Access prey from here.

Construction Tips

Small ventilation holes can be made by poking the sides of a bottle with a sharp, thick needle (sharp darning needles work well). Push the back end of the needle into a short piece of wooden dowel to make a handle.

Use several pieces of waterproof tape (such as postal tape) between the inside of Piece B and Piece A to hold these two pieces together.

These columns may need frequent maintenance and attention.



Growing Venus Fly Traps

You can purchase Venus Fly Traps (or other carnivorous plants) at a local garden store or biological supply house. Carnivorous plants generally prefer a moist habitat with peaty soil. Peat can also be purchased at a garden store. A healthy planting of Venus Fly Traps can eat a large number of fruit flies.

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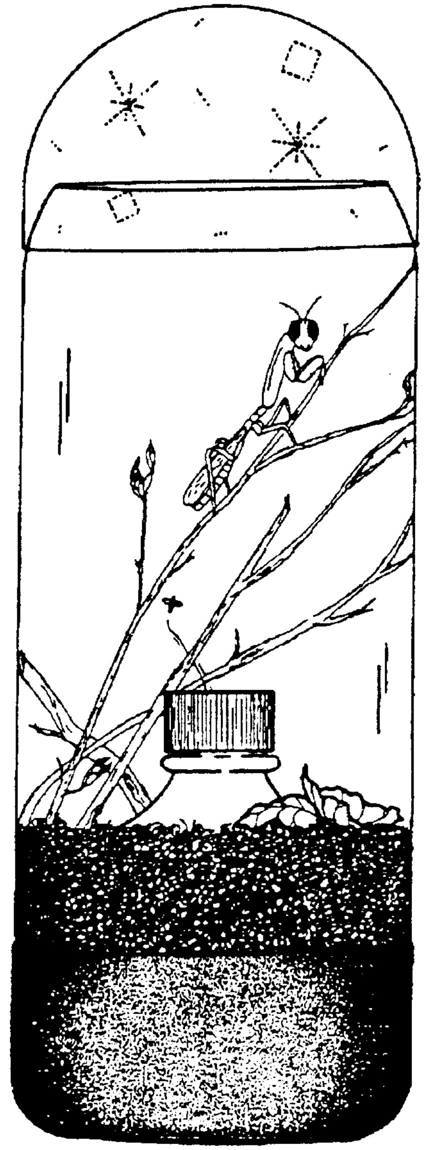
Raising a Preying Mantis

You can purchase or collect preying mantises as adults. However, you may find it more exciting to try hatching an egg case and raising the mantises to full maturity.

You can purchase an egg case from most biological supply or pest biological control catalogues* or collect one on your own. In a refrigerator, the cases will store for many months. Then simply warm them to room temperature and the clock will start ticking! After about 3-6 weeks in a mantis bottle column hundreds of tiny mantises will hatch from the egg case. These mantises must have water in the first 12 hours, so keep a moist wick in the cage during the last weeks before hatching. Without another source of food in the first 24-48 hours the mantises will begin to eat each other. Don't be alarmed if many mantises will die in the first week--this is common.

Place 4-8 mantises in a bottle column with 1-3 canisters of breeding fruit flies below. (See accompanying article for directions on how to trap and breed fruit flies.) In order to insure an ample number of flies, the fly canisters should be started at least 3-6 weeks before hatching. Depending on the number of mantises you wish to raise, you might need to start a number of fly traps and breeders. It is probably best not to take the egg case out of the refrigerator until you are certain that you will be able to trap and raise sufficient flies.

The growth rate of a mantis depends largely on how much it is fed. They will repeatedly shed their exoskeleton with the final molt revealing their wings. Females can be distinguished from males at this time by a more swollen abdomen. An older mantis will need to eat larger insects such as house flies or crickets.



Extensions

- Try breeding mature mantises. Be aware that the female mantis will usually kill the male mantis during or after breeding.
- Use a Prey-Predator Column as part of a larger ecocolumn bottle construction. For more information on construction of an ecocolumn see the Spring 1991; Vol 4, No. 2 newsletter or write to the Bottle Biology Program.
- Use the column to explore questions of population sizes or stability. What might happen if the prey population grows very large or if the predator population is large? What factors determine the size of a population? What happens if two predator populations are put together?

** One pest biological control catalogue we've found is Gardens Alive, Hwy. 48, P.O. Box 149, Sunman, IN 47041, (812) 623-3800*

WISCONSIN FAST PLANTS

Bioassays with Fast Plants

Determining the effects of substances on living organisms is accomplished with a **bioassay.** A substance is tested at various concentrations with living test organisms to determine what concentrations are beneficial or harmful to the organism. The pharmaceutical industry evaluates new medicines by measuring the quantity of a drug that results in a defined effective dose, **ED**.

One standard measurement of toxicity of a substance is the LD_{50}, the lethal dosage that causes death to fifty percent of the test organisms. The most common LD_{50} is the acute oral toxicity, that is, the single internal dosage of material necessary to kill half the test organisms. These LD_{50} values are expressed in milligrams of chemical per kilogram of body weight. Therefore, the lower the LD_{50} value for a substance, the greater the toxicity.

There may be visual or measurable symptoms of toxicity at sub-lethal levels. Organisms that are sensitive to a particular substance can be used as indicator species for the presence of that substance. The Environmental Protection Agency (EPA) have begun using plants, in addition to animals, to test the toxic effects of materials in the environment. A simple bioassay with plants examines the effects of a substance on seed germination.

Materials Needed

-- 14 Fast Plant Seeds
-- water
-- 7 clear plastic 35 mm film cans
-- 7 wicks made of pellon (absorbent fabric)
-- 1 one pound cottage cheese container with lid
-- 10% liquid detergent solution (1 part detergent, 9 parts water. Liquid detergent is the substance whose effect on Fast Plant seed germination is being assayed. Assay any substance you like).

Tips and Suggestions

-- See reverse for bioassay experiment diagram.
-- An alternative method of designating the dilutions or concentrations of the substance being assays would be to have the students mark the full strength solution as "x", and successive dilutions (each reduced by $^1/_2$) a $^x/_2$, $^x/_4$, $^x/_8$, $^x/_{16}$, and $^x/_{32}$.
-- A local film processing outlet or camera store is the source of the film cans. Ask them to save the film cans for you, since they are usually discarded.
-- Pellon is available at fabric stores. Pellon must be washed and double rinsed before being used. Washing removes chemicals used in the manufacturing process which are toxic to the germinating seed. Wicks should be approximately 1.5 centimeters wide and 6 centimeters long.

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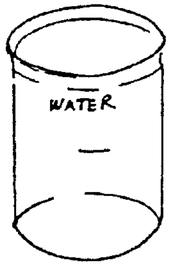
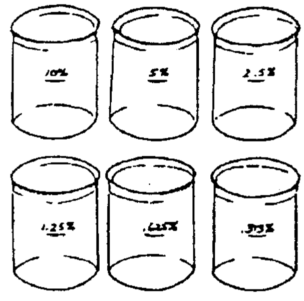
Wisconsin Fast Plants is an NSF funded instructional materials development project in the biological sciences

Bioassay Experiment Diagram

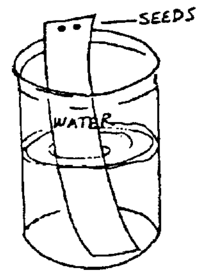
1. Label one film can "water" and mark the half-full line with a permanent marker. This is the control. Mark the other 6 cans at the half-full line also.

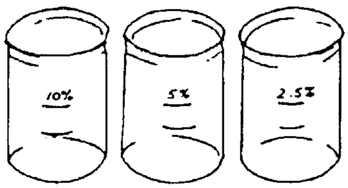




2. Label the 6 cans as above.

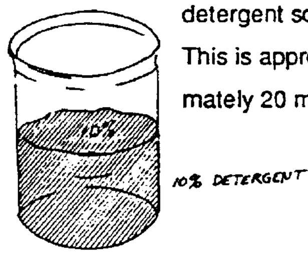
3. Fill the "water" can to the mark with water, and insert a wick. When the wick is moist at the top, place two seeds on the wick.

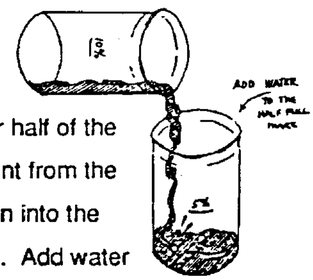




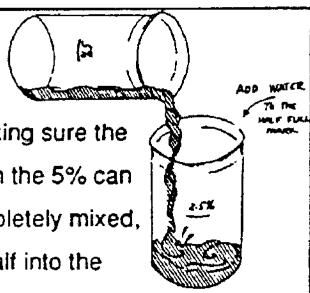
4. Make a mark on the other six film cans half-way between the first mark and the bottom of the can.

5. Fill the 10% can to the top mark (half-full) with the 10% liquid detergent solution. This is approximately 20 ml.

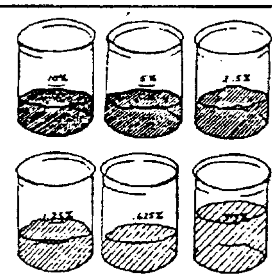




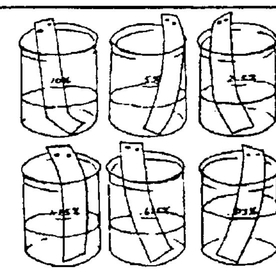
6. Pour half of the detergent from the 10% can into the 5% can. Add water to the 5% can to the half-full mark. The 5% can now contains a 5% detergent solution.



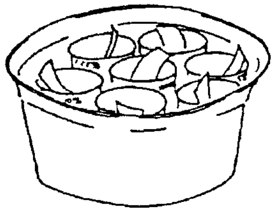
7. Making sure the liquid in the 5% can is completely mixed, pour half into the 2.5% can to the half-full mark, making a 2.5% solution.



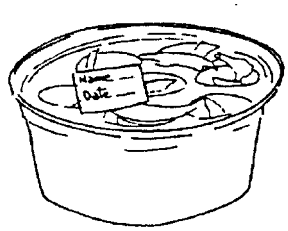
8. Repeat this procedure until all 6 cans are prepared.



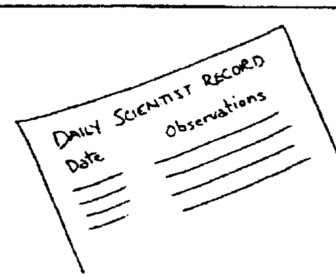
9. Insert wicks in all 6 cans. When the wicks are moist at the top, place two seeds on each wick.



10. Place the 6 cans inside the cottage cheese container around the edge. Place the "water" can in the center.



11. Secure the lid on the container and label your container with your name and the date.



12. Observe each day for the next 3-4 days and record observations.

Developing a Community Survey -- Appendix C

(From E E News, Winter 1993, by Al Stenstrup, Education Outreach Coordinator, Wisconsin Department of Natural Resources.)

Is air pollution a problem in your community? What is your community's average vehicle occupancy? How do students travel to school? What do your neighbors think of carpooling? What are they willing to do to reduce pollution? How does your community compare to others in the state?

One method for investigating air issues in your school is through the use of a survey. It is an interactive process that requires preparation, involvement, and interpretation. The results can help led students to take an active role in solving or reducing a problem in their community.

Several different methods can be used to study environmental issues. Here are three of them.

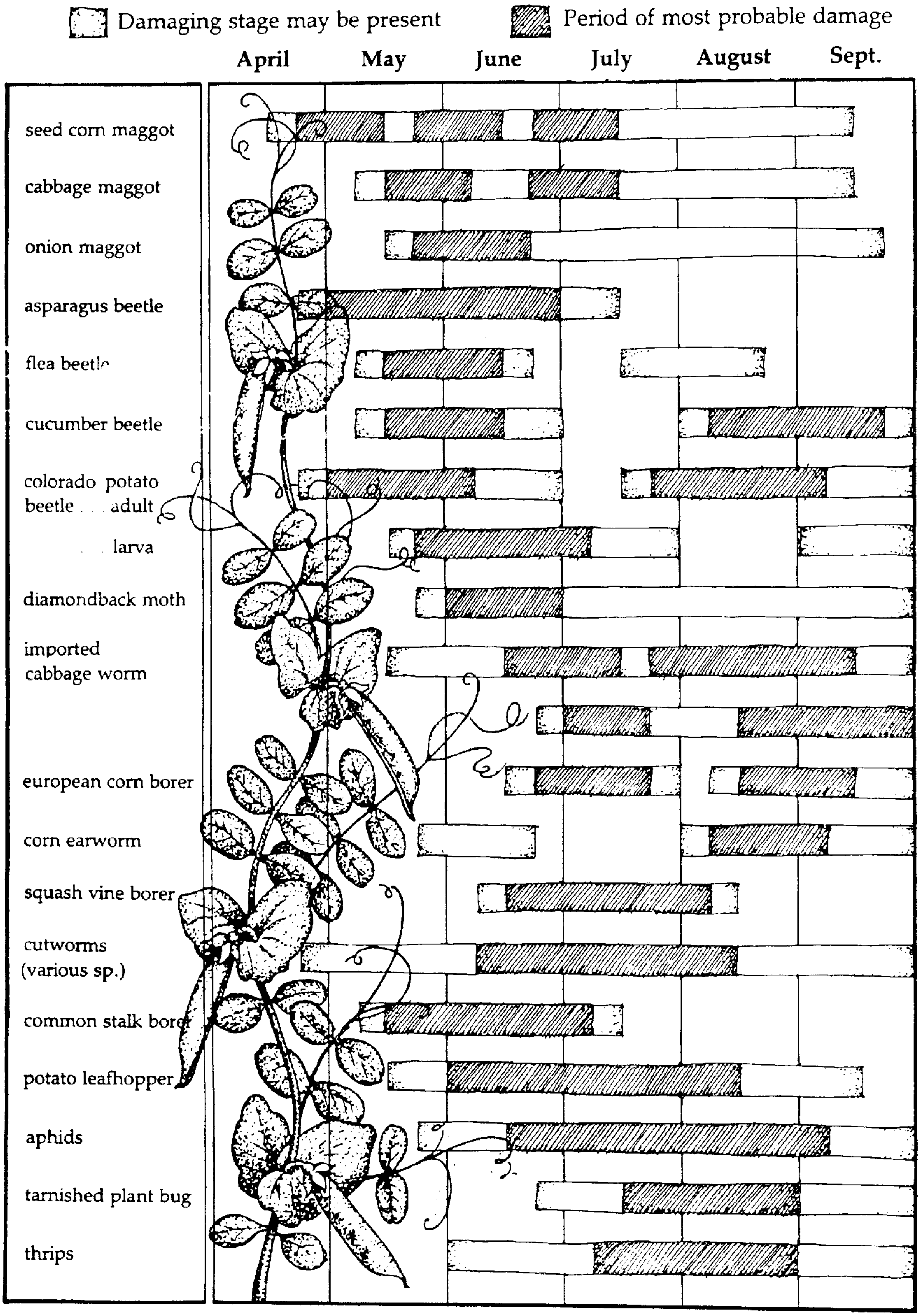
> **Surveys**. A survey can be used to collect information about environmental conditions in your school or community. They focus on information about a specific problem in a certain area.
>
> Example: How many cars are in the school parking lot?
>
> **Questionnaires**. These sets of questions focus on a particular subject and are given to a carefully selected population of people. They collect only the facts -- not the person's opinion.
>
> Example: How many teachers carpool to school?
>
> **Opinionnaires**. Opinionnaires are similar to questionnaires except that they measure the beliefs or opinions of people on certain subjects at a specific time.
>
> Example: Do you consider air pollution to be a problem in your community?

Before a method is selected, it is important that students carefully decide the exact information that needs to be collected, the geographic area, and the target population that will be surveyed. A combination of methods can also be used. Accurate collection information is next. The students should prepare a data summary sheet to record their information.

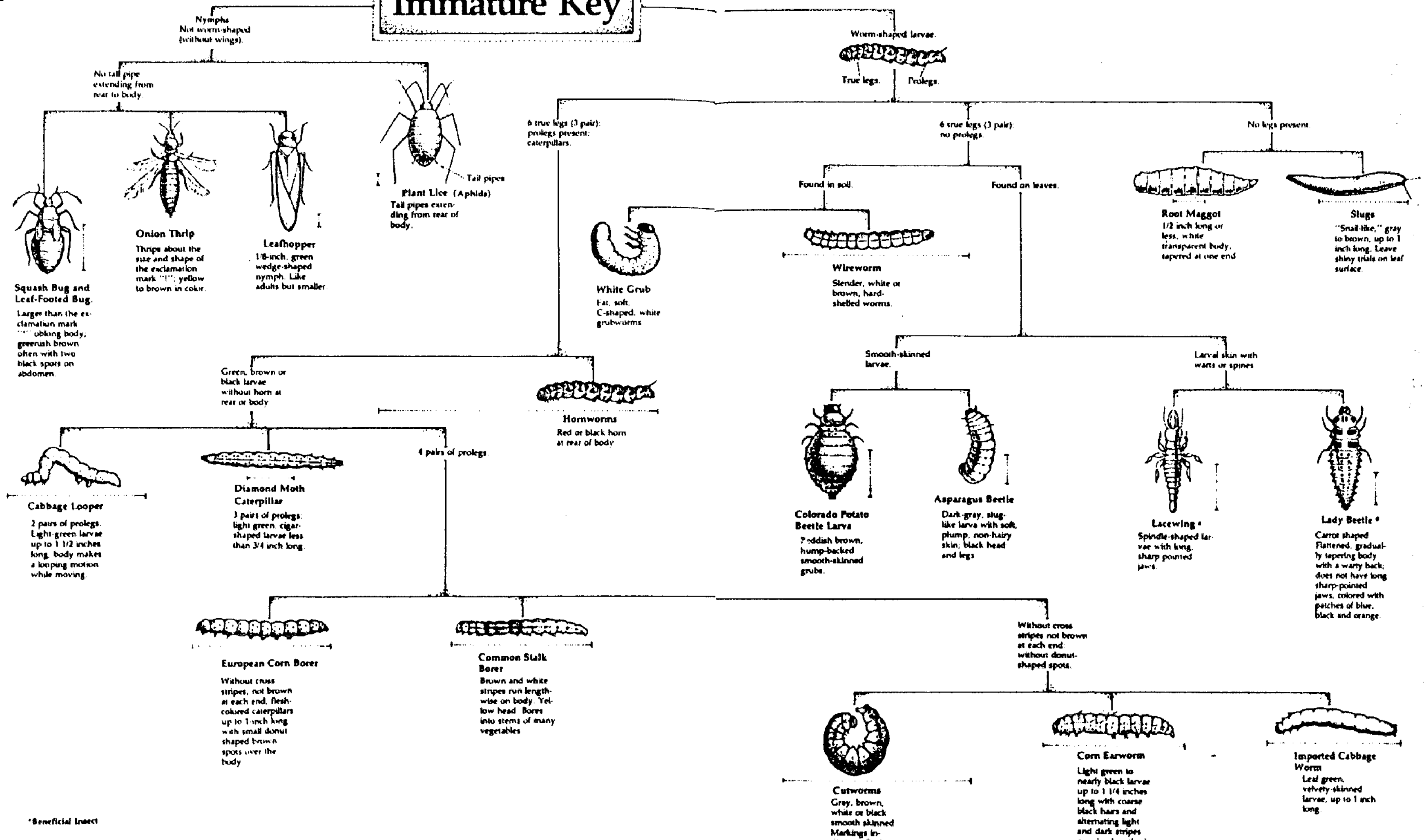
Once the data has been collected, students will be challenged to interpret the information and suggest recommended actions that need to be taken.

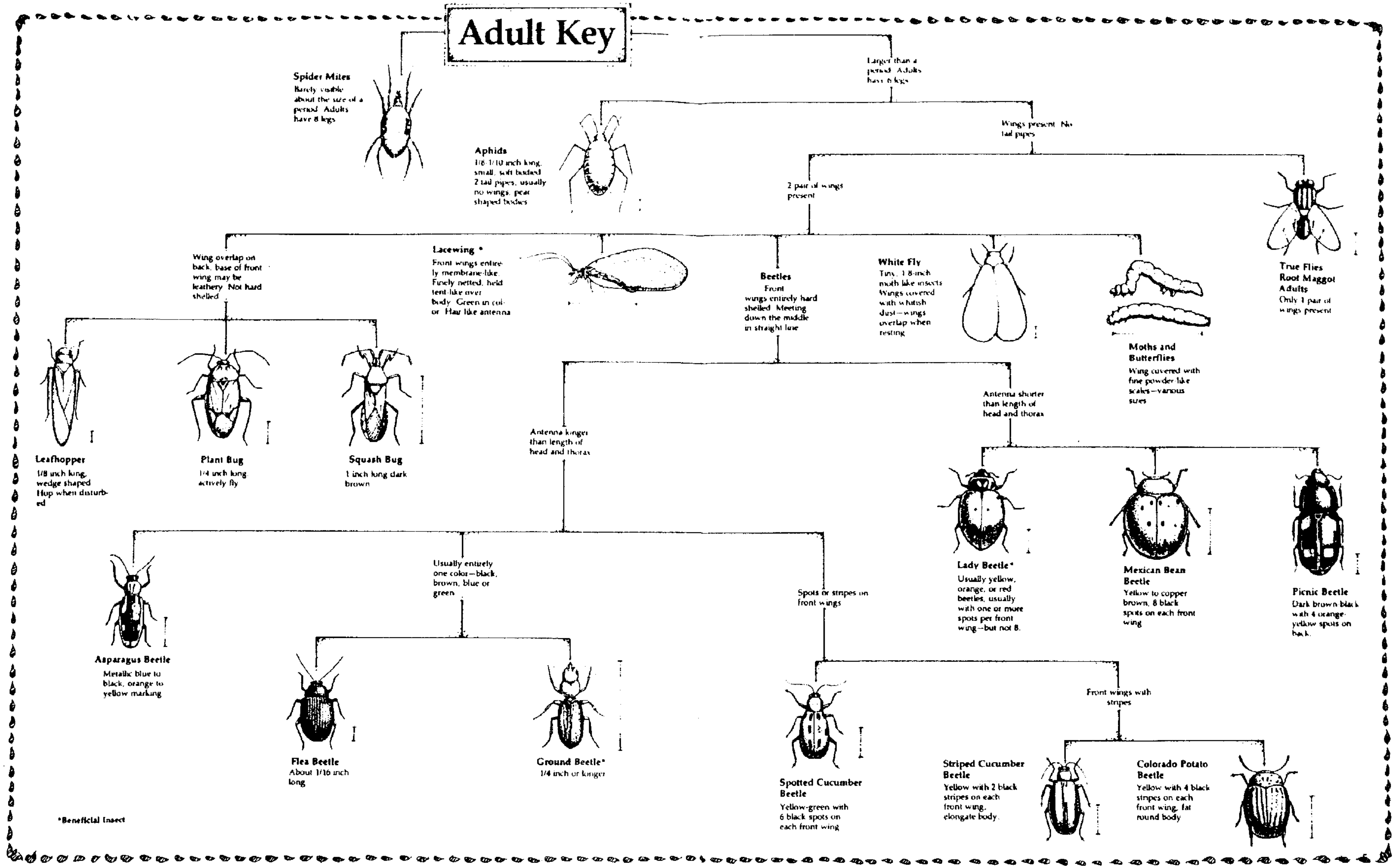
A valuable book to assist you in developing and utilizing surveys is, *Investigating and Evaluating Environmental Issues and Actions: Skill Development Modules* by Harold Hungerford and others, Stipes Publishing Company, 10-12 Chester Street, Champaign, IL 61820.

Timetable of Pest Abundance and Damage



Immature Key




Adult Key
Spider Mites
Barely visible about the size of a period. Adults have 8 legs
Larger than a period. Adults have 6 legs
Aphids
1/8-1/10 inch long, small, soft bodied 2 tail pipes, usually no wings, pear shaped bodies
Wings present. No tail pipes
2 pair of wings present
True Flies
Root Maggot Adults
Only 1 pair of wings present
Wing overlap on back, base of front wing may be leathery. Not hard shelled
Lacewing *
Front wings entirely membrane-like. Finely netted, held tent-like over body. Green in color. Hair like antenna
Beetles
Front wings entirely hard shelled. Meeting down the middle in straight line
White Fly
Tiny, 1/8-inch moth like insects. Wings covered with whitish dust—wings overlap when resting
Moths and Butterflies
Wing covered with fine powder-like scales—various sizes
Leafhopper
1/8 inch long, wedge shaped. Hop when disturbed
Plant Bug
1/4 inch long actively fly
Squash Bug
1 inch long dark brown
Antenna longer than length of head and thorax
Antenna shorter than length of head and thorax
Lady Beetle*
Usually yellow, orange, or red beetles, usually with one or more spots per front wing—but not 8.
Mexican Bean Beetle
Yellow to copper brown, 8 black spots on each front wing
Picnic Beetle
Dark brown black with 4 orange-yellow spots on back.
Usually entirely one color—black, brown, blue or green
Spots or stripes on front wings
Asparagus Beetle
Metallic blue to black, orange to yellow marking
Flea Beetle
About 1/16 inch long
Ground Beetle*
1/4 inch or longer
Spotted Cucumber Beetle
Yellow-green with 6 black spots on each front wing
Front wings with stripes
Striped Cucumber Beetle
Yellow with 2 black stripes on each front wing, elongate body
Colorado Potato Beetle
Yellow with 4 black stripes on each front wing, fat round body
*Beneficial Insect

County Extension Offices -- Appendix E

Adams	608-339-4237	Courthouse, Box 217, Friendship, WI 53934
Ashland	715-682-7017	Room 301 Courthouse, Ashland 54806
Barron	715-537-6250	Courthouse, Barron 54812
Bayfield	715-373-2221	Courthouse, Washburn 54891
Brown	414-497-3216	1150 Belleview Street, Green Bay 54302
Buffalo	608-685-4560	308 South Second Street, Alma 54610
Burnett	715-349-2151	County Government Center, RR 1, Box 300-107, Siren 54872
Calumet	414-849-2361	Courthouse, Chilton 53014
Chippewa	715-723-1831	21 East Spruce Street, Chippewa Falls 54729
Clark	715-743-3241	Courthouse, Neillsville 54456
Columbia	608-742-2191	County Administration Building, Portage 53901
Crawford	608-326-6431	111 West Dunn, Prairie du Chien 53821
Dane	608-266-4271	57 Fairgrounds Drive, Madison 53713
Dodge	414-386-4411-400	County Office Building, Juneau 53039
Door	414-743-5511	Courthouse, Sturgeon Bay 54235
Douglas	715-394-0363	Courthouse, Superior 54880
Dunn	715-232-1636	Courthouse, Menomonie 54751
Eau Claire	715-839-4712	227 First Street West #A, Altoona 54720
Florence	715-528-4480	County Highway Building, Route 1 Box 1, Florence 54121
Fond du Lac	414-929-3170	UW Center-Campus Drive, 112 Classroom Building, Fond du Lac 54935
Forest	715-478-2212	Courthouse, Crandon 54520
Grant	608-723-2125	Fairgrounds, Box 31, Lancaster 53813
Green	608-328-9440	Agricultural Building, Box 120, Monroe 53566
Green Lake	414-294-6573	Courthouse, Green Lake 54941
Iowa	608-935-3354	216 North Iowa Street, Dodgeville 53533
Iron	715-561-2695	Courthouse, Hurley 54534
Jackson	715-284-0227	Courthouse, Black River Falls 54615
Jefferson	414-674-2500	Courthouse, Jefferson 53549
Juneau	608-847-9329	Courthouse, Mauston 53948
Kenosha	414-656-6793	714 52nd. Street, Kenosha 53140
Kewaunee	414-388-4410	Courthouse, Kewaunee 54216
La Crosse	608-785-9593	Courthouse, La Crosse 54601
Lafayette	608-776-4494	Ag Center, Darlington 53530
Langlade	715-627-6236	Fairgrounds, Box 460, Antigo 54409
Lincoln	715-536-0304	Lincoln County Annex, 1106 E. 8th St. Box 917, Merrill 54452
Manitowoc	414-683-4167	County Offices Building, 1701 Michigan Avenue, Manitowoc 54220
Marathon	715-847-5433	Courthouse, Wausau 54401
Marinette	715-735-9661	Courthouse, Box 320, Marinette 54143

Marquette	608-2297-2141	Courthouse, Box 388, Montello 53949
Milwaukee	414-257-5351	9668 West Watertown Plank Road, Wauwatosa 53226
Monroe	608-269-8722	Courthouse, Box 309, Sparta 54656
Oconto	414-834-5322	Courthouse, 300 Washingotn Street, Oconto 54153
Oneida	715-369-6160	Box 1208, Airport Terminal, Rhinelander 54501
Outagamie	414-735-5119	Courthouse-Room C103, Appleton 54911
Ozaukee	414-284-9411	Courthouse-Room 21, Port Washington 53074
Pepin	715-672-5214	307 West Madison, Box 39, Durand 54736
Pierce	715-273-3531-243	Courthouse, Ellsworth 54011
Polk	715-485-3136	Agricultural Center, Balsam Lake 54810
Portage	715-346-1316	County-City Building, Stevens Point 54481
Price	715-339-2555	Normal Building, Phillips 54555
Racine	414-866-2744	14200 Washington Avenue, Sturtevant 53177
Richland	608-647-6148	1100 Highway 14 West, Richland Center 53581
Rock	608-755-2196	Courthouse, Janesville 53545
Rusk	715-532-2151	Courthouse, Ladysmith 54848
St. Croix	715-684-3301	Agricultural Center, Baldwin 54002
Sauk	608-356-5581	Box 49, Baraboo 53913
Sawyer	715-634-4839	Courthouse, Box 351, Hayward 54843
Shawano	715-526-6136	Courthouse, Shawano 54166
Sheboygan	414-459-3141	UWEX Office, 650 Forest Ave., Sheboygan Falls 53085
Taylor	715-748-3327	224 South Second Street, Medford 54451
Trempealeau	715-538-2311	Courthouse, Whitehall 54773
Vernon	608-637-2165	Box 392, Viroqua 54665
Vilas	715-479-3648	Courthouse, Box 369, Eagle River 54521
Walworth	414-741-3190	Box 1007, Elkhorn 53121
Washburn	715-635-3192/8725	342 Walnut Street, Spooner 54801
Washington	414-338-4479	432 East Washington Street, West Bend 53095
Waukesha	414-548-7770	County Office Building, 500 Riverview Dr., Waukesha 53188
Waupaca	715-258-7681	Courthouse, Waupaca 54981
Waushara	414-787-4631-220	Courthouse, Box 487, Wautoma 54982
Winnebago	414-424-0050	Sunnyview Complex, 500 E. Sunnyview Rd., Oshkosh 54901
Wood	715-421-8440	Courthouse, Wisconsin Rapids 54494

Resources for Alternative Pest Control -- Appendix E

Insect Identification:

Adventures with Insects, UWEX Circular 4-H, 142

Alfalfa Insect Pests, UWEX 2156

Alfalfa Analyst, UWEX 217

Alfalfa Weevil, UWEX 2995

The Armyworm, UWEX 3327

Biological Control and Insect Pest Management, University of California Agricultural Experiment Station Bulletin 1911

Collection and Preservation of Insects, USDA Publication No. 601,

Common Fruit Insects, UWEX A2116

Common Soybean Insects, NCR Picture Sheet #6

Corn Insects Above Ground, UWEX A2046

Corn Insects Below Ground, UWEX A2047

Corn Pest Management in Wisconsin, UWEX A1684

Corn Rootworms, UWEX A2338

Destructive and Useful Insects, C. L. Metcalf, et. al., McGraw Hill Company

European Corn Borer, UWEX A1220

Forage and Small Grain Pest Management in Wisconsin, UWEX A1981

Handbook of the Insect World, Hercules Powder Company

How to Detect and Manage the Potato Leafhopper Problem, UWEX A3208

How to Know the Insects, H. E. Jaques, William C. Brown Company, Dubuque, IA.

Managing Insects in Sustainable Agriculture, UWEX Management Guide for Sustainable Agriculture, Soils Department.

Nutrient and Pesticide Best Management Practices for Wisconsin Farms, UWEX and WDATCP, 1989.

Small Grain Insects, UWEX A2558

Soybean Pest Management in Wisconsin, UWEX A2782

Stalk-boring Insect Pests of Corn, A3354

Survey and Appraisal Guide for Insect Pests of Wisconsin Field Crops, WDATCP

USDA Yearbook of Agriculture, 1952.

Vegetable Insects, UWEX A2093.

Weed Management

Annual Broaldleaf Identification. North Central Regional Extension Publication 90, Available from UWEX.

Annual Broadleaf Weed Seedling Idnetification. North Central Regional Extension Publication 89, Available from UWEX.

Annual Grass and Perennial Weed Identification. North Central Regional Extension Publication 92, Available from UWEX.

Resources for Alternative Pest Control -- Appendix E

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The Armyworm, UWEX 3327

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Prediction of infestations

Degree day concepts used in some insect control strategies

Degree days (also known as "day-degrees" or generically as "heat units") provide a means of predicting insect phenology (the timing of life history events). Degree days combine time and temperature to measure insect development and activity. The utilization of degree days is becoming increasingly important in insect pest management programs, due to the potential for increased accuracy over calendar time in predicting phenological events. Applications to pest management include the scheduling of pest scouting and in some cases insecticide application or other types of control tactics (Hogg, 1989).

Calculating degree days

A degree day can be defined as one degree of temperature above the threshold for one day. There are several methods available for calculating degree days. The easiest is to use the high and low temperatures for the day, calculate an average temperature, and subtract the threshold:

[(High + Low)/2] - Threshold = Degree Days for one day

For example, if a threshold of 50F is used, and a high of 80F and a low of 60F have been recorded, the number of degree days for the day would be: [(80 + 60)/2] - 50 = 70 - 50 = 20

This procedure is accurate as long as the low temperature is greater than or equal to the threshold. However, if the low temperature is less than the threshold, this procedure underestimates the actual number of degree days. When this occurs, there are several other methods available for calculating degree days. One approach to overcome computational difficulties is to prepare a table that gives the number of degree days above some threshold temperature for every possible combination of high and low temperatures.

Other resources for degree days information include:

- HEATSUM program available on IPM menu of WISPLAN computer system. The heatsum program was developed to calculate heat unit accumulation between two dates at a user-selected base temperature.

- The weekly WDATCP Cooperative Pest Survey Bulletin lists Growing Degree Day (GDD) accumulations from nine key sites in Wisconsin throughout the growing season. Highlights from the Pest Survey newsletter are also available via the recordings on the Pest Phone, or on the WISPLAN computer system as part of the IPM menu.

Applications of degree days to agricultural pest control.

For degree days to be useful in a management program for a particular insect pest, two criteria must usually be met. First, the pest must overwinter locally. In Wisconsin, this is by hibernation in a physiological condition known as diapause. Examples of insect pests that are unable to survive the winter in Wisconsin are the potato leafhopper and the corn earworm. These species overwinter only in areas well to the south of Wisconsin, and each year both migrate into the state. Usually the potato leafhopper arrives during May and the corn earworm arrives during August, but the arrival times of migrants are not predictable enough to calibrate with degree day seasonal totals. The second criterion is that the pests have discrete generations. For example, the pea aphid overwinters in Wisconsin; however, the aphids have a very short generation times and reproduce continuously, so that in a short time generations overlap. As a result, all aphid stages are present in the field during virtually the entire growing season. Aphid abundance is thus related to factors other than degree day totals.

Two pest species that meet both criteria and for which degree days have proven useful in management programs are the alfalfa weevil and the European corn borer.

The alfalfa weevil is a pest of first crop alfalfa in Wisconsin. It overwinters in the adult stage. In the spring the adults come out of hibernation, feed and lay eggs. The larvae that hatch from these eggs can cause significant feeding damage to alfalfa. Only one generation of larvae occurs each year, and it either is completed by the time the first cutting is taken or is interrupted when the field is cut. The developmental threshold of the alfalfa weevil is 48F. In southern Wisconsin damaging populations of weevil larvae do not occur until a seasonal total of at least 300 degree days above 48F has been accumulated. Thus in southern Wisconsin, it is recommended that *SCOUTING* for alfalfa weevil be initiated when a total of 300 degree days is reached.

The European corn borer is a pest of field and sweet corn in Wisconsin. The corn borer overwinters as a mature larvae. In the spring the larvae pupate, emerge as adults, and lay eggs. Two discrete generations of this pest are normally completed during the growing season in southern Wisconsin. The developmental threshold of the European corn borer is 50F. Degree day (DD) totals above 50F for various events in the seasonal history of the corn borer in southern Wisconsin are shown in Table 8-4.

See Table 8-4: Degree days and corn borer.

Degree days, by combining time and temperature, provide a much more accurate means of measuring insect activity and development in the field than does calendar time alone. Because of this capability, degree days can be useful in the development of management programs for certain insect pest species.

Blacklight trapping

Another means of predicting insect infestation is to use blacklight traps to attract and count certain pests. Blacklight traps are operated throughout the state by vegetable processors. An example of how

Figure 8-7: Monitoring European corn borer using blacklight traps.

"The best procedure for detecting damaging levels of egg laying adult corn borer is to operate blacklight traps in the area and count trapped moths daily. If moth counts increase significantly for several consecutive nights (25 or more moths/trap/night but may be lower is individual traps regularly catch lower numbers) at any time during the interval from 35 to 10 days before harvest, control measures are recommended."

Source: Vegetable and Apple manual, Integrated Pest management, UWEX, 1989.

Table 8-4: Degree days and corn borer.

First generation (Spring)	Degree Days
First moth	374
First eggs	450
Peak moths	631
Treatment period	800 -1000

Second generation (Summer)	Degree Days
First moth	1400
First eggs	1450
Peak moths	1733
Treatment period	1550-2100

The values in the table represent averages of 5 years of data collected at the Arlington Agricultural Research Farm.

Source: Hogg, D., 1989.

these results are used is the management program for European corn borer in snap beans. The recommended management practices for control of this pest are illustrated by Figure 8-7.

See Figure 8-7: Monitoring European corn borer using blacklight traps.

The WDATCP Cooperative Pest Survey Bulletin receives blacklight trap reports from about 30 sites scattered in the major corn or canning crop areas. Providing counts of moths enables the producer to anticipate the next life stage, the eggs. The moth counts provide a general indication of the relative abundance of pest species. The Bulletin reports of black light trapping are nearly a week old by the time readers get them, but this is usually adequate for anticipating egg laying and the appearance of larvae. The blacklight trap results are not a good indicator of activity of some insects. The corn earworm and cabbage looper respond poorly, whereas, the European corn borer responds very well.

Summary of recommended practices for insect management

- *Use appropriate cultural controls.*
- *Protect natural controls.*
- *Use pest resistant plants.*
- *Adopt biological controls as alternatives to insecticides.*
- *Adopt an Integrated Pest Management (IPM) approach.*
- *Incorporate environmental risk into insecticide selection.*
- *Avoid resistance.*
- *Predict insect infestations to increase scouting efficiency.* □

Profits or Production: The Economics of Low-Input and Conventional Dairy Management*

Wisconsin Rural Development Center
UW-Madison, Center for Integrated Agricultural Systems
UW-River Falls

Introduction:

Since 1988, a small group of Wisconsin dairy producers has challenged the notion that "more is better" when it comes to pesticides and fertilizer use. They have been looking at how reducing farm chemicals and fertilizers affect their crop and livestock enterprise profits, for a number of reasons. They are concerned about the long-term effects of non-organic fertilizers and pesticides on soil and water quality and the profitability of using these inputs. They have questioned the philosophy that more production really leads to higher profits.

Although a number of them stated that personal and family goals, quality of life, and stewardship were reasons for reducing these inputs, profitability is the main issue for these farmers -- as it is for every farmer. With milk prices currently at or below cost of production, reducing input costs has become a management virtue and financial necessity. However, many farmers are concerned about the economic risks involved with either reducing inputs or substituting alternative production methods for their current practices.

To make informed decisions, farmers need reliable farm-level information about the economics of low-input management practices. A joint project of the Wisconsin Rural Development Center (WRDC), the Sustainable Agricultural Program of the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP), and the University of Wisconsin-Madison Center for Integrated Agricultural Systems (CIAS) assembled a joint project to conduct research on 45 Wisconsin dairy farms to get answers on the profitability of cutting farm inputs.

Funding sources for this project include the USDA/SARE Program, the University of Wisconsin's College of Agriculture and Life Sciences, and the Wisconsin Department of Agriculture, Trade and Consumer Protection's Sustainable Agriculture Program.

Project Description:

The project conducted comparative economic analysis across three groups of 34 farms which used differing chemical and fertilizer application rates and production strategies for a three year period. The groups were defined on the basis of per acre costs of these inputs. The conventional group's average chemical costs were $31.98 per acre as compared to $9.69 for the low-chemical and $1.12 for the no-chemical group. Individual participating farms were analyzed on an enterprise-by-enterprise crop, livestock and whole-farm basis.

Farms were selected on the basis of size (35 to 60 cows, 150 to 200 crop acres), mix of enterprises (feed grain/small grain/forage crops and dairy), and management ability. The farmers provided annual detailed information about their field work (machine use, hours of labor, estimates of fuel use, etc.) their purchased inputs and their production. Similar information was also provided on livestock enterprises and included information on raised and purchased feed use, purchased livestock services and inputs, labor requirements, and equipment and facility use.

Farmers also provided a complete list of machinery and equipment as well as assessed land, building and storage facility values, which was updated annually. Estimated fair market values were placed on all items and from those values each farm's equipment, machinery and land ownership costs (depreciation plus interest) were calculated. Ownership costs were then allocated to various enterprises in proportion to use.

General Farm Information:

Results show that farmers who reduced chemical use were generally smaller and generated less production. On average, farms in the low- and no-chemical use group cropped fewer acres, managed smaller herds and made lower overall investments in land, machinery, equipment, facilities, and buildings. Investments per cow were $1,056 lower for no-chemical than conventional producers (see Table 1).

	Conventional-Chemical	Low-Chemical	No-Chemical
Tillable Acres	254	177	162
Cow Numbers	57	45	40
Total Investment per cow	5,672	4,613	4,616

Table 1

Crop Enterprise Comparisons:

For a third year, the project has shown that there are benefits to reducing purchased inputs for Wisconsin dairy farmers. Lower-input farms reported lower fixed and cash costs and higher net and net cash returns per acre than similar conventional dairy operations. Although crop returns averaged $16 per acre higher for conventional producers, low- and no-chemical producers received over $33 per acre higher net returns. Total production costs for all crop acres averaged nearly $50 less per acre for low- and no-chemical farms (see Table 2).

	Conventional-Chemical	Low-Chemical	No-Chemical
Crop Value/Acre	238	222	223
Cash Costs/Acre	106	90	66
Total Cost/Acre	171	122	118
Net Cash Return /Acre	132	132	157
Net Return/Acre	67	100	105

Table 2

The greatest savings for low- and no-chemical farms were seen in reductions of nearly $20 per acre in pesticides and fertilizers costs, $8 per acre less in seed, custom and miscellaneous costs and $13 per acre less in capital recovery costs and labor costs (see "Crop Cash Costs, Table 4). In general, low- and no-chemical farms reduced these costs by limiting crop rotations to one year of corn, one year of alfalfa and companion crop, and two years of alfalfa; lowered costs by adding less costly crop enterprises such as small grain and pasture; and reduced overall investments in machinery and facilities.

Dairy Enterprise Comparisons:

Although there was only marginal differences in direct dairy related costs between producers, low- and no-chemical farms had lower purchased feed, vet and medicine and fixed costs (see Table 4 lines 14, 16 and 18-20). Total costs for no-chemical farms were $197 less per head than for conventional producers (see Table 4 line 21). Due to higher production for conventional producers however, per/cwt total costs equaled no-chemical production expenses but were still $.31 above low-chemical farm expenses.

In spite of over 2,700 pounds more production per cow for conventional-chemical producers, dairy enterprise profits were highest for low- and no-chemical producers. Lower overall production was offset on low- and no-chemical farms by lower raised feed costs and a higher per/cwt value for milk (see Table 4 line 27). Higher milk value was achieved through specialty marketing of organic milk and higher butterfat premiums for colored breeds on no-chemical farms. No-chemical farm net returns were $319 per head or $1.82 per/cwt equivalent higher than conventional producers. Net cash returns were $1.09 per hundredweight equivalent higher for no-chemical producers (see Table 4 lines 28 and 29). Average dairy enterprise net returns for all three groups of farms was $14,130. Conventional-chemical farms received the lowest returns which averaged $6,384. Low- and no-chemical farms received $18,765 and $17,240 respectively (see Table 3).

	Conventional-Chemical	Low-Chemical	No-Chemical
Gross Milk Income	154,185	107,145	98,320
Total Expenses	147,801	88,380	81,080
Net Return	6,384	18,765	17,240

Table 3

Whole-Farm Results:

Although gross incomes were consistently higher for conventional farms, total earnings from the 34 farms studied were 8 percent less for 1991 for all three groups of farms when compared to 1989 and 1990 levels. This decline in income was due to the lower milk prices received in 1991. Milk price averaged $11.99 per/cwt compared to an average price of $13.93 the year before. Higher cull cow and stable crop prices helped to offset declines in milk. Lower prices received by all farms were reflected in net income averages. Net income over the three years for all three groups averaged $20,939. This is the balance available for debt retirement and family living.

Average higher income for conventional farms was achieved primarily through additional livestock and crop sales and government program payments. Of the total gross income reported by conventional producers of $184,594, 16 percent or $30,409 was from the sale and income of these items (see Table 4 line 30). Additional sales income and payments, other than milk, reported by no-chemical producers was lower and accounted for 6 percent or $4,397 of the total gross revenue of $102,717. These trends remained constant throughout the three years of analysis.

Whole-farm net returns and net cash returns were higher for conventional-chemical producers. An indicator of the short-term farm financial health, net cash returns averaged $83,400 for conventional producers compared to $57,885 for low-chemical and $51,227 for no-chemical farms. Additional income realized by conventional producers, however, required over 2,000 hours of extra annual labor or just over 39 hours per week (see table 3 line 35). Net cash return is the balance remaining for family living, debt retirement, new capital purchases and savings. Similarly, conventional producers received a net return of $31,854, low-chemical farms $15,172, and no-chemical farms $15,801.

Conclusions:

Results suggest that the economic efficiencies normally associated with larger herd size and increased production may be overstated. Reducing input costs appears to be a significant factor in increasing enterprise profits for Wisconsin dairy farmers. The data also indicates that the farms who were more specialized (dairy only) were more vulnerable to drops in price or increases in input costs. Less specialized farms had lower investment costs, higher overall gross income, and increased whole-farm profitability.

A number of participating farmers have taken the lessons demonstrated by this project to heart. Over the last three years, farmers have increased milk production while reducing average herd sizes. They have begun to experiment with herbicide banding, side dressing of fertilizers, mechanical tillage and cultivation practices, nitrogen crediting and testing of manure and alfalfa, pasture systems and seasonal dairying. This project has shown that reduced chemical use has financial benefits. Many farmers are finding that the "bottom line" not only includes short-term profits but involves longer-term goals and investments which preserve and protect farm and family resources.

Over the three years of the project, low commodity prices, increases in input costs and tightened credit restrictions have combine to reduce profits for all Wisconsin farmers. Results from the Farm Analysis Project suggest that there are benefits to reducing costs. However, long-term financial viability also depends on promoting changes in marketing orders, pricing and marketing structures and research which responds to the needs of the family farm.

SUMMARY 1989-1991
WRDC/CIAS FARM ANALYSIS PROJECT

		Convent-Chem	Low-Chem	No-Chem
1	Farm Name/Numbers	[11]	[11]	[12]
			COST/COW/YEAR	
2	Crop Cash Costs:			
3	Pesticide/Fertilizer	143	52	31
4	Fuel/Repairs	201	142	160
5	Seed/Custom/Misc	131	86	78
6	Crop Fixed Costs:			
7	Capital Recovery Cost	188	106	116
8	Labor Cost	101	92	93
9	Land Cost	221	183	191
10	Overhead Cost	124	66	71
11	TOTAL CROP COST			
	per cow	1,109	727	740
	per cwt	5.26	3.95	4.04
12	Dairy-Related Cash Costs:			
13	Supplies/Utilities	147	126	148
14	Vet/Medicine	76	52	64
15	Repair/Breed/Misc	174	169	180
16	Purchased Feed	477	437	420
17	Dairy-Related Fixed Costs:			
18	Capital Recovery Cost	121	96	107
19	Labor Cost	238	222	223
20	Overhead Cost	251	135	145
21	TOTAL DAIRY COST			
	per cow	1,484	1,237	1,287
	per cwt	7.03	6.72	7.03
22	TOTAL CASH COST			
	per cow	1,349	1,064	1,081
	per cwt	6.39	5.78	5.91
23	TOTAL COST			
	per cow	2,593	1,964	2,027
	per cwt	12.29	10.67	11.08

SUMMARY 1989-1991
WRDC/CIAS FARM ANALYSIS PROJECT

	Farm Name/Numbers		Convent-Chem [11]	Low-Chem [11]	No-Chem [12]
				INCOME/COW/YEAR	
24	Average Cow Numbers		57	45	40
25	Production per Cow/cwt		186	159	159
26	Cwt Equivalent per Cow		211	184	183
27	Average Product Return				
		per cow	2,705	2,381	2,458
		per cwt	12.82	12.94	13.43
28	NET RETURN				
		per cow	112	417	431
		per cwt	0.53	2.27	2.35
29	NET CASH RETURN				
		per cow	1,356	1,317	1,377
		per cwt	6.43	7.16	7.52
				WHOLE-FARM INFO	
30	Total Gross Revenue		184,594	114,843	102,717
31	Total Cash Costs		101,194	56,958	51,490
32	Total Cost - Cash/Fixed		152,740	99,671	86,916
33	NET RETURN		31,854	15,172	15,801
34	NET CASH RETURN		83,400	57,885	51,227
35	Total Labor Hours		5,882	5,004	3,848
36	Net Return to Labor		61,266	40,192	35,041
37	Net Return per Labor/hr		10.42	8.03	9.11
38	Percent Cash Cost/Income		42	42	42
39	Percent Fixed Cost/Income		38	35	37

WRDC/CIAS FARM ANALYSIS PROJECT

Explanation of Summary -- 1989-1991 Comparisons

The following summary describes crop and dairy enterprise costs and returns on 34 western Wisconsin family dairy farms for 1989 through 1991. The analysis focus on comparisons of three groups of farms using differing pesticide and fertilizer application rates and crop production strategies. The Conventional group's average cost per acre (in all crop acres) for pesticides and synthetic fertilizers was $31.98, the Low group's average per acre of cost was $9.69, and the No group's average per acre cost was $1.12.

NOTE: All costs and income are represented on a per cow or per hundredweight equivalent basis (cwt equivalent equals the value of all milk, cull cow and calf sales divided by the average hundredweight price received for milk sold) unless otherwise noted.

COST/COW/YEAR

1. "Farm Numbers": The numbers [11], [11] or [12] under the chemical use groups designates the number of farms in each group.

2. "**Crop Cash Costs**": This represents all cash costs for all crops produced.

3. "Pesticides/Fertilizers": This includes all herbicide, insecticide, synthetic fertilizers and bio-fertilizers (organic or natural) used in crop production.

4. "Fuel/Repairs": This includes all diesel, gasoline or LP used in crop production plus any repairs made to field machinery or equipment. It does not include major repairs such as tractor overhauls which were charged to capital recovery costs.

5. "Seed/Custom/Misc": This is the sum of all seed, custom services, crop insurance, soil testing, etc, related to crop production.

6. "**Crop Fixed Costs**": These are all non-cash fixed ownership costs of machinery, equipment, land, labor and overhead used in crop production.

7. "Capital Recovery Cost": The fixed cost for owning all field equipment used in crop production pro-rated on how the machinery was used. This includes a fixed charge of 13.5% -- 8.5% depreciation and 5% interest on the assessed value of all machinery.

8. "Labor Cost": This is the number of hours for all the crop field work times $ 5.00 per hour.

9. "Land Costs": This is total tillable acre land cost based on average rental rates for cropland in participant's county.

10. "Overhead Costs": This is a one-third of all cash costs which cannot be charged to a particular crop or livestock enterprise. This includes real estate taxes, insurance, mileage expense, 20% of supply cost and 10% of electricity costs.

11. "TOTAL CROP COSTS": All cash and fixed costs for all crop enterprises divided by cow numbers and per cwt equivalent (see line 24 and 25 for cow numbers and cwt equivalent).

12. "**Dairy-Related Cash Costs**": This represents all cash costs which can be directly charged to the dairy enterprise. These costs include dairy replacement expenses but do not include any costs for additional livestock enterprises.

13. "Supplies/Utilities": This is the sum of supplies cost (80% reported on tax returns -- the other 20% was included in "Overhead Cost") and electricity costs (90% reported on tax return -- the other 10% was included in "Overhead Costs").

14. "Vet/Medicine": The total vet and medicine costs as reported on tax returns.

15. "Repair/Breed/Misc": This includes all repairs to livestock facilities and equipment (except major cash repairs which were charge to capital recovery costs), all breeding expenses, and all miscellaneous costs such as DHIA, milk hauling, hoof trimming, etc.

16. "Purchased Feed": This includes all cash costs for any purchased feed and/or concentrates and minerals.

17. "**Dairy-Related Fixed Costs**": This includes all non-cash fixed costs charged to the dairy enterprise.

18. "Capital Recovery Cost": This includes the fixed ownership cost of dairy buildings, equipment and facilities based on assessed value (4.5% depreciation plus 5% interest).

19. "Labor Costs": This the total number of hours which was reported for milking, cleaning barn and feeding livestock, times $5.00.

20. "Overhead Cost": See above.

21. "TOTAL DAIRY COST": This is total cash and fixed cost for the dairy enterprise divided by cow numbers and cwt equivalent.

22. "TOTAL CASH COSTS": This is the sum of all crop and dairy cash costs.

23. "TOTAL COST": The sum of all crop and dairy fixed and cash costs.

INCOME/COW/YEAR

24. "Average Cow Numbers": This is the average number of cows milked.

25. "Production per Cow": The total volume of milk sold during the year divided by the number of head.

26. "Cwt Equivalent per Cow": (see NOTE: beginning of summary).

27. "Average Product Return": The total gross revenue earned from milk, cull cow and calf sales during the year, divided by the number of cows and the average price received for milk per hundredweight sold.

28. "NET RETURN": The sum of "Average Product Return" minus "TOTAL COST".

29. "NET CASH RETURN": The sum of "Average Product Return" minus "TOTAL CASH COST".

WHOLE-FARM INFO

30. "Total Gross Revenue": This is average total farm revenue. It includes all sales of milk, livestock, crops, all government payments, and any miscellaneous farm revenue.

31. "Total Cash Costs": The sum of all cash costs for the farm, including all cash costs for crops, livestock, and farm overhead (note: in the enterprise comparisons listed above, farm overhead is treated as a "fixed" cost and is not included as a "cash expense"as it is in the whole-farm analysis).

32. "Total Cost - Cash/Fixed": This is the sum of all costs - cash and fixed.

33. "NET RETURN": "Total Gross Revenue" minus "Total Cost - Cash/Fixed".

34. "NET CASH RETURN": Total Gross Revenue" minus "Total Cash Costs".

35. "Total Labor Hours" (see "Labor Costs"). This includes hours reported for all crop and livestock enterprises.

36. "Net Return to Labor": "Total Labor Hours" times $5.00 per/hr plus "NET RETURN".

37. "Net Return per Labor/hr": "NET RETURN" divided by "Total Labor Hours".

39-40. "Percent Cash/Fixed Costs/Income": the percentage of "TOTAL CASH COST" and "TOTAL FIXED COST" to "Average Product Return".

No. 1097. Farm Income—Farm Marketings, 1989 and 1990, Government Payments, 1990, and Principal Commodities, 1990, by State

[In millions of dollars. Cattle include calves; sheep include lambs; and greenhouse includes nursery]

DIVISION AND STATE	1989			1990				
	Farm marketings			Farm marketings			Government payments	State rank for total farm marketings and four principal commodities in order of marketing receipts
	Total	Crops	Livestock and products	Total	Crops	Livestock and products		
U.S.	**160,893**	**76,761**	**84,131**	**169,987**	**80,364**	**89,623**	**9,298**	Cattle, dairy products, corn, hogs
N.E.	**1,951**	**978**	**973**	1,976	971	1,005	**20**	(X)
ME	444	228	216	460	240	220	7	42-Potatoes, dairy products, eggs, blueberries
NH	139	73	65	134	71	63	2	48-Dairy products, greenhouse, apples, cattle
VT	429	50	379	447	49	398	6	43-Dairy products, cattle, hay, greenhouse
MA	434	321	113	418	303	116	3	45-Greenhouse, dairy products, cranberries, eggs
RI	78	65	13	71	58	13	(Z)	49-Greenhouse, dairy products, eggs, potatoes
CT	426	240	186	446	250	196	2	44-Greenhouse, eggs, dairy products, tobacco
M.A	**7,118**	**2,373**	**4,745**	**7,421**	**2,528**	**4,893**	**116**	(X)
NY	2,854	917	1,937	3,006	1,023	1,983	59	23-Dairy products, greenhouse, cattle, apples
NJ	662	464	197	647	452	196	16	39-Greenhouse, dairy products, eggs, soybeans
PA	3,602	992	2,611	3,767	1,053	2,714	41	18-Dairy products, cattle, greenhouse, mushrooms
E.N.C	**23,369**	**11,933**	**11,437**	**25,930**	**13,577**	**12,353**	**1,298**	(X)
OH	3,787	2,088	1,698	4,172	2,335	1,836	197	14-Corn, soybeans, dairy products, hogs
IN	4,281	2,456	1,826	4,931	2,871	2,060	244	10-Corn, soybeans, hogs, cattle
IL	6,979	4,727	2,251	7,938	5,461	2,477	507	5-Corn, soybeans, hogs, cattle
MI	2,923	1,611	1,311	3,183	1,785	1,398	169	21-Dairy products, corn, cattle, greenhouse
WI	5,400	1,050	4,350	5,706	1,125	4,581	181	9-Dairy products, cattle, corn, hogs
W.N.C.	**39,890**	**15,972**	**23,918**	**42,995**	**17,025**	**25,970**	**3,902**	(X)
MN	6,513	2,820	3,693	7,011	3,253	3,758	512	6-Dairy products, corn, soybeans, hogs
IA	9,049	3,755	5,293	10,319	4,437	5,882	754	3-Hogs, corn, cattle, soybeans
MO	3,920	1,751	2,169	3,939	1,668	2,271	299	15-Cattle, soybeans, hogs, dairy products
ND	2,152	1,483	669	2,537	1,724	813	545	26-Wheat, cattle, barley, sunflower
SD	2,982	951	2,031	3,349	1,036	2,313	333	20-Cattle, hogs, wheat, soybeans
NE	8,726	3,080	5,646	8,845	2,808	6,037	625	4-Cattle, corn, hogs, soybeans
KS	6,548	2,132	4,416	6,995	2,099	4,896	835	7-Cattle, wheat, corn, hogs
S.A.	**20,329**	**10,811**	**9,518**	**20,039**	**10,346**	**9,693**	**363**	(X)
DE	662	159	503	644	184	460	3	40-Broilers, soybeans, corn, greenhouse
MD	1,336	477	859	1,345	517	828	17	35-Broilers, dairy products, greenhouse, soybeans
VA	2,039	694	1,345	2,120	741	1,379	32	29-Cattle, dairy products, broilers, tobacco
WV	310	60	250	338	70	269	6	46-Cattle, broilers, dairy productss, turkeys
NC	4,593	2,082	2,510	4,867	2,214	2,653	73	11-Tobacco, broilers, hogs, turkeys
SC	1,235	680	554	1,176	599	577	63	36-Tobacco, cattle, broilers, soybeans
GA	3,908	1,626	2,281	3,842	1,574	2,268	131	16-Broilers, peanuts, eggs, cattle
FL	6,246	5,031	1,215	5,708	4,448	1,260	37	8-Oranges, greenhouse, sugar, dairy products
E.S.C	**9,817**	**3,807**	**6,010**	**10,307**	**4,094**	**6,213**	**441**	(X)
KY	2,924	1,266	1,658	3,098	1,400	1,698	82	22-Tobacco, cattle, horses, dairy products
TN	1,946	863	1,082	2,039	928	1,111	91	30-Cattle, dairy products, soybeans, tobacco
AL	2,671	696	1,975	2,737	655	2,083	82	25-Broilers, cattle, greenhouse, eggs
MS	2,276	981	1,295	2,433	1,111	1,322	186	27-Cotton, broilers, cattle, soybeans
W.S.C	**20,303**	**7,790**	**12,513**	**21,715**	**8,297**	**13,419**	**1,761**	(X)
AR	4,157	1,496	2,661	4,259	1,553	2,706	313	12-Broilers, cattle, soybeans, rice
LA	1,708	1,094	614	1,921	1,284	637	155	31-Cotton, soybeans, cattle, rice
OK	3,515	1,137	2,377	3,554	1,191	2,363	319	19-Cattle, wheat, greenhouse, broilers
TX	10,923	4,063	6,861	11,981	4,268	7,712	975	2-Cattle, cotton, dairy products, greenhouse
Mt	**13,479**	**5,726**	**7,754**	**14,003**	**5,687**	**8,316**	**848**	(X)
MT	1,554	625	929	1,606	742	864	300	33-Cattle, wheat, barley, hay
ID	2,745	1,662	1,084	2,935	1,781	1,154	133	24-Cattle, potatoes, dairy products, wheat
WY	827	163	664	767	157	610	31	37-Cattle, sugar beets, hay, sheep
CO	3,969	1,321	2,649	4,213	1,184	3,029	237	13-Cattle, corn, wheat, dairy products
NM	1,459	485	974	1,529	483	1,046	64	34-Cattle, dairy products, hay, chili peppers
AZ	1,926	1,182	744	1,865	1,046	819	43	32-Cattle, cotton, dairy products, hay
UT	755	188	567	755	179	576	35	38-Cattle, dairy products, hay, turkeys
NV	244	102	142	333	115	218	5	47-Cattle, hay, dairy products, potatoes
Pac	**24,638**	**17,373**	**7,264**	**25,601**	**17,839**	**7,762**	**549**	(X)
WA	3,689	2,457	1,233	3,816	2,420	1,396	205	17-Dairy products, cattle, apples, wheat
OR	2,285	1,546	738	2,312	1,557	755	89	28-Cattle, greenhouse, dairy products, wheat
CA	18,050	12,857	5,193	18,859	13,344	5,515	252	1-Dairy products, greenhouse, cattle, grapes
AK	29	20	9	27	19	8	1	50-Greenhouse, dairy products, potatoes, hay
HI	585	493	92	588	499	88	1	41-Sugar, pineapples, greenhouse, nuts

X Not applicable. Z Less than $500 thousand.

Source: U.S. Dept. of Agriculture, Economic Research Service, *Economic Indicators of the Farm Sector: State Financial Summary, 1990.*

Table 1-2. Major Fresh Vegetable-Producing Areas and Crops Grown in the United States and Canada

State	Region	Major Crop
Washington	Yakima	Asparagus, mixed vegetables
	Columbia Basin	Potato, onion
	Umatilla	Potato
Oregon	Klamath Basin	Potato
	Malheur County	Onion, potato
Idaho	Western Idaho	Onion, potato
	Magic Valley	Potato
	Eastern Idaho	Potato
California	Butte Valley	Potato, onion
	Sacramento/Stockton	Mixed vegetables
	Salinas Valley	Celery, asparagus, lettuce, artichoke, garlic, broccoli, cauliflower
	Central San Joaquin	Melon, honeydew, cucumber, carrot, onion
	Central Coast	Celery, lettuce, artichoke, broccoli, cauliflower
	San Diego County	Cucumber, tomato, radish
	Coachella Valley	Melon, sweet corn, onion
	Imperial Valley	Lettuce, asparagus, melon, carrot, sweet corn
	Blythe	Lettuce, cantaloupe, onion
Texas	West Texas	Potato, onion
	Trans Picos	Onion, potato, cantaloupe, pepper
	Winter Garden/Laredo	Onion, melon, mixed vegetables
	Lower Rio Grande Valley	Onion, cabbage, pepper, cantaloupe
Louisiana	Apelousas/central	Sweet potato, mixed vegetables
Arkansas	Warren/Monticello	Tomato
Alabama	Sand Mountain	Potato
	Baldwin County	Potato, sweet corn
Florida	Homestead/Dade	Tomato, bean, mixed vegetables
	Pompano Beach/Everglades	Tomato, celery, radish, sweet corn, cucumber, lettuce, okra
	Immokolee/Naples	Cucumber, pepper, squash, tomato
	Ruskin/Palmetto	Tomato, pepper, cauliflower
	Zellwood/Apopka	Sweet corn, carrot, celery, potato
	Hastings	Potato, cabbage
Georgia	Valdosta/Tifton/Thomasville	Watermelon, cucumber, green bean
	Macon/Americas	Mixed vegetables
	Vidalia	Onion
South Carolina	Beaufort/Ridgeland	Tomato, cucumber, watermelon
North Carolina	Folsom/Benson/Tabor City	Sweet potato, cucumber

Table 1-2. (Continued)

State	Region	Major Crop
Arizona	Yuma Valley	Lettuce, cantaloupe
	Central Arizona	Lettuce, mixed vegetables
Colorado	Northern Slopes	Onion, carrot, sweet corn
	San Luis Valley	Potato
	Rockyford	Onion, cantaloupe
New Mexico	Los Cruces	Lettuce, onion
North Dakota	Red River Valley	Potato
Minnesota	Osseo/Big Valley	Potato
Wisconsin	Rice Lake	Potato
	Antigo	Potato, onion
	Central Sands	Potato
	Racine/Kenosha	Potato, cabbage, sweet corn, onion
Michigan	West Central	Celery, carrot, onion, mixed vegetables
Ohio	Northwest	Canning tomatoes, fresh vegetables
	Hendersonville/Waynesville	Cabbage, bean, tomato
Virginia	North	Tomato
Delaware	Delmarva/Eastern Shore	Potato, cucumber, bean, watermelon
Maryland	Hagerstown	Mixed vegetables
Pennsylvania	Northwest	Potato, cabbage, sweet corn
	South central	Cantaloupe, mixed vegetables
	Kennett Square	Mushroom, tomato
New Jersey	South New Jersey	Sweet potato, cucumber, potato, lettuce, asparagus
New York	Orange County	Onion, celery, lettuce
	Hudson Valley	Sweet corn, mixed vegetables
	Oswego/Fulton	Onion, lettuce
	Northwest	Onion, cabbage
	Castile	Potato
	Long Island	Potato, cauliflower, cabbage
Maine	Aroostook County	Potato
	Presque Isle	Potato
	Canada	
Province	Region	Major Crop
Ontario	Holland/Thedford	Carrot, onion, lettuce
	Grand Bend	Celery, cauliflower
	Leamington	Greenhouse tomato and cucumber, onion, pepper, asparagus
	Exeter	Rutabaga, cauliflower
	Essex-Kent	Processing tomato, peas, sweet corn
	Toronto Region	Broccoli, cauliflower, cabbage, Brussels sprout, mushroom, salad crop
	Alliston	Potato

SOURCE: VEGETABLE PRODUCTION
IB LIBNER NONNECKE (NEW YORK:
VAN NOSTRAND REINHOLD). 1989

(Continues)

Food Production Flow Chart – Appendix I