DOCUMENT RESUME

ED 108 890 SE 019 068

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TITLE Horse Manure and Other Fun Projects. Field Studies and Laboratory Experiences in Environmental Biology - A Book of Experimental Ideas for Secondary School Biol . Teachers.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE 71
NOTE 140p.; The product of a conference held on Isle Royale National Park, June 1971. Best copy available; occassional marginal legibility

EDRS PRICE MF-$0.76 HC-$6.97 PLUS POSTAGE
DESCRIPTORS *Biological Sciences; Biology; Conservation Education; *Environmental Education; *Instructional Materials; Interdisciplinary Approach; Natural Resources; Outdoor Education; *Science Education; Secondary Education; *Teaching Guides

ABSTRACT

This guide contains a collection of laboratory and field inquiries designed to promote ecological awareness, sensitivity, and understanding. The activities compiled by 28 teachers are for use in teaching biology at the secondary level. They are presented in a "recipe" form to make it possible for teachers without prior experience or training to use the activities with ease and confidence. The experiments are generally open-ended, leaving the teacher and students with extensions for further activities. Nine chapters are included in the guide: Planning Outdoor Field Experiences; Field Studies, Physical Factors; Field Studies, Plants; Field Studies, Animals; Field Studies; Succession; Field Studies, Water Organisms; Laboratory Studies; Human Ecology, Pollution, and Population; and Permanent Outdoor Facilities Development and Use. Each chapter contains a number of activities. The activities contain, when appropriate: the purpose, procedures, materials, observations, suggestions and discussion topics, and conclusions. A reference section including books, programs, and resource people completes the guide. (TK)

HORSE MANURE AND OTHER FUN PROJECTS

Field Studies and Laboratory Experiences in Environmental Biology - A Book of Experimental Ideas for Secondary School Biology Teachers

ACKNOWLEDGEMENTS

We are fortunate to have been associated with many fine secondary school teachers during the past four years. Their resourcefulness has made this book possible. The National Science Foundation provided first the funds necessary to carry out the Summer Institute and then the funds to bring back past-participants on this project.

We wish also to thank Hugh Beattie, Superintendent of Isle Royale National Park and his professional staff for the aid and support they have given to the project.

But most credit for aid in this undertaking must go to Mr. Elbridge H. Curtis, associate director and to Mr. Donald Weiss for their unflagging support and assistance. The twenty-five others, all of whom contributed experiences are as follows:

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INTRODUCTION

This collection of laboratory and field inquiries is the product of a unique National Science Foundation sponsored conference held on Isle Royale National Park in June, 1971. The participants were twenty-eight secondary school biology teachers, all "graduates" of the National Science Foundation Summer Institute in Ecology, held at Michigan Technological University during the summers of 1967-70. The Institute Director, Dr. Robert Thorson Brown, Professor of Botany and Field Ecology at Michigan Tech arranged and directed the conference for the purpose of developing this book.

Throughout the years of directing the Ecology Summer Institute and through continued correspondence with many of the one hundred and twenty participants, it became apparent that these teachers were making far greater use of outdoor and ecologically oriented laboratory experiences in their teaching than is common. These ex-participants also shared with the director a keen awareness of the desperate need for today's young people to understand more fully than ever before the finite nature of the environment and man's place in it. So with the belief that biology teachers who are teaching successfully can better help their peers than anyone else, this conference was called to create an environmentally oriented laboratory idea-book for teachers.

The inquiries contained herein are presented in "recipe" form to make it possible for teachers without prior experience or training in these kinds of activities to use the ideas with ease and confidence. The experiments have all been used successfully with students. They are generally open-ended, leaving the teacher and students with suggestions for further extensions. They are all simply organized and the necessary materials are inexpensive and available in most situations.

It is not expected that all the material in the book will be applicable in any one course or that it will be used as a syllabus or lab guide. Rather, it is the hope of the writers that these ideas will provide interest and enthusiasm in teachers who wish to place their students in direct contact with the environment.

The fact that the Conference was held on beautiful, wild Isle Royale in June where the distractions were bird songs, blossoming orchids, insects and weather was in keeping with the intended emphasis: to promote ecological awareness, sensitivity and understanding and thereby to improve the teaching of biology in many secondary schools.

Barbara G. Clark
Participant in Conference
and Associate Director of
1971 Summer Institute

Contents

Contents (Cont'd.)

CHAPTER 1

PLANNING OUTDOOR FIELD EXPERIENCES

ORGANIZING AND PLANNING AN OUTDOOR LABORATORY EXPERIENCE

Introduction

This introduction is for the teacher who is not accustomed to taking field trips, or who may question the usefulness of an outdoor exercise. The outdoor lesson should be defined as a learning experience which takes place outside the regular classroom. It may be as simple as a foray into the school yard or other local site, or a bused trip to an area away from the school. One point remains: it is a learning experience that takes the student outside the physical and psychological confines of the classroom.

A successful field trip requires advance preparation as well as enthusiasm. Preparation should be norough and complete. Without the students being aware of the actual reason for going out, the trip could become an unfortunate experience, for teachers and students. The following points should be considered while planning a trip:

1. When will the trip take place? Consider the weather and suitable clothing, repellent, lunches, etc. Consider the timing in relation to a part of the classroom study. Students appreciate knowing in advance when they will participate in new experiences.
2. Where will the trip be? This depends on the subject of study and the area of study. Knowledge of where they will go reduces the mystery of a trip and often increases the enthusiasm. The teacher should also have some advance knowledge of the area to be studied. A map of the area may be presented to the students. Don't hesitate to identify off-limit areas.
3. Prepare research information in advance if it will add to the field study. It will help to know in advance some of the technical terms and techniques that can be used during the trip. A review of identification techniques would be helpful to both the teacher and student.
4. Use pictures, slides, booklets or other information to inform the student. In some special sites, various agencies have prepared information to explain the area to be studied. Samples or specimens of the area are also useful.
5. Budget your time. If the trip is for longer than one class period, a time schedule should be used - at least for a guide to reduce wasted time and fumbling. If you have to rush through an area, much will be lost.
6. Anticipate problems. Don't look for trouble but be prepared. Have an alternate plan in mind. It may be another lesson or some recreational activity to keep the group active and interested.
7. Whenever possible let some or all students be responsible for acquiring or manufacturing equipment. Familiarity with equipment before the trip will cut down on time wasted in the field. Use of any equipment, recorder,

measuring devices, sampling instruments, markers and others, increases student interest and activity.

8. Organization of groups differs with teachers and the planned activity. Small groups are usually more efficient. If the purpose of the trip is to collect data that is to be shared in a post trip activity, it is not necessary for all students to do all the exercises. If time and equipment permit, it is helpful if all students can do all parts of the lesson.
9. Student preparation: students should be thoroughly prepared and instructed as to the exact materials they are to bring. This may include personal gear, study materials, food, snacks, cameras and others. Personal equipment depends on the teachers wishes and needs of the trip.
10. Think safety. Stress safe ways of behaving on a trip. Don't take unnecessary chances. If the trip is very long, a small first aid kit may save much discomfort. Remember that some students are not as physically able as others. If it can be arranged, an assistant to bring up the rear of the class is very helpful. Explanations should be delayed until the assistant has arrived.
11. An awareness of local hazards in the area can prepare the teacher and the students for the possible emergency. For instance, if the area is infested with poison ivy, long trousers, identification and yellow naptha soap will usually be all that is necessary.
12. Data records and summaries: In some cases it may be advantageous to designate the persons responsible for tabulating data. Record the data on the trail while it is fresh and available. Summarize the data, briefly at the end of the trip, and later in the classrooms. Don't make data collecting a busy work project, and remember that specimen collecting may seriously damage the site.

CONDUCTING AN OUTDOOR LABORATORY EXERCISE

Each person will wish to conduct a field trip in the manner best suiting the situation and the teacher's personal wishes and ability. No single list of instructions will suit all outdoor experiences. It is suggested that the reader use the following materials as a guide to fit his or her situation.

Purpose:

"If the subject can be taught outdoors better than in the classroom, then it should be taught outdoors". (In part from L. B. Sharp in reference to Outdoor Education). This partial quote explains very simply the criteria of selecting a topic to study or a purpose for an outdoor laboratory. The exercise selected may be a part of an established curriculum or used as an enrichment experience. After the topic has been selected, the actual mechanics of the trip can be considered.

Trail type lessons: look and see exercises

1. You may use an established nature trail or make your own in the area you wish to study. In many areas established and marked trails are made available. For the beginner, this is a fine way to get acquainted with the mechanics of a field trip. Resource people are also available from many sources and agencies to assist the teacher and class.
2. Make the teaching stations or stops relatively short and concise. For some cases such as group orientation, general directions, or lecture, a longer stop in a well chosen spot, where all can see and hear, may be desired.
3. Allow for student questions or comments. Asking questions often brings out added ideas and information.
4. Encourage students to make observations during a teacher presentation as well as at other times. Some hints of items to look for may increase this activity.
5. Data sheets and summaries should be a part of the field experience. With clipboards or note books, the student can easily keep a record of the trip. If possible, data sheets may be printed and explained before the trip. This saves time and insures the students knowledge of what to look for.
6. For general information studies, the learning stations need not be in any particular sequence. For most specific topics, a positive sequence may be necessary to produce the desired end result.
7. Do not overlook anything unusual, even if it does not fit exactly to the unit being studied. If it doesn't distract, use it. In the same manner, do not pass over student questions or inquiries.
8. Summarize briefly at the end of the trip (in the field). Further follow-up may be used as the teacher wishes or as is needed to complete the lesson.

CONDUCTING AN OUTDOOR LABORATORY EXERCISE (Cont'd.)

Group projects: data collecting, student research and individual investigations

In many cases, it may be desirable or necessary for students to work on their own or in small groups with very little or even no supervision and instruction. Activities of this nature have several drawbacks that might seem frightening to a beginner, but with proper preperation and a minimum of discipline are often very productive. Data collecting, or specimen collecting are two types of exercises that can be used in this manner.

1. The size of the groups depends on the topic, study area and amount of supervision needed or available. In most cases, small groups usually operate with the most efficiency.
2. Allow for some brief periods of change or free time if the exercise is very long. Even in a classroom there is a between period break or study period.
3. Each group may be assigned a specific investigation to be shared in the follow-up studies or data calculations. If time and space or equipment is available, each group may be able to do the entire lesson.
4. The use of equipment increases student interest and participation. Often the construction of simple equipment may be a pre-trip activity in the classroom.

Discipline:

Problems in an outdoor laboratory or field trip exercise are really no different than in a regular classroom. An outdoor exercise is a learning experience, not recess time. Only the setting is different. Good discipline is essential to a successful field trip and can be handled in the same manner as the classroom. More activity is to be expected, but if it is guided properly, it will be a part of the lesson and not a disturbance.

General Ideas:

1. Be sure students understand the purpose of the trip and are well informed concerning the procedures and activities.
2. Make presentations so that all students can see and hear. Don't shut anyone out.
3. Pre-trip orientation will save time and confusion during the trip.
4. Staff members or chaperones should circulate among groups or at the front and rear of trail groups to provide control.
5. Take notes and data on the spot. Don't have the students trust to memory and try to put it all down later.
6. Adjust the speed of the group to meet their physical abilities and the material being presented.
7. In many cases, permission slips may be desired or required. If for no other reason, a permission slip sent home to parents may be good public relations. If using areas on private property or in public parks, reservations or permission may be necessary.

CONDUCTING AN OUTDOOR LABORATORY EXERCISE (Cont'd.)

8. Plan well and carefully; both the teacher and the student will have a richer and easier learning experience if the trip is well planned.
9. Do not hurry: "haste makes waste".
10. If the attention span is short or the students begin to lose interest, change the subject or move to another station.
11. Be prepared for the unexpected. If it is distracting, leave quickly. If it is interesting or unusual, take advantage of the situation and turn it into a learning experience. Allow some flexibility.

A SELF-DIRECTED STUDY

Purpose:

To provide a learning experience for individuals who are capable of conducting a study with a minimal amount of direction from an instructor. This study should be undertaken with the understanding that it could possibly be shared with the rest of the class, thus expanding the value of the experience.

Procedure:

Have a student discuss an area of interest with the teacher. A purpose should be established or a goal determined. An outline should be drawn up preferably by the student and then reviewed by the teacher. The student then begins his investigation. Periodically he checks with the teacher who checks his direction and makes appropriate comments. When the study is completed or carried as far as possible the student then writes up his observations and conclusions. This may be used to help determine a grade.

To enhance the value of the study the student may present his work to the class. This may be done by using slides or appropriate visual aids.

Suggestions as to projects might be, a study of a polluting factory by effluent or exhaust emissions, attack of trees or shrubs by insects or fungus, use of pesticides by a community, what the effluent from a city sewage disposal plant does to a lake or stream, or anything else that is appropriate or worthwhile.

SELF-GUIDED FIELD TRIP

Purpose:
To develop a self-guided field trip.

Procedure:
1. Select a familiar route that will contain "stations" covering desired topics. These topics can be identification or interrelationships of plant and soil and of plant and animal. Use your imagination.
2. These "stations" may be designated by a marker, a house number, a compass direction, or any such combinations, e.g. Go north on Birch Avenue to the 300 block and stop at house #337. DO NOT walk on the grass. Notice an oak tree in the yard with ivy growing up the trunk. What do you think will happen if the ivy is allowed to grow?

Teacher Notes:
1. General or specific questions for each station depend upon the level of the student.
2. Obtain permission of property owners where applicable.
3. Caution students to respect public and private property.
4. Keep station instructions simple. Check by having a student take a trial run.
5. In wooded areas plastic ribbon may be used as station markers.
6. Field trips may be taken by small groups or individuals.
7. After students have completed the field trip, discuss the experience.
8. The possibility exists that students can develop their own self-guided field trip which could be used by elementary students.
9. Strict orders against specimen collecting must be given.

ECOLOGY OF THE SCHOOLYARD

Purpose:

To study ecological relationships that exist in the schoolyard.

Since all schoolyards are not identical, it is not possible to give a standard procedure. Some of the following ideas may be incorporated into individual situations.

Look for little piles of soil around a tiny hole indicating an ant's nest. Where do the ants get their food? If you are lucky, you may be able to locate the trail on which they walk to a tree or to a hole in an apartment wall.

There may be weeds like the dandelion, plantain, and ragweed living in the cracks in the sidewalk and perhaps a tree surviving in the hard ground.

There will be visitors to the school yard, attracted there by bits of food dropped by children from their lunches. The English sparrows, starlings, and pigeons make this and the city park their feeding places. Their water is provided by the overflow from the drinking fountain.

The schoolyard is also a watershed--possibly even two watersheds. A watershed is simply the area which drains into a stream, in this case the gutter which runs along the street. This watershed is not the same in appearance as that of the forest or grassland, but is is a watershed just the same. On a rainy day, trace the water from the place it falls on the school yard until it runs into the gutter. You can use a sieve or plankton net to see what the water is carrying.

After the rain has stopped, look at your watershed. Note where deltas of sand and mud have been left behind by the stream of water. Make a map of the school grounds, showing all the watersheds and the streams--or catch basins--into which they drain.

In the city park you can check the lawn for grass, sedges, and weeds and keep a record of the birds and animals--what they eat, where they live, who their enemies are and other information about them. You can study ecology on a city street. You can study ecology no matter where you go: every area of the earth, including the driest deserts and the icy wastes of Antarctica, is the home of living things. All are related to one another and to their environment.

A CITY BLOCK LAB

Purpose: To acquaint students with the plant and animal life and their habitats in what seems to be a barren environment.

Materials: pencils, paper, collecting jars, thermometer, guide books

Procedure:

1. Divide the class into groups of six or less with a chairman responsible for group progress, further subdivide the group into smaller units of two.
2. Have each group do the following tasks, assigning the work as they and their chairman desire.
   - A. Map and measure the block as accurately as possible.
     1. Put in all the buildings.
     2. Put in all trees over 12 centimeters.
     3. Record flora in the sidewalk cracks. Do not collect specimens or ravage the area.
     4. Identify trees and shrubs in the area and record.
     5. Identify plants growing on trees, at the base of trees or on the buildings and record.
     6. Record all animals seen, vertebrates or invertebrates, their approximate location, feeding habits and behavior.
     7. Measure and enter on the map any puddles of water. Take samples to the lab and check each for animal and plant life.
     8. Take air samples using slides taped on a hanger. Hang five minutes in different areas to get particle samples. Take to lab, observe, count, and make a quantity comparison and record. (See Exercise)
     9. Compare similar data taken in each season.

A COMPARISON OF URBAN, SUBURBAN, AND RURAL AREAS

Purpose:

To illustrate man's effect on his environment and how nature has compensated for this change.

Materials:

An urban area (any downtown section of any size town or city), an area being developed, an established area such as a subdivision that is at least 10 to 15 years old, and a rural area.

Procedure:

Have small groups of students locate themselves in "sub-areas" within each ¼ block area. Within each group, have the students list and count the number of different living organisms found. This should include all plants, insects, birds, people and visible life. Identification and listing of these organisms can be done using common names.

example:

organism	#of individuals	where found	sizes	anything unusual
ants red	102	on sidewalk	¼"	
birds pigeons	34	roof of bldg. sidewalk		
people	23	walking by		

If species are not known to the students, have them write descriptions for later identification. Specimen collection may be done only where it will not deplete the population seriously. One class period is usually long enough to make the observations that are needed. Using areas close to the school grounds first, can cut down on the transportation needed and can develop techniques that will be necessary in other places.

Observe at least two different types of areas listed, if possible, use all four. Collect information for the different areas and compare the results. The direction of comparison can be outlined by using questions or mimeographed guide sheets.

Examples of some of the guide questions:

1. Are plants of the same species found in the different areas: What are the differences in the appearances of these plants in the different areas?
2. Are animals of the same kind found in all the areas? If so, are there any differences?

3. How do the population sizes vary? Where are the greatest populations of each organism found? Why are these populations different in different areas?
4. What environments are common to all? How do they vary?
5. How do these factors influence the life in these areas?

(As the teacher, you may have to help the students correlate their material in the end, but let them draw their own comclusions first.)

STUDENT PRODUCTION OF A PERMANENT ECOLOGICAL STORY

Purpose:

To allow students to investigate and to make a permanent record of an ecological phenomenon.

Materials:

1. Camera and film
2. Tape recorder

Methods and Ideas:

1. Students should have instruction in the operation of the camera and tape recorder and work in small groups.
2. Colored slides offer several advantages:
   a. cheaper than colored prints
   b. colored prints can be made from desireable slides
   c. can be shown to an entire class
   d. can be programmed in a slide projector with a tape recorder
3. It is possible to photograph pictures from books and thus "travel" great distances and duplicate unique pictures for a slide presentation
4. Some students may want to work just on sound effects. It is possible to collect "noise" on tape and investigate the effects it has on individuals, either human or animal.
5. No one method can be given, as the methods are as diverse as the ideas. However, the following is a list of possible titles:
   a. The story of an animal
   b. Evidence of pollution
   c. What is a river or a stream?
   d. Stories on erosion
   e. Animal homes
   f. Phenology studies
   g. Vegetation on school grounds
   h. Diversity of the plant kingdom
   i. Fungi
   j. Local birds, their songs and habitat
   k. Bare rock succession
   l. Fallen log succession
   m. Abandoned field succession

Discussion:

This activity may be done wither in class or on the students' free time. It may also be incorporated into a camping trip, or any outdoor experience. Students many times learn by mistakes, but in this case they can become costly, so close supervision is necessary.

ORGANIZING AND PLANNING AN OVERNIGHT CAMPING TRIP

A camping trip, or some type of overnight experience for students is as varied in form as are the activities. Very simply, the trip may be as an enrichment experience or it may be educational. The most ideal and productive trip would combine both aspects. Whatever is suggested here must be adjusted to the local area and situation. The "sky is the limit"; all it takes is imagination and enthusiasm by teacher and student.

A long list of objectives may be written to justify a camping experience; many have been written and could be very helpful. Whatever the objective may be, the trip should provide a worthwhile experience for the student. It may be a new learning experience to motivate students or an experience of living and working together. Whatever the purpose or objectives, a camping trip is a rich learning experience for students.

Planning:

1. Location of camp
    a. Established camp site - An established camp site offers many conveniences for a beginner that might not be evident to one experienced in a camping activity. An established camp offers modern conveniences such as tables, fireplaces, and toilets. Many areas have group camping areas that are made for school groups in various State or Federal Forest and Park areas. Some of these areas provide guided tours and informative lessons of many types.
    b. Wilderness area camping - This is the most strenuous type of trip to take with students. Often it is done with canoes, but need not be. There are many good wilderness areas that provide canoeing or hiking for groups. Any trip of this nature demands more of the participants and all other phases of a camping experience. The participants do not need be experienced campers, but there must be some of the staff that are.

    Wilderness trips are more of an enrichment program than a definite "lesson plan" type of trip. It is definitely a new experience for many people. The participants will do all the regular chores and activities that are required of campers in a wilderness area. Of more importance are the esthetic values, the personal reaction to small inconveniences, and the natural beauty. Wilderness camping takes more and different equipment than a regular established camp. If cost is too great, equipment of this nature can be rented in many cases.
2. Duration of trip

    The length of the trip is of local concern. Basic points such as the time of the year, school calendar, reservations and transportation need to be considered.

3. Permission Slips

   In most cases, it is prudent to get the parent's permission for a camping trip. This allows for a contact with the parent and gives the teacher a chance to find out information concerning the student's health, allergies, medication and physical limitations of the student. In cases of considerable physical activity, long hikes, climbing and such, a doctor's permit may be desired.

4. Transportation

   This is again a local problem for each teacher. The transportation may be in any form, just so that it meets the requirements of the school. One point often overlooked by the beginner is transportation of gear. A camping trip of any kind requires much more equipment than other types of class outings.

5. Program planning

   For most school trips, part of the emphasis is educational. This part should be well planned in advance. The objectives and what is likely to be seen should be explained to the students before the trip starts. Certain pieces of equipment might be needed such as reference books and field equipment. With a small amount of inquiry, one can find many people who will be of great assistance in planning and carrying out an educational program. Explore the possibility of local persons; a member of a bird watchers club, a local "rock hound", and others with a special interest. Most governmental agencies have personnel that are trained and qualified to help. Most parks have naturalists or rangers to help with educational programs. Some areas may be able to use research units or may find an education station set up with prepared programs.

   If the camping experience is for more than one or two days, some forms of recreation should be planned. This might be swimming if available, fishing, canoeing, or some planned form of entertainment; maybe a class play put on in the outdoors, a ballgame, archery, riding or whatever is desired and available. It is often interesting and beneficial to have the students plan a part of the entertainment. Students are rich in imagination and usually produce some very fine activities.

6. Supervision

   Supervision and discipline is a part of all the members of the group. This may be divided or shared between the professional staff, camp counselors, teacher aids and so forth. A well run trip functions with the same efficiency as a well run classroom. A good motto is to enjoy yourself, but don't make life miserable for your neighbor. Leave the campsite neat and clean.

ORGANIZING AND PLANNING AN OVERNIGHT CAMPING TRIP (Cont'd.)

7. Food Supplies
   The food needed depends on the type of trip planned. A trail trip cannot make use of large, heavy items. In some cases, the school lunch program might supply the needed items. A class planned menu, purchased and prepared by the class adds to the experience. Campfire cooking is enjoyed by students, and if at all possible, should be included. Possible menus, trail foods, camp recipes and techniques can be obtained from many sources; Scouts, commercial outfitters and school cooks.
8. Clothing
   The leader must explain what is suitable dress and footwear for the trip. Precautions should be taken about poison ivy, poison sumac, poison oak, insects, and other natural problems that may be encountered.

Whatever the reason, whatever the objectives, or whatever the personal tastes of the teacher, a camping experience should not be overlooked. If it is at all possible in a school program to include this type of activity, a teacher should try it. Get the help of someone familiar with school camping, plan the program well, try a short trip first and then extend the activity into other fields. The results will be gratifying.

LIST OF MATERIALS THAT STUDENTS CAN BRING FROM HOME

Put your list on the board the first couple of days while enthusiasm is high. The following are suggestions. Add or delete as desirable.

1. baby food jars
2. junior food jars
3. margarine tubs
4. soup cans
5. cottage cheese containers
6. bleach bottles (plastic)
7. liquid detergent bottles
8. milk cartons, all sizes
9. Windex spray bottles or hair set bottles
10. clothes hangers
11. discarded nylons can be used as netting
12. egg cartons
13. plastic bread bags
14. tops of aerosol cans, can be used to hold small items
15. shoeboxes
16. styrofoam meat and produce trays, can be used instead of corkboard to line insect collection boxes
17. used single edge razor blades
18. large plastic bags such as those newspapers come in
19. netted produce bags
20. popsicle sticks
21. plastic or glass pill bottles
22. coffee cans, shortening cans with plastic lids
23. newspapers, magazines; can be used for reports as well as lining animal cages, wrapping "garbage"
24. old toothbrushes, can be used to clean equipment
25. gallon vinegar or cider jugs

CHAPTER 2

FIELD STUDIES: PHYSICAL FACTORS

Seasonal Changes

Wind-chill Factor Determination

Snow-related Activities

Snow as an Accumulator of Pollutants

Microclimates

Investigating a Micro-environment Without the Sense of Sight

Soil Investigations - Six Activities

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SEASONAL CHANGES

A student or a small group of students interested in photography may be encouraged to begin a series of slides taken weekly throughout the school year at specific locations. At the end of the year, the entire set of slides will provide a time-lapse series to show seasonality. The presentation may be supplemented with weather data acquired from the school weather station, or daily and monthly temperature and precipitation averages may be requested from the nearest U. S. Weather Service Station. A trip to the weather station is helpful. From this data, prepare weekly weather average slides that can be used with the time-lapse series. This investigation may be repeated each year, and the sets of slides may be compared with one another.

A series of slides may be taken at a specific location periodically during several years with the purpose of showing plant succession.

WIND - CHILL FACTOR DETERMINATION

Our skin is one of the chief agents for regulating the body temperature. Excess body heat is given off by radiation. Our sweat glands moisten the skin surface and breezes evaporate the sweat, cooling the body. When more wind dries the sweat as rapidly as it comes to the surface, we no longer are aware of sweat but we are still losing moisture from the body. If we lose 10% of the body moisture, the results are fatal. The more skin exposed to wind, the quicker we succumb. Actual chilling can occur at a normally comfortable temperature if there is a moderate wind. The skin surface may get down to the freezing point of water. One result is that surface blood vessels shut down, the skin turns white, and blood distribution in the body becomes unbalanced. Strong steady winds that you may easily encounter in mountains or at the beach can produce dramatic losses of body heat that may be damaging to the body.

Your head and feet are the most efficient radiators of body heat. Knowing this, keep your head covered and your feet dry and warm if you want to avoid chilling the whole body.

By checking the following charts of wind velocity and air temperature, you should be convinced that proper clothes are needed.

Wind Velocity	Indications
0 - 1 mph	Calm; smoke rises vertically
1 - 3 mph	Smoke shows wind direction
4 - 7 mph	Wind felt on face; grass or leaves rustle. Snow eddies
8 - 12 mph	Leaves and small twigs in constant motion; light flag extended by breeze
13 - 18 mph	Dust, snow, or leaves are raised; branches move
19 - 24 mph	Small trees in leaf will sway; crested waves form on inland water
25 - 31 mph	Large branches in motion; white caps on most waves; tents billow and strain
32 - 38 mph	Whole trees in motion; walking against wind difficult
39 - 45 mph	Twigs break off trees; walking generally difficult
46 - 54 mph	Branches break off trees

To determine the wind-chill factor: estimate the wind velocity in miles per hour from the table above or from other weather data or forecasts. Read the temperature from the thermometer or get the lowest temperature forecast for the area. Locate the wind speed in the left-hand column and the actual temperature at the top of the table. Now read across for wind speed and down for temperature. The block where these two "columns" intersect is the value that will indicate the effective equivalent temperature at zero miles per hour.

WIND - CHILL FACTOR DETERMINATION (Cont'd.)

Chill Factor on Dry Bare Skin (Read as equivalent temperature at 0 mph, and dress accordingly. Consider any temperature lower than -20°F. as dangerous conditions.

Estimated Wind Speed in MPH	Actual Temperature (°F.) 50	40	30	20	10	0	-10	-20	-30	-40
calm	50	40	30	20	10	0	-10	-20	-30	-40
5	48	37	27	16	6	-5	-15	-26	-36	-47
10	40	28	16	4	-9	-21	-33	-46	-58	-70
15	36	22	9	-5	-18	-32	-45	-58	-72	-85
20	32	18	4	-10	-25	-39	-53	-67	-82	-96
25	30	16	0	-15	-29	-44	-59	-74	-88	-104
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116

SNOW

Introduction:

There are many activities related to snow. The following are several that can be used effectively in regions where snow accumulates.

I. Measuring Snow Depth:

This should be done in an undisturbed area if you intend to determine the total accumulation up to the time of the activity. Permanent snow depth measurement markers can be set in the fall. To obtain an average you may wish to set three measurement sticks in a triangular pattern at 50 foot intervals. Measurement sticks can be made from 5 to 6 foot lengths (or longer if snow fall accumulates over 4 feet) of board that are painted yellow with black gradation marks to facilitate easy reading from a distance, as this will avoid trampling the snow next to the stick. It might be a good idea if the measurement sticks are to be permanent to: 1) treat the bottom 18-24 inches with creosote or penta preservative and 2) nail or screw a crosspiece to the bottom of the board to prevent it from being pulled out. Obviously, to obtain data on annual accumulation recordings must be made after each snowfall in an area where little or no drifting takes place.

II. Weight of Snow:

An exact volume of snow must be collected to obtain reliable data. A discarded heating pipe from a local furnace shop will work well. You must use a long enough pipe to extend above the snow level when pressed to the ground. The open-ended pipe is pressed vertically to the ground and the snow inside the pipe is collected by slipping a tin sheet or card-board underneath and removing the contained snow into a bowl or tub. The volume of snow is determined by multiplying the area of the pipe (pi) (r^2) X the depth of the snow sample. The mass of the snow can most easily be determined by measuring the amount of water obtained from the melted sample (by volume). The density of the snow sample will then be the mass (volume of water) divided by the volume of the snow sample. Comparisons can be made of snow density falling at different temperatures, different times of the winter, or under different conditions of wind. Snow density and total weight of the snow level can be determined for flat roofs and sloped roofs of different pitches to relate the architecture of an area with this climatic characteristic or to relate structural needs in garage and house design. How much heat was required to melt the sample? How much water is on an acre of land?

III. Effect of snow on various trees:

Count the number of branches stripped from long needle pine trees in a plantation. Contrast this with the number of branches stripped from short needle trees (spruce or fir) and with those stripped from deciduous trees by snow. How does snowfall compare with temperatures, rainfall and other climatic factors in determining vegetation type? Can it be a limiting factor? Under what kinds of conditions is snow most harmful?

SNOW (Cont'd.)

IV. Questions Related to the Accumulation of Snow:

1. What happens to the snow in the spring? (run off, percolation, evaporation)
2. What factors affect the flood potential of snow melt? (speed of snow melt, type of soil, frost depth, water table level)
3. Is it possible for any of this water to return to its original position? How?

SNOW AS AN ACCUMULATOR OF POLLUTANTS

Introduction:

Snow may be used to determine the comparative relative amount of sulfates and chlorides in our atmosphere and the influence of the pollutants upon vegetation.

Procedure:

1. Divide students into groups of 2, and have half of the groups do the following with snow from various places such as cities, villages, hills, valleys, etc. The other half start with Part 7.
2. Collect 10 liters of snow and melt. Filter, dry, weigh to determine particulate matter (soot, fly ash, etc.) Save the filtrate.
3. Boil the remaining filtrate until a volume of 20 ml. remain. Divide this into two 10 ml. parts.
4. In order to determine the mass of sulfate materials resulting from pollution complete the following:
   a. Add 1.0 ml. of 1N $BaCl_2$ (barium chloride) to 10 ml. from step #2.
   b. Weigh a piece of dry filter paper and record the mass.
   c. Using the same piece of filter paper, filter the residue (if any) from step #3. Wash with 5 ml. distilled water.
   d. Dry filter paper and residue at 100° C.
   e. Determine mass of filter paper and residue when cool.
   f. Subtract the mass of filter paper (step #3b) from the mass of dried filter paper and residue (step #3d) in order to obtain the mass of sulfate materials found in 2.5 liters of snow.
5. In order to determine the mass of chloride materials resulting from pollution complete the following:
   a. We hope you have saved the other 10 ml. of filtrate from step #4 as it is now necessary to add 1.0 ml. of 1N $AgNO_3$ (silver nitrate) to this filtrate.
   b. Continue this portion of the investigation as you did with steps #4 b, c, d, e and f, but finding this time the mass of chloride materials in 2.5 liters of snow.
6. Compare the amounts of various pollutants found in a city or village with those in less populated places.
7. The other half of the class in groups of 2 accompany the snow collectors and sample the lichens and mosses as follows: Estimate the % cover of moss and lichen cover on trees of the same species (e.g. hard maple) and correlate differences with forms of pollution. Estimates can be made using a square frame 10 cm. on each side made of cardboard or plastic divided into 1 cm. square parts by strings. The cardboard can conform to the tree shape and the smaller squares aid in estimation of cover. Sample 5 trees at each snow collection site on the east side of the tree 4 feet above ground level.
8. Correlate measured pollutants with lichen and moss abundance. Graphs are appropriate. Might the killing of lichens or moss be an indicator of possible long term damage to humans?

MICRO-CLIMATES

Purpose:

Within many school systems, it is often difficult to take classes of students out of the school for laboratory activities. The following exercise may be conducted within a limited area of the school property. This activity is designed to acquaint students with the variations of climatic factors within a relatively small geographical area. It provides an opportunity for students to use weather instruments, to collect and record weather data and to observe the different species of plant and animal life that exist together.

Materials:

1. Thermometers
2. Sling psychrometer
3. shovels and trowels
4. containers (large juice cans, coffee cans, etc.)
5. writing materials

Possible Sites of Study:

1. A sunny open area of the school.
2. A shaded side of the school.
3. The north and south side of a fence or wall.
4. In a ditch or hole.
5. Dark and light surfaces such as black top and cement.
6. The highest point and the lowest point on the property.
7. If snow is present, the surface, ground level and bottom of depression.

Procedure:

Divide the class into small groups, one group for each site chosen. At each site:

1. Have the students measure and record the temperature of the air and the temperatures of the soil at the surface and at specified distances above and below the surface: example - 8 cm below surface; 5 cm and 180 cm above surface.
2. The relative humidity may be determined and recorded.
3. Observe the texture and condition of the soil.
4. Draw attention to the kinds of plants within the area and their general appearance. Encourage the students to correlate climatic factors with soil and plant conditions.
5. Samples of the soil and plants may be removed for further study in a classroom laboratory period.
6. Count invertebrates and record activities (e.g. running, flying, crawling, etc.)

In the Classroom:

The students may wish to continue this exercise in the classroom by noting the effect of a changed environment on the plants, or they may wish to attempt to duplicate the outdoor environment. Charts may be constructed to compare the variations of temperature and humidity, and the soil can be analyzed for mineral or particle size. The data collected could be saved and comparisons made during the following years. Correlations between physical factors and kinds of organisms, numbers, and activities can be made.

INVESTIGATING A MICRO-ENVIRONMENT WITHOUT THE SENSE OF SIGHT

Purpose:

To make students aware of the problems of a handicapped person. It is intended that the student learn to investigate a small area while blindfolded, and by so doing, gain insight into his environment and his ability to observe it through his limited senses.

Materials:

1. Heavy cloth material to be used as a blindfold. (one for each student pair)
2. Lengths of heavy cord or light rope, to be used as a tether. Length of cord depends upon the size of area to be investigated, usually between 10-20 ft. (one for each student pair)
3. Each student will need paper and pencil to record information and the experience upon completion of the activity.
4. This outdoor activity may be done on any area (e.g. school grounds, school arboretum, campsite)

Methods:

Students should work in pairs. One is blindfolded, led to his area and tethered. The "seeing eye" records observations dictated by the blindfolded student regarding sizes, shapes, textures, locations, sounds, temperatures, types of vegetation, soil, etc.

Upon completion of his investigation the student is released and encouraged to find out what he missed. Then the process is reversed.

The length of time the student is allowed to investigate depends primarily on the area and the diversity of objects and organisms in that area.

A discussion between class members led by the instructor is the best way of concluding this experience.

Precautions:

If class size is large, it is suggested that the instructor have student aides to help with the tethering, and observation of students while they are investigating their plots. It is also wise to make sure that there are no poisonous plants or other objects in the plots in which may cause harm or discomfort to the students.

SOIL INVESTIGATIONS

The differences in soil show effects on vegetation and animal life. The study sites chosen should vary as to topography, light and vegetation. Groups of 2 or 3 students may do the following activities.

ACTIVITY I - SOIL PROFILE

Materials:
1. Spade
2. Soil
3. Thermometer
4. Containers for collecting soil samples

Procedure:
Dig holes which show the soil layers. Things to note:
1. Color of various soil layers
2. Texture and smell of different layers
3. Temperature of soil layers
4. Depth of various layers

Discussion:
1. How do each of the above factors correlate with the growth of vegetation?
2. What hypotheses can be made regarding type, density, and general appearance of the vegetation as related to the profile characteristics?

ACTIVITY II - SOIL CLUMP DISINTEGRATION

Materials:
1. Beaker
2. Soil samples collected from different areas
3. Small 5 x 5 cm. basket fashioned from window screen

Procedure:
Students carve a cube of soil (1 cm. dimension), place in basket, and lower into beaker of water. Gently raise and lower the basket without raising it above the water surface. Observe what happens and record the time elapsed before disintegration begins, and time when disintegration is complete.

Discussion:
After receiving data from different soil types, discuss the following:
1. Soil from what area disintegrated most rapidly?

2. What observable factors appeared to affect rate of disintegration?
3. What influence would the rate of disintegration have on the rain falling on the soil surface?

ACTIVITY III - WATER-HOLDING CAPACITY OF SOIL

Materials:

1. Empty juice cans of identical size and shape
2. Nails (10 penny)
3. Hammer
4. Beaker
5. Graduated cylinder
6. Stop watch

Procedure:

Students punch holes in bottom of cans making sure holes are located in the same places and the number of holes are the same in each can. Oven dry (105°C) a half a can of each soil type. (This should be done the previous day.) Place 5 cm. of soil in each can. Gently pour in 200 ml. of water and collect the water that drips out. Collect the following data:

1. Time elapsed before water begins to drip from holes
2. Time elapsed before all water enters the soil
3. Time elapsed before water stops dripping
4. Quantity of water collected from each can

Discussion:

1. Which soil type holds the most water and why?
2. Which soil type holds the least water and why?
3. What might happen to plants growing in each soil during a wet season? A dry season?
4. What adaptation might the plants possess in each soil type?
5. Check the vegetation where soil was collected. Are differences in the plants apparent?

ACTIVITY IV - PERCOLATION RATE

Materials:

1. Several vegetable cans of identical size and shape
2. Stop watch
3. 600 ml. beaker

Procedure:

Remove the bottom from several empty vegetable cans. Drive the cans into the ground on different soil plots until only 3 cm. remain exposed above ground. Remove, fill with water and record the time required for water to disappear. Also record the time for the water to go through the soil. Samples may be returned to the laboratory for testing.

SOIL INVESTIGATIONS (Cont'd.)

Discussion:

1. Of all the different sites which type of soil might have the greatest run-off?
2. Is there any correlation between percolation rate and water-holding capacity?
3. How does the type and density of the vegetation affect the percolation rate?
4. How do the soil layers affect percolation rates?
5. How does compaction influence percolation rate?

ACTIVITY V - SAND, SILT, CLAY CONTENT

Materials:

1. Large glass cylinder
2. Ruler

Procedure:

This activity will provide a rough approximation of the amounts of sand, silt, and clay in the soil. Shake the soil through a screen which allows particles less than 2 mm. in diameter to pass through. This will remove the gravel and other large objects. Place 2 or 3 inches of soil in the glass cylinder. Add water until the cylinder is two thirds full. Shake thoroughly for several minutes, then allow the cylinder to stand for two or three days. The sand particles being the largest will settle first, the silt next, and finally the clay. Measure the amounts of the resulting layers to find the approximate percentage of sand, silt, and clay by volume.

Discussion:

1. What correlation is there between the water holding capacity and the percentage of sand, silt and clay?
2. Is there a correlation between percolation rate and sand amount? If so, what hypotheses can be made regarding water absorption, run-off, and soil compaction in soils that are predominately sand? Silt? Clay?
3. Are there hypotheses to be made regarding plant adaptations in soil that is composed entirely of sand? If so, what?
4. Are there significant differences in the amounts of sand, silt, and clay in the soils studied by the class? If so, are these differences reflected in the vegetation in each place where soil was collected?

ACTIVITY VI - SOIL CHEMICAL TESTS

Materials:

1. Soil testing kit-Sudbury or Hellige-Truog are available from biological supply companies

Procedure:

Test for acidity, nigrogen, phosphorous, and potash contents as stated in instruction booklet.

SOIL INVESTIGATIONS (Cont'd.)

Discussion:

1. How does the general appearance of the same kind of plant compare in soils with different degrees of acidity and mineral deficiencies?
2. How does the density of plants of a particular kind compare in soils with measurable differences as to acidity and mineral dificiencies?
3. Are the same kinds of plants found in soils of different degrees of acidity and mineral deficiencies?
4. What factors other than those tested could contribute to appearance, density and species composition of the vegetation?
5. What could be done to improve soil which shows a mineral deficiency or considerable degree of acidity?

CHAPTER 3

FIELD STUDIES: PLANTS

Methods for Determining Population Size and Density

Lawn Investigation - Related Studies

Plant Size and Environment

METHODS FOR DETERMINING POPULATION SIZE AND DENSITY

Object:

To acquaint the student with two ways the biologist determines population size: (1) complete census, and (2) random sampling.

(1) Procedure: complete census

1. Any type of plant may be used
2. A football field is a good study area as it is permanently marked out and contains 10 yard stripes that serve as guide lines when counting. The complete field does not have to be utilized. Let the size of the class determine the area used.
3. Make certain students are familar with the "target" plant (e.g. dandelion).
4. Line students along the sideline and have them march across to the other sideline counting as they go.
5. Total all data collected. This sum equals the population size of the target plant in a given area.
6. Calculate the number of plants per unit area (polulation density).

(2) Procedure: random sampling

1. A sampling device is needed. Wire coat hangers can be bent into uniform squares or circles. It is possible to collect and use old bike tires. There is a safety factor involved in the second sampling device.
2. Divide the class into groups of two.
3. In each team of 2, one student will toss the sampling device onto the study area. Before he tosses, he should close his eyes to insure a random toss.
4. When the team member is ready for the next toss, he should stand where the device landed the first time, close his eyes, and toss it in a different direction from the first toss.
5. If more than ½ of a "target" plant is within the sampling device, count it. If less than ½ of the plant is within the sampling device, do not count it.
6. One team member tosses and counts while the other member records the data for 5 tosses. Then the members of the team should trade jobs and repeat the procedure five more times.

Individual Team Data

Sample or Toss Number	Number of Plants Counted
1	
2	
.	.
.	.
.	.
10	
Total	
Average	

7. Collect the entire data from all teams using a table similar to the one below:

Total Class Data

Group number	Number of Samples	Total number of target plants
1		
2		
.		
.		
.		
14		
15		
Total		
Average		

8. The average from data table 7 will be the average number of "target plants" per sampling device and thus per unit area.
9. It is now possible to calculate the population of the entire study area. Since the sample population, sample area, and total area are known, the total population can be calculated.

Discussion:

1. How does the population size by complete census compare with the population size by random sampling?
2. Is there a difference? If so, how would you account for this difference?
3. What method do you think is the most reliable? Why?
4. Is there a time when one method might be better to use than another?

LAWN INVESTIGATION - RELATED STUDIES

I. Effects of fertilizers on sample plots

Materials:

Sudbury or other soil testing equipment

Commercial chemical fertilizers (quite often garden suppliers have broken bags of fertilizers which they will donate for studies of this kind.)

This study works best as a small group study, or utilize several plots to involve the whole class. It should be initiated as early in the spring as possible in your area so that longer range effects can be observed.

Procedure:

1. Assign plots to groups of 2-4 students. Size of plot can vary according to need and availability.
2. Test the soil for some basic characteristics, such as pH, nitrates, phosphates, potash content.
3. Chemically fertilize different plots with varying amounts and ratios of the minerals. Augment insufficiencies in some plots, overfertilize with a certain mineral in others. Leave at least one plot untreated as control.

Results:

1. How soon after application are signs of change apparent?
2. Which mixture produces the greatest increase in growth? Greenest lawn?
3. Does excessive amounts of certain minerals help or hinder growth? Do different kinds of plants respond the same?
4. Examine the soil for earthworms, ants, other invertebrates. Does the use of chemical fertilizers appear to affect these organism populations?

II. Effects of chemicals and cutting on lawn plants

Materials:

Commercial weed killer

Lawn mower with adjustable cutting height or scythe, sickle or grass-cutting shears

If your school lawn is typical, it is a mixture of grasses and broad leaf plants, including dandelions. This situation may be used to illustrate selective plant control and man's modification of his environment. These experiments must be begun as early in spring as possible.

Procedure:

A. Chemical control
   1. Assign plots to small groups of students. Record the numbers of dandelions and other broad-leaf plants within each plot. Compute population densities.
   2. Apply designated amounts of commercial weed killers to specific plots, leaving some as controls.

3. Observe plots at regular intervals.
4. Determine population density for plants being observed each month.
5. Make a determination of earthworms, ants and other invertebrates populations in treated and control plots.
6. Evaluate results:
   a. How long does it take for the weed killers to begin affecting plant growth?
   b. How effective are the types and concentrations of weed killers in controlling different broad-leaf plants?
   c. How does the use of weed killers affect the soil organisms?
   d. How might long-term use of herbicides affect the lawn?

B. Cutting

Keep several similar plots mowed regularly at ½", 1", 3", 4" or other heights possible with your equipment. (Plots could be hand cut with scythe, sickle or grass shears - beware of blisters.) At least one plot should be allowed to grow uncut. Compare growth and population density of broad-leaf plants as affected by cutting. Some aspects of this study could be extended through two or three growing seasons if school policy and personnel will permit uncut plots to remain in the school lawn. Care must be taken to keep watering, sunlight and other factors constant. Compare the longer range effects of cutting length over more than one season to the effects observed in the first study.

Similar techniques could be used to investigate the effect on grass and broad-leaf plants of watering, wear or trampling, shading and addition of fertilizers.

PLANT SIZE AND ENVIRONMENT

Purpose:

To relate plant size to physical factors in the environment.

Materials:

1. Samples of a specific plant taken from different areas (e.g. dandelions growing in the schoolyard)
2. Soil samples taken along with each plant sample
3. Teaspoon
4. Drying oven (or ordinary range oven)
5. Soil testing equipment

Methods:

A. Field work
   1. Locate plant samples in areas that differ in conspicuous, measurable ways.
   2. Record the conditions such as: high or low ground (water drainage patterns), soil texture, water content, amount of humus, compactness, pH and other chemical determinations as feasible, shade (daily hours of full sun), nearness of buildings, trees and any other seemingly significant factors. (Directions for some determinations follow.)
   3. Using the teaspoon, very carefully dig each plant out of the soil, leaving as much of the delicate root system intact as possible. Place in a plastic bag and label.
   4. Measure the area from which the plant was taken, depth of roots, area of surface covered.
   5. Collect a sample of the soil from which roots were removed. Label.

B. The following measurements and tests may be done the next day in the laboratory or classroom, provided soils and plants have been sealed against moisture loss.
   1. Measure the plant
      a. Leaves - number, length and width of blade.
      b. Stem - length, diameter at ground level.
      c. Roots - wash dirt off, blot dry, cut from plant and weigh
   2. Soil moisture
      a. Weigh a clean can (small soup can or individual juice can)
      b. Add 50g or 100g of soil (about 1/3 full)
      c. Place samples in a drying oven or slow oven overnight or longer (105°C).
      d. Weigh can and soil again and subtract from original combined weight to obtain weight of water lost.

$$\% \text{ Soil moisture} = \frac{\text{wt. of water lost}}{\text{wt. of sample (50 or 100g)}} \times 100$$

   3. Humus determination
      a. Weigh 10g dried soil
      b. Place in small crucible and carefully heat on a triangle over a Bunsen burner until all the humus has been burned off.
      c. Reweigh the sample and subtract from 10g to determine weight of humus

$$\% \text{ humus} = \frac{\text{wt. of humus}}{10g} \times 100$$

4. Soil texture
   a. Place some dry soil in a tall glass or plastic cylinder (graduated if available).
   b. Add water, a little calgon to reduce surface tension and shake thoroughly and vigorously.
   c. Allow to settle overnight and measure the amounts of coarse sand, fine sand, silt and clay (in order from bottom up). Humus will probably float and can be disregarded. Find percent sand, silt and clay: $\frac{\text{ml. depth of specific layer}}{\text{ml. of entire sample}} \times 100$
5. Soil ph and soil chemical tests can be done according to test equipment available.

C. Correlation of data

Compare by graphs, charts or other methods the relationship of leaf area and root mass to the determinations made of the environmental conditions. Do root mass and leaf area correspond equally to the factor of light? Soil moisture? What factors appear to stimulate root growth? What factors affect stem length? Is stem diameter affected in the same way as stem length in response to light?

Any seeming correlation of factors can be further tested by using more samples which are taken from areas as alike as possible except for one factor (e.g. beyond the reach of a sprinkler compared to well watered; under the shade of a fence or building compared to just beyond the shade).

Laboratory confirmations could be designed which would even more carefully control the conditions of potted samples of the chosen plant.

CHAPTER 4

FIELD STUDIES - ANIMALS

Investigations in Animal Behavior, Especially Mammals and Birds

~~Investigation of Invertebrate Activity~~

Protective Coloration

An Observation of Bird Mortality as a Result of Man-made Structures

Deer Yard Study

Construction of a Mechanical Camera Trap

Preserving Tracks

Analysis of Owl Pellets

INVESTIGATIONS IN ECOLOGICAL - ENVIRONMENTAL SCIENCE FOR THE SECONDARY TEACHER

I. Animal Behavior

Observe and record animal behavior for five minutes or more daily for one week, two, six or whatever is practical. Ants, flies, crickets, or other animals are generally not too difficult to find on or near schools. Indoors, aquariums, vivariums and caged animals may be used. Some observations you may wish to record are:

A. travel patterns
B. behavior toward other animals
C. color changes
D. behavior changes
E. effect of the animal in its environment or vice versa.

Charts and/or graphs can be devised to record observations of this kind for long periods of study. What conclusions can be reached as a result of this study?

II. Animal Behavior

Designate an area of suitable size. Design a map of the area, indicating major vegetational types and construct grid lines on the map. Individual students can be assigned a portion of the area in which he will walk the grid lines to observe and investigate bird life and behavior. If bird songs are known, they can be used to indicate a bird even if it is not seen. Students should proceed in their designated routes, walking slowly. If a bird is observed in or crossing their area, a mark on the map should indicate where the bird was first observed and in which direction it moved. Record any behavioral patterns exhibited such as:

A. Manner of flying - darting, undulating, soaring, flapping, alternate flap and glide, etc.
B. Special actions - tail wagging, darting from perch and quickly returning, hovering, descending tree trunk head first, mating, fighting, gathering nesting materials, etc.
C. Feeding - type of food being consumed, apparent method of eating, e.g. probing, packing, crushing, tearing, etc.
D. Communication - calls, songs, drumming, crowing, etc.
E. Habitat - (if observed) swamp, marsh, woods, meadow, lawn.

In the classroom the observations and recordings can be tabulated so that, in a period of several days, the bird population of the area can be estimated. The exercise can be extended by attempting to identify the bird species by sight and/or by sound. In any event, a few pairs of binoculars and identification books should be available. This investigation may work better if the class is divided into teams rather then working individually. Teams could go outdoors to investigate their plot independently during different time blocks and thus give better coverage of a specific area.

III. Animal Signs

This investigation is basically designed to allow students to explore, discover, and record. In the process, some conclusions should be reached. Even in a "sterile" school site, there are often many invertebrate animals whose signs are in evidence. Worm castings sometimes number twenty per square foot, yet they are either unobserved or ignored. Map the school site and construct grids on the map. Individually or by team, have students investigate assigned grid areas. Some parameters they may record:

A. Weather (be sure they know how this may affect the survey)
B. Signs - castings, nest, browse, droppings, tracks, burrows, seed cache, runways, feathers, fur, etc.
C. Density of signs - 10 worm castings/sq. yard, 1 nest/grid area, 3 unidentified droppings/grid area, etc.
D. Type of area - grass, flowerbed, fence row, etc.

IV. Bird Nest Research

Very few birds utilize a nest more than one season. Therefore, in the fall the nests may be collected for investigative study. With imagination, this study can lead to many avenues. Nests can be collected in the school site, on field trips or brought from the student's home area. Some approaches for study would include:

A. Weigh the nest
B. Measure outside diameter, inside diameter and outside and inside height.
C. Make a hypothesis as to what kind of bird built the nest, based on the sizes, location, etc.
D. Carefully disassemble the nest, identifying all the different materials. If identification is not possible, at least [illegible]ber the different materials.
E. With hand lens and/or microscope examine some of the nest materials for organisms, such as mites, lice, etc.

Other aspects of this investigation would be to identify the nest, using a taxonomic nest key. Often an old nest will "grow" if watered. Various seeds may be in the nesting material when the bird builds the nest. Wind, squirrels and insects may introduce new seeds into the mass. In any event, fungi will grow and decomposition of organic matter demonstrated.

PROTECTIVE COLORATION

Many animals survive because they look like something else. The walking-stick enhances its survival chances because it resembles a twig. The plumage of a woodcock blends with the dead leaves on the forest floor. A viceroy butterfly is avoided by birds because of its resemblance to the distasteful monarch. Many creatures are patterned and colored to escape notice. This protective coloration makes the organism more likely to survive. The following exercise provides students with the opportunity to learn how this function increases the likelihood of survival.

Materials:

Small discs of paper
Small containers such as baby food jars
Large containers such as quart jars
Freshly mowed lawn, (alternatives - black top driveway, stretch of sand, dirt road)
Measuring tape, stakes and string

Procedure:

The small discs of paper must be colored various hues to get a gradation of colors. If a lawn is utilized, the colors would range from yellow, yellow-green, green-yellow, green, green-blue, blue-green to blue. (For the alternative sites the hues would range from white to brown, or white through various tans and browns to black). A convenient way to produce the discs is to paint large sheets of white paper the desired hue on both sides and punch out the small discs with a paper punch. This can be done by the entire class prior to the laboratory period. Fifty discs of each hue are needed for each student or team. These discs (350, if seven hues are employed) are placed in the small containers.

At the study site, the lawn (or sandy stretch, driveway, etc.) is measured off into square areas of uniform size such as four square meters. The dimensions can be determined by the instructor. Each area is marked by pegging the corners with stakes and running strings between the stakes to establish the quadrat.

One small container of discs is scattered uniformly over a marked area. The students become the "predators" and the discs the "prey". The objective of each student or team is to retrieve as many discs from the marked area as possible in five minutes. The student or team places all discs regardless of hue into one of the large containers. Note: Since some of the discs will "escape" because of their protective coloration, new areas should be used for subsequent classes or periods.

At the completion of the five minute "hunt", each student or team sorts the discs by color and counts them. Then the discs can be placed in the small containers for later use. Each student or team then plots the results on a graph recording hues and number of discs found.

Discussion:

1. How do all the graphs of the class compare as to the

number of discs retrieved?

2. How do all the graphs compare with regard to the number of each hue retrieved?
3. What might account for the differences in the ease with which certain hues were found by the different teams?
4. Were discs of a particular hue more easily found than others?
5. Which hues tended to escape retrieval attention?
6. Might good color vision be a survival factor in a predator?
7. How does this experience relate to survival in nature?
8. How might protective coloration function in the evolution of a species? (Read Chapt. 17, pages 581-585 of BSCS Green Version Biology, 1st edition.)

AN OBSERVATION OF BIRD MORTALITY AS A RESULT OF MAN-MADE STRUCTURES

(Note): This activity might best be done either at night, or in the early morning hours. Various housecats, raccoons, skunks and other predators will discover this source of free food very quickly, with a resulting reduction in the length of time these birds are available for study. Parental consent should probably be obtained.

Visit a radio or television transmission tower, or a microwave relay tower, during the fall or spring periods when bird migration is at its peak in your area. Collect the birds that are dying as a result of colliding with the tower and its supporting structures, such as guy wires. These specimens may also be found around skyscrapers. Contact janitors or gardeners for information or help in collecting the dead birds.

Count all similar birds and discover whether there are more of some types than others. Students need not identify the species of birds that they find, but rather observe how many birds of different kinds they find. Identifying fall warblers usually requires an experienced ornithologist.

During the fall, the heavy migration periods usually coincide with the passage of cold fronts through a locality. During the spring migration, the migration usually peaks during the passage of warm fronts.

Discussion:

1. What inferences can be drawn from this observation?
2. Are these deaths a significant factor in the population size of the various species?
3. Why do more birds collide with obstacles when storm fronts move through?

DEER YARD STUDY

Purpose:
1. To show aspects of game management
2. To show plants not eaten by deer
3. To show the reduction of total range in winter compared to summer

Procedure:
1. Visit a deer yard in the fall, collect and identify different species of vegetation thought to be eaten by deer.
2. Determine how to separate rabbit browse from deer browse. (Rabbits cut twigs as if by a knife. Deer break them off as they have no upper incisors.)
3. Divide students into teams of two. Assign a specific bush or tree to each team. Count browsed twigs on specified tree or bush.
4. Visit area in February or March, bring your fall list of vegetation.
5. Collate data from all groups
   a. Check off species not eaten
   b. How high can food be reached?
   c. Does the snow hide any food?
   d. Develop a "preference" food list
   e. After determining what constitutes good deer browse have students collect browse. Measure time needed to obtain five pounds. (Four to five pounds of good browse is required per day for average adult deer to maintain their body weight.)
   f. Check browse consumption on a deer trail vs. off trail.

Conclusion:
1. What percent of food in the yard can be eaten?
2. Why are fawns part of the vulnerable winter herd along with the aged, injured and those with disease?
3. What game management practices can be utilized to reduce winter starvation?
   a. Hunting regulations
   b. Game surveys
   c. Timber harvest vs. artificial feeding
4. Compare your "food preference list" to previous research. (White-tailed Deer of Wisconsin, Dahlberg and Gettinger, Wisconsin Department of Natural Resources, 1956 or White-tailed Deer of Minnesota, Erickson et al, Minnesota Department of Natural Resources, 1961.)

Make sure students:
1. Know types of food preferred, good food and stuffing foods
2. Review quality and quanity of food needs for deer
3. Compare reproduction studies of well fed deer in relation to starved ones.
4. Relate the goals of good game management

Discussion: (Field or classroom)
1. Explain starvation as a natural control of population

2. Why are deer reluctant to leave their established trails in search of additional food?
3. What are the advantages and disadvantages a deer receives from yarding?
4. How is the age of a deer determine

It is suggested that you contact personnel from the Department of Natural Resources for assistance in location of deer yards, previous research studies, food preference lists, etc. A game manager may also be willing to accompany you on a trip.

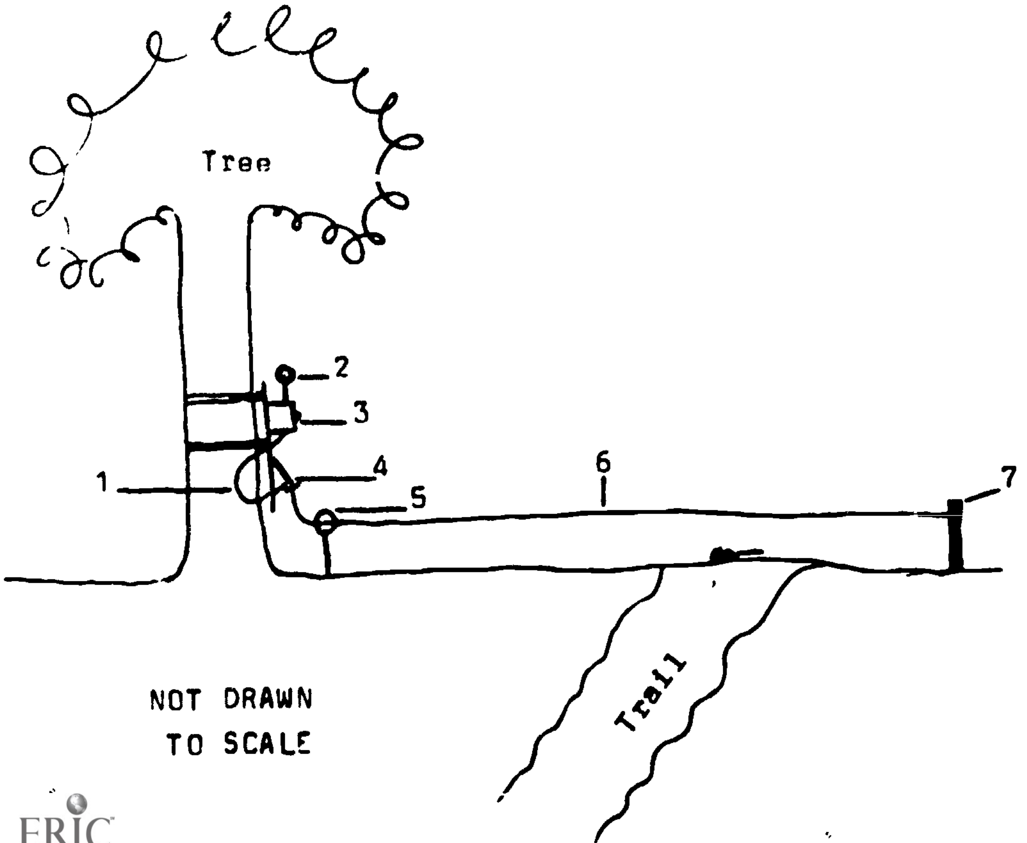
CONSTRUCTION OF A MECHANICAL CAMERA TRAP

Purpose:
To "automatically" photograph wildlife.

Introduction:
A mechanical camera-trap has several advantages over electrical ones. They are light weight, cheap and easy to build, and dampness does not influence them. There is a possibility that an animal will trip the trap at the wrong location. In order to encourage the animal to be in focus, branches may be placed along the trip wire so the path of least resistance will be taken.

The height of the trip wire depends upon the size of the animal: deer, 3-4 feet; small mammals (skunk size), 6-8 inches; rodents, 1-2 inches. The following drawing illustrates the method:

1. Cable release
2. Strobe or flash
3. Camera lashed securely to tree
4. Mechanical camera trap
5. Loop of wire around stick
6. Trip wire
7. End of trip wire tied to bush or stake in ground



NOT DRAWN
TO SCALE

CONSTRUCTION OF A MECHANICAL CAMERA TRAP (Cont'd.)

1. Obtain a small mousetrap.
2. Remove the bail-holder and discard.
3. Remove the straight wire that holds down the killing bar and mount it with its own staple in the opposite end of the base.
4. Make a "dog-leg" bend in the straight wire in order that this bend will hold up the killing bar.
5. Adjusting the "bend" can increase or decrease the sensitivity
6. Solder a flat piece of metal to the killing bar which will trigger the cable-release plunger.
7. Drill a hole in the base that will allow the cable-release plunger to pass through.
8. Attach "string" from the straight piece of wire to bait or across animal trail. See fig. 1.

Reference:

Kinne, Russ, The Complete Book of Nature Photography, A. S. Barnes and Company, Inc., 1962.

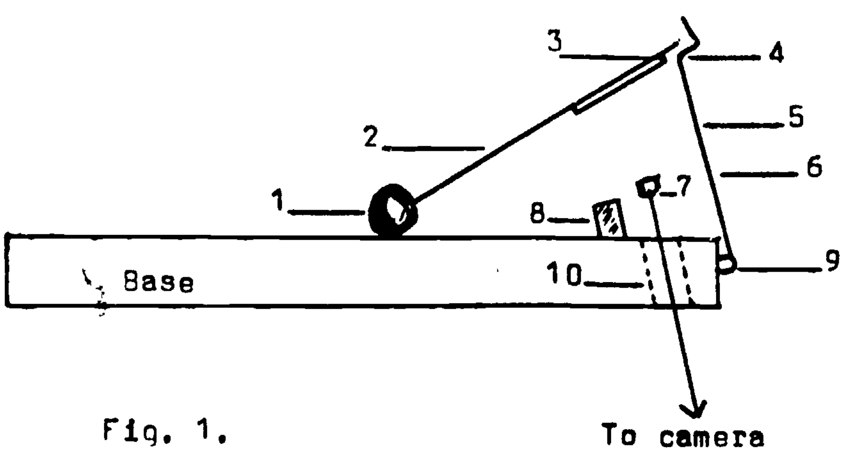


Fig. 1.

1. Spring
2. Killing bar
3. Soldered piece of metal
4. "dog-leg" bend
5. String attached and the end to stake in ground
6. Straight piece of wire
7. Cable release plunger
8. Wood block to prevent damage to shutter mechanism
9. Staple replaced
10. Hole for cable

PRESERVING TRACKS

Object:

To make a permanent record of animal tracks for study or for hobby

Materials:

1. plaster of Paris
2. tin can
3. strips of acetate or other flexible material
4. water
5. small paint brush
6. pieces of wire
7. vinegar

Method:

1. Carry plaster in a container that can be tightly stoppered. Loose plaster causes a problem.
2. Find suitable track in the mud.
3. Place strip of acetate around the track so that it forms a ring or collar.
4. Place plaster in the tin can and add water gradually. Practice will determine correct proportions. A thick paste sets at once. A thinner paste allows more time to work and will enter all crevices of the track as it should. (The addition of vinegar to the paste will delay hardening.)
5. Pour plaster into mold. Wait 10 or more minutes until the plaster is hard. (Or pick it up on the way back.)
6. Remove collar and gently pick up the cast. Brush off dirt and gently "wash" at a later time. It is also possible to cast several tracks or two sets of four to show the stride or jump. In order to give support to a large cast add pieces of wire while the plaster is still soft. If an impression of the track is desired (as seen in the mud) a casting of the original cast is feasible. Tracks in the snow offer a greater challenge. The following steps can be helpful:
   a. Spray the track surface with water from an atomizer to coat the track with ice.
   b. Add snow to the plaster of Paris to lower the temperature of paste so the track will not melt.
   c. Don't give up - TRY AGAIN!

ANALYSIS OF OWL PELLETS

Purpose:
To investigate the dietary pattern of owls by owl pellet analysis.

Introduction:
Discussions on animals often center around the type of food they eat. Animals are frequently classified as to their food-getting habits. Student investigations are often both impractical and wasteful because of the necessity of killing the animal. Owls, however, offer an opportunity for the study of feeding habits by the examination of regurgitated pellets. During the months of November through January most conifer stands in the eastern United States may harbor up to seven species of owls. This provides many opportunities to find and examine the pellets of a variety of species.

Procedure:
This investigation could be implemented by an entire class or with individual students searching for the pellets and bringing them to the classroom, or by one or two students undertaking an independent study.

Upon discovering pellets, the students should attempt to identify the birds utilizing the roosting site. Any of the modern field guides to birds will be helpful.

The pellets can be dissected with the following discoveries possible:

1. The kinds of prey determined by examining the skulls, bones, hair, feathers and exoskeletons found in the pellets.
2. The changes in diet that may occur when significant weather changes occur; such as heavy snowfalls or ice storms.
3. The changes in diet that may occur as the birds continue to occupy the same area for the duration of winter.
4. The changes in types of owls using the roost over a long period of time.

CHAPTER 5

FIELD STUDIES: SUCCESSION

Community Studies, Succession

Rock Succession

Succession in Your Backyard

Succession of Decomposers

COMMUNITY STUDIES, SUCCESSION

Introduction:

Succession is a continual process that can take place in any ecological niche. To appreciate this phenomena one can take students into urban, suburban and rural situations. The very presence of life, great or small can be observed and recorded within the specific environment. The following lab exercises are designed to give some assistance in studying succession.

A. Purpose:

To study succession in a community

Methods of studying succession in a community

1. Selecting an area. Suggestions: vacant lots, city parks, school grounds, window wells, railroad tracks and grades, planter boxes, footings around buildings of homes, open fields, forest preserves, marsh areas, bogs, rock outcrops, beaches, rain water, hay infusions, pond water, aquariums, terrariums, ditches, or any available place that contains living organisms.
2. Mapping the study area.
   This can be as simple or as complex as you wish it to be or can be omitted. Maps of planter boxes or vacant lots can be made. Maps are most useful over a period of years. (See unit on mapping.)
3. Sampling
   a. distribution of organisms, plant and animal-describe where they are in the community being studied.
   b. frequency of organisms, what are the relative numbers of the organisms that were found?
   c. classification of organisms, you don't have to be too specific, but it is important that the student be able to tell the difference between a rose and an onion.
   d. reproduction of organisms, Which organisms are reproducing themselves and will thus replace the non-reproducers?
   e. succession of organisms, why do some reproduce and others fail? Is this a static or a dynamic community? Why?
4. Physical factors of the ecosystem.
   (See Physical factors Chapter 2)

B. Purpose:

To illustrate succession in the classroom.

Materials:

1. Concave slides
2. Pond water
3. Microscope - compound
4. Cover slips
5. Data sheet
6. Illustration of common protozoa

Procedure:

Once a week, using a concave slide, make a wet slide of the pond and observe. Take samples from near the surface, the middle region and from the bottom and sides. Record the number of individuals found on each slide. Diagram and identify the organisms found as to multicellular or unicellular, green or other color, appendages, etc. Compare the numbers and types of organisms found with those found in similar samples taken at the end of 2 week periods. Note how the types of organisms change as the water stagnates. Comparisons can be made between water samples kept at different temperatures and light conditions to observe the effect of these physical factors on the succession of organisms.

EXERCISE II

STUDY OF A BOG LAKE

Purpose:

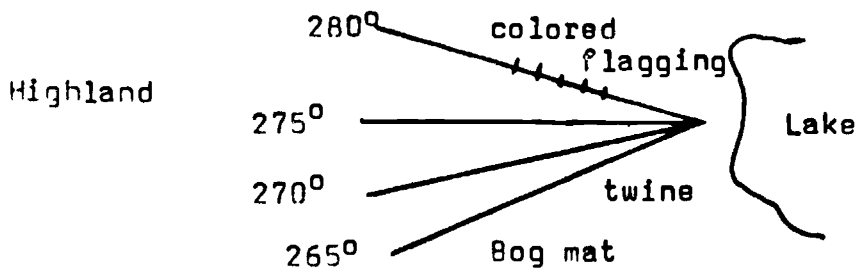
To show how a lake ages by studying vegetation distribution in a bog environment.

Materials:

1. Dissolved Oxygen Test Kit
2. pH paper
3. Collection vials
4. Baby food jars
5. Increment borer
6. Hand saw
7. Premeasured lengths of twine - 60 meters - used as a guide line to keep groups in proper work areas
8. Colored flagging
9. Clipboard

Procedure:

1. Each team will start at the designated starting point and stretch the piece of twine provided along their assigned compass bearing. (See illustration.)



2. After the twine is stretched into position, attach colored flagging at 3 meter intervals so that the vegetation along the line can be located.

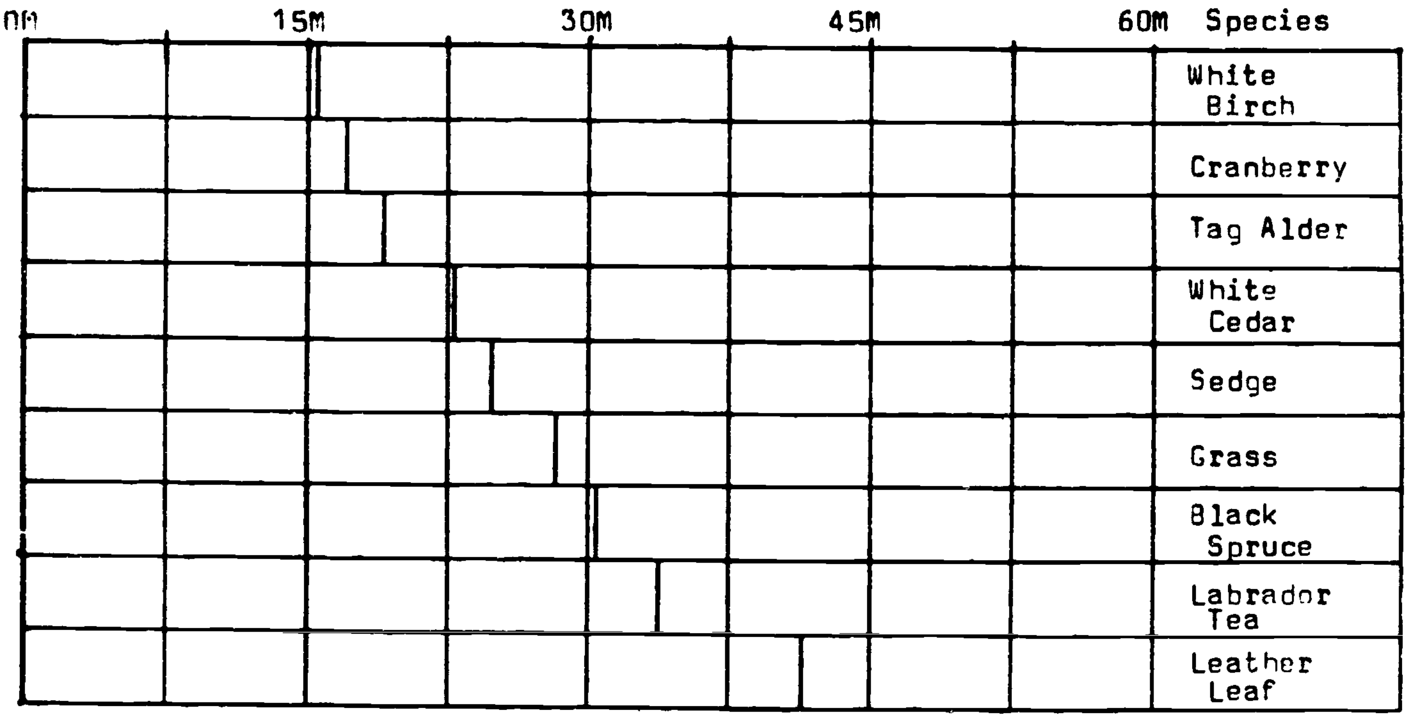
COMMUNITY STUDIES, SUCCESSION (Cont'd.)

3. After the flagging is attached to the twine, go back to the starting point. Work along the line, noting the types of vegetation and where they are found. Record your observations.

   (0 ~~feet~~ meters, grasses and sedges ---20 meters)
   (3 meters, labrador tea---------37 meters)

   Data may be reported as follows or in any way that you can devise to show the vegetative distribution.

DISTRIBUTION OF VEGETATION ALONG A 60 METER TRANSECT BOG LAKE



4. Suggested activities and questions to answer:
   a. Test the pH of the bog soil - is it acid or alkaline? Does this affect the types of plants found here?
   b. Search the soil for invertebrates - do you find any? Compare this with well drained soils.
   c. Measure dissolved oxygen content of the lake water. How does it compare to that of a fast flowing stream?
   d. Dig down into the bog mat 15-30 cm. and collect samples for pollen extraction. Procedure for this may be found in Pollen Study investigation in this manual. If you find pollen 15-30 cm. below the surface, what does this mean? If you can identify the type of pollen, what could you tell about the past history of the area?
   e. Collect some of the liquid from a pitcher plant and look for organisms that have died. Can you find any that appear to be living residents? How many different ecological relationships are present in this micro-

environment?

Possible activities that could be used in the study of a bog lake:

1. Sample peat layers at different levels and collect samples for pollen extraction.
2. Sample tree growth. Needed: increment bore to measure annual growth rate, Biltmore stick to measure diameter and height, saw to collect cross sections of slow growing trees.
3. Soil samples to test acidity and minerals present. Needed: pH paper, distilled water, simple soil test kit.
4. Search soil for invertebrates. Needed: cake pan or white enameled pan, hands.
5. Probe the mat with a pole to determine depth of the original "young" lake. Needed: pole.
6. Test dissolved oxygen content of lake water. Needed: test kit or follow procedure outlined in a test book. (See Ecology and Field Biology, Robert L. Smith, Page 629 for instructions on how to test for dissolved oxygen.)
7. Compare soil from bog with well-drained soil:
   a. living things
   b. water
   c. acidity
   d. porosity
   e. texture
   f. smell

   Needed: pH paper, water holding capacity apparatus (take soil and oven dry, then add water in measured amounts until the soil is saturated.)

ROCK SUCCESSION

Purpose:
To investigate the various stages of rock succession.

Materials:
An area containing rocks in various stages of succession.

Introduction:
Succession is the somewhat orderly change from those organisms which occupy bare rock to those which need a bit of soil, to those which need more soil. Pioneer communities, comprised of plants and animals, are the first to occupy sites where nothing has ever grown before. Initially no soil exists on primary sites. As soils develop, there is a gradual change from one community to another.

Procedure:

1. Identify the following stages of succession:
   a. bare rock
   b. rock colonized by lichens
   c. rock colonized by lichens and mosses
   d. depression in rock where soil has accumulated allowing plants to take root
   e. rock covered by a thin layer of soil with plant cover
   f. rock with deeper soil layer allowing woody or desert or prairie plants to become established

Discussion:

1. As succession proceeds, what can you say about:
   a. the complexity of the communities
   b. the species diversity
   c. the density of the species
2. As succession proceeds, are you able to visually determine if there is an increase or decrease in total mass of living organisms and organic matter accumulation.
3. How do you think this increase or decrease, in question 2 will affect the consumers (e.g. mice, rabbits, hawks)?

SUCCESSION IN YOUR BACKYARD

Purpose:
To observe the development of a community.

Materials: Equipment found at home was usually sufficient.

1. shovel and rake
2. thermometer
3. paint and scrap lumber
4. yardstick
5. carpenter's level
6. camera (suggested but not necessary)

Procedure: The experiment should be observed for a minimum of two months.

Locate a vacant lot in your neighborhood. A part of your backyard, with your parents permission, would be suitable. Select an area that is not watered artificially. Some of you may elect to use a small pond which will be satisfactory too. Your plot should be three to four feet square.

Strip your plot of all its vegetation. Remove all the weeds and grass. Use a spade to turn over the soil. If there are any rocks do not disturb. Do not disturb any tree roots. Place a log or old board in your plot and observe once a week by carefully turning over and then put back in its original position.

Begin your investigation with a detailed observation of the barren plot. What is the condition of the soil? Is there water nearby? Is the plot sheltered from wind or is it an open area? Are there trees and other plants nearby? Record all your observations.

Examine the plot at least once a week throughout the assignment. Look for changes. Are plants beginning to grow? What kind? Are there signs of erosion? Is there a growing population of insects? Are there other signs of animals? Does the changing weather bring about changes? Is there evidence that the plants help the animals? In what way do the animals help the plants? What changes do you observe beneath the log?

Record your weekly observations and include the temperature (mean) and precipitation. As the plot changes from week to week compare its appearance and condition with the nature of the plot at the beginning of the investigation.

The ecologist makes many measurements in his study of the environment. From his measurements he can determine much about the interaction between living things and the nonliving things around him. Strive for accuracy in measurements. Be a patient, careful worker.

Splash erosion---- The steady patter of rain causes soil to erode. Soil particles are sometimes splashed to a height of more than two feet.

You can make a splashboard from a piece of wood three and a half feet long, one inch thick, and four inches wide. Whittle a point on one end of the board. Paint the board white or some light color. Then mark lines across the board at one foot intervals starting from a point six inches from the pointed end.

By using two splashboards you can make an interesting comparison.

SUCCESSION IN YOUR BACKYARD (Cont'd.)

Install one board on a grassy plot and place the other board on your bare plot. Drive each board into the ground a depth of six inches. Be sure the top is an even three feet above the ground. After a rainfall observe each board. Look for particles of dirt splashed onto the boards. Which board indicates more splash erosion? How high has the rain splashed the soil particles? What do you conclude?

Knowing the extent of field slope is helpful to the conservationist. By measuring the slope he can decide whether a plot of land is suitable for trees, grass, or a farm crop. Slope is measured in per cent. The measurement expresses the number of units (inches for example) the land rises or falls in 100 units of horizontal distance.

All you need is a yardstick, carpenters level, and a straight stick fifty inches long. Place one end of the fifty inch stick at the peak of the slope. Let it extend horizontally. Use the level to make sure the stick is level. Then use the yardstick to measure the height of the extended end from the ground. Measure accurately and note the reading in inches. Multiply this reading by two and you will have the percent of slope.

Further studies conducted by some students are:

1. Finding the amount of moisture in the soil at various times
2. The soil sample is dried, sifted with a soil seive and percentages of organic matter, silt, sand, etc. calculated.
3. Find pH of their sample
4. Use a simple soil analysis kit and find amounts of potash, nitrates, etc.

When the project is completed have the student write up his observations and conclusions to hand in with his field notes. The use of pictures should be encouraged.

The degree of sophistication could be increased at the teacher's discretion. Some further activities:

1. The student could classify the plants and animals that return to the plot.
2. Devise an experiment to show phototropism on the plot.
3. Observe food web for the plot.
4. Comparison of organisms found between two different locations.
5. Determine composition of soil.

SUCCESSION OF DECOMPOSERS

Introduction:

In a natural situation wherein a plant or animal is being recycled into the systems from which it grew, a host of decomposers - organisms of decay, responsible for the physical and chemical breakdown into soil of the various components of once-living organisms - is involved. You have probably observed flies over dung or dead animals, or seen insect larvae, ants, and worms in rotten logs, but did you ever consider that each of these organisms occupies a specific niche - has a specific task - in the complete process of decay?

Purpose:

In the following investigation, we shall make careful observations of kinds and numbers of decomposers which visit or develop on a sample of animal material, and attempt to determine what each does and how it is important to the recycling process, our hypothesis of inquiry being that each decomposer does, indeed, have a specific occupation in the tearing down and recycling of dead organisms.

Materials:

Shallow metal pans, about 8" x 12", one per station
Fine sand, about 5 lbs.
Hardware cloth pieces, about 4" square - one per station
Animal material, either meat or "road-killed" animal
Four wooden stakes, about 1' in length - one per station

Procedure:

If possible, select and stake out several small, different outdoor areas for study, such as open field, shaded woodland, streamside, etc. as this variable can add to the effectiveness of the experiment. Prepare each station by sprinkling about ½" of sand into a shallow pan, laying the square of hardware cloth on the sand and placing the material for decomposition on the square. This square will enable you to life the sample to examine and collect decay organisms beneath it. Road-killed mammals and birds are excellent subjects for experimentation, and unfortunately, are easily collected in abundance. Meat scraps, usually obtainable rather inexpensively from food markets, are also useful.

Place the prepared trays on the ground, one per staked position, and arrange twigs, grass, or leaves around it such that small organisms will have easy access to the meat from the soil level(the tray may be set into the ground as well). Make daily observations of species and numbers of organisms visiting the flesh or of larvae developing on the flesh, graphing number and species of organisms at each station versus time in days after the initiation of your experiment.

Alternate procedure:

Fruit may be used for experimentation, but results are far less dramatic with such vegetable material than with animal flesh. A long-term investigation of a similar type can be conducted with a decaying log, using photographs and samples of populations from year to year.

Observations:

The graphs of species and numbers of organisms show very effectively the trends of decay of a particular organism. Species diversity indices may also be calculated for the various station locations. All variables should be carefully controlled, or, at least, taken into account in final analyses. What variables are possible in addition to location of station (1) ? How will these influence visiting species of organisms(2)?

Studying the Data:

Was there any period of time during which the number of organisms on the station showed a marked increase?(3) Why do you suppose this happened?(4) If you did notice such an increase, did it continue or did it drop sharply?(5) When did this happen?(6) How can you account for this?(7) Did you observe any succession of decomposers?(8)

Conclusions:

The location of experiment station will influence not only the species visiting the station, but also the number of individuals and the length of their visit, as certain organisms prefer the liquid fractions of an animal, while others, notably dermestid beetles and larvae, will appear after the material has dried out considerably. This variation among visitors and their preference for particular parts of a decaying organism presents a distinct succession of decomposers visiting each station.

To the Teacher:

In the course of this experiment, some elementary insect taxonomy will be involved. A good reference for this work is How To Know The Insects, H.E. Jaques, Wm. C. Brown Co. This investigation may be conducted by a class or by a few students; it must be emphasized that variation in substrate from station to station will cause considerable variation in decomposer succession.

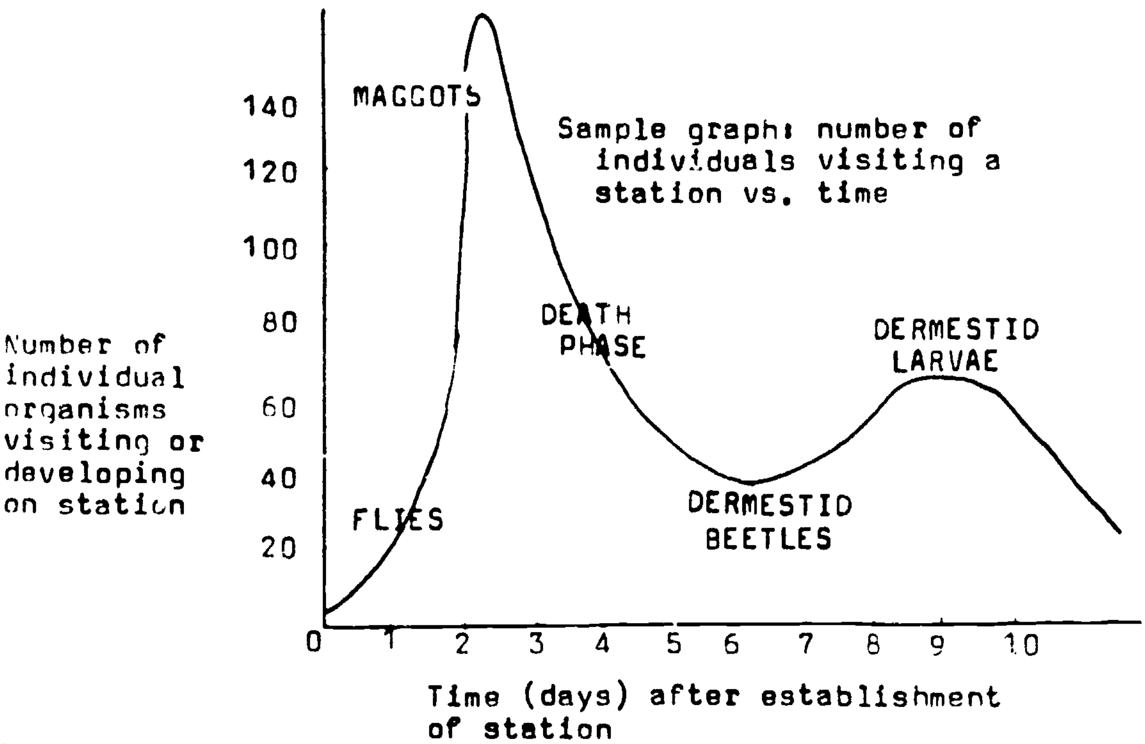
In addition to location of station, variables are type of substrate used, ambient temperature and humidity, and vegetation in the area, all affecting the length of time the substrate will remain moist and attractive to decomposing organisms.

Various species of flies (diptera) will appear immediately after the station has been established, and the subsequent population of maggots will generally be uncountable for the second or third day, until the edible mass has largely been consumed or has dried in the sun, at which time that population will drop sharply as many individuals pupate or perish.

SUCCESSION OF DECOMPOSERS (Cont'd.)

or perish. It is at this time that ground beetles (carabidae) and scarabs (scarabildae) and carrion (burying) beetles appear to reduce furthr the material left at the station. Dermestids appear only the drier portions of the flesh, hair, or feathers, showing marked rejection of moist animal materials. In the course of less than a week, 90% of the animal mass has been digested, evaporated, or carried away by organisms working to return it to the soil to recycle the materials into the pool of soil nutrients.

X. There is a noticeable succession - sequence in time and species of visitors - at the stations if the experiment is conducted at a time when insects are abundant, that is, in autumn or in spring.



CHAPTER 6

FIELD STUDIES: WATER ORGANISMS

A Sponge Condominium

An Artificial Habitat in an Aqueous Ecosystem

Measurement of Near-shore Currents

A SPONGE CONDOMINIUM

Purpose:

To discover types of organisms that live in the sponge.

Materials:

1. dissecting kit
2. jars
3. dissecting microscopes
4. rulers
5. live sponges-either marine or fresh water sponges

Procedures:

1. Slice off thin sections of sponge and examine for animal life.
2. Sort out animals and classify.
3. Record populations found in sponge.

Related Activities:

1. Compute per cent of total population of each group.
2. Make a food chain for a resident in the sponge.
3. Prepare a graph showing:
    a. frequency distribution of sponge population.
    b. weight distribution of the species.

Discussion:

1. What advantages are there to the animals inhabiting a sponge?
2. What if any benefits does the sponge derive from its inhabitants?
3. What if any harm do the inhabitants do to the sponge?
4. Can the inhabitants live without the sponge?

Reference: Source Book of Marine Sciences
Dept. of Education
Tallahassee, Florida

AN ARTIFICIAL HABITAT IN AN AQUEOUS ECOSYSTEM

Purpose:

To observe micro and macro flora and fauna. In the natural environment these forms are widely diffused. The artificial habitat offers a "home" whereby a concentration of organisms can be rather rapidly built up.

Materials:

1. 8 pieces of Scotchbrite 3M scouring pads
2. upholstery tacks
3. small boards, approximately 10" x 2" x 2"
4. nylon line
5. fish line, 20 lb. test
6. darning needle
7. weights (brick, stone, etc.)
8. gravel, sticks
9. hardware cloth
10. thermometer
11. record book
12. refractometer or other equipment to determine salinity (if along ocean)

Procedure:

1. Sew with fish line 2 of the 4"x6" scouring pads together, repeat, making 4 flaps, each measuring 6"x8".
2. Tack the four flaps onto the board at 1 inch intervals.

The habitat now resembles a book with the board as binding and the flaps as leaves.

3. Secure the weight to the top of the board.
4. Attach rope of desired length securely to the habitat.
5. Place in water.
6. The habitats can be used in fresh or salt water.

Other types of material for constructing the habitat could be explored such as old carpeting, screening material, filters from forced air furnaces, or air conditioner filters.

Another habitat that has been found useful is a cage 12" square of ½" hardware cloth. Put a piece of finer mesh on the bottom of the habitat. Fill the habitat with stones or sticks from the water and place in the water for two weeks.

At the time of observation, data should be recorded as to date, time, water temperature, air temperature, general population estimate, variety of organisms, water condition, salinity, and tides. For the student who has no access to a pond, river, estuary, and ocean, smaller models of the same basic structure could be constructed and placed in a class room aquaria.

When returning the habitats to the laboratory for study, place them in separate containers being careful not to wring or shake the habitats. If in a marine environment, check the tides.

AN ARTIFICIAL HABITAT IN AN AQUEOUS ECOSYSTEM (Cont'd.)

Observations, discussion, suggestions:

1. Are the same organisms found in fast moving and slow moving water? Are there similar numbers of organisms?
2. Are the same organisms found on different artificial habitats?
3. Which is more important, the speed of water movement or the nature of the artificial habitat as a determining factor for the organisms?
4. Are organisms found in polluted water the same as those in non-polluted water?
5. Devise an organism index of pollution. Interview local health authorities and limnologists on this and other subjects.
6. Are the organisms in the same location different at different seasons? Why?
7. Does depth have any influence on kinds of organisms? How?
8. Does clarity of the water influence organisms? How?
9. Does the composition of the bottom - stones, clay, sand, etc. influence the organisms? Explain.

The following books were found helpful.

Miner B. W., A Field Book of Seashore Life, Putnam, N.Y.
Stanbury, David, Living World Volume 1 and 2, Crowell-Collier
Amos, Wm., Life of the Seashore, Putnam, N.Y.
Amos, Wm., Life of the Pond, Putnam, N.Y.

MEASUREMENT OF NEAR-SHORE CURRENTS

Purpose:

To determine local current systems and their relation to land forms and living organisms.

Materials:

1. dye (fluorescent)
2. rubber balloons
3. ping pong balls
4. local coastal chart

Procedure:

Instructor should demonstrate the following and then assign pairs of students to ½ mile sections of coast line.

1. A cup of sand and a teaspoon of dye is wrapped in a paper towel, secured with a rubber band and tossed into the breaker zone. The direction of colored water can be traced from shore but preferably from a pier.
2. Observe rubber balloons filled with fresh water put beyond the surf zone where they float. In fresh water put in just enough air with the water so the balloons will float.
3. Ping pong balls may be substituted for balloons.

Related Activities:

1. Draw a map and insert the results of student groups.
2. Study seasonal changes and changes due to storms.
3. Study the influence of a long pier or jetty.
4. Interview fishermen and surfers.

Discussion:

1. Why not fill balloons with air?
2. Can you see any evidence of transport of sand by the currents?
3. Are any land forms - islands, hooks, bays, spits formed by currents?
4. What kinds of animals and plants inhabit these places? Contrast with the open water forms where the current is stronger. (Interviews with fishermen and surfers may suffice or if time permits, trips to different land forms, rocky and sandy beaches may be taken.)

Reference: Source Book of Marine Sciences
Dept. of Education
Tallahassee, Florida

CHAPTER 7

LABORATORY STUDIES

SUCCESSION ON HORSE MANURE

Introduction:

Succession of plants involves one of the fundamental concepts of ecology. Normally, succession involves a period of time so lengthy that the student is not able to complete the investigation during the academic year. The following activity allows the student to make his own observations.

Procedure:

1. Collect a "bucket" of horse manure. As a substitute for a horse, it would be possible to use rabbit, moose, deer, donkey or other herbivores.
2. Place the manure in a small aquarium or other suitable container such as a large culture dish.
3. Add enough water to the container so that the bottom is wet.
4. Do not place a cover over the container, keep the bottom damp, and record results.
5. A data table similar to the following one could be used.

Growth

Day	Date	Odor	Color	Height	Gen. Appearance	Other Characteristics
0						
1						
2						
3						
.						
.						

Questions:

1. Why do the changes in fungi take place?
2. Why doesn't the first type of fungus return after the second dies?
3. What has this to do with soil building processes?
4. Would the rotting of logs be similar?
5. If you planted radishes in fresh manure and in manure which had rotted for six months, which would grow better? Why?

EFFECTS OF GERMINATING SEEDS

Purpose:

To determine whether germinating seeds of 2 varieties of plants have an effect on each other - inhibitory, stimulatory, neutral - especially as it relates to successional changes.

Materials:

1. Seeds of at least 2 types of plants: mustard, beets, carrots, peas, radish, corn, sunflower, beans, etc.
2. Paper towels
3. Plastic bags or plastic wrap

Procedure: (Use Rag-doll Method, see page ____)

1. Place 40 seeds of variety A in a rag-doll
2. Place 40 seeds of variety B in a rag-doll
3. Place 20 seeds of each A and B in a rag-doll
4. Set all 3 rag-dolls aside at room temperature or 85°F for 48 to 72 hours
5. Determine the percent germination in both of the controls and the experimental setup

Variation:

In order to have the students learn for themselves the importance of controls, appropriate size of samples, length of time required for germination give general directions:

1. Use moist paper towels for a water source
2. Wrap in plastic to retain moisture

If this method is used, the experiment is then repeated using the knowledge gained from the first experiment related to size of sample, controls, time, etc.

NORMAL CURVE

Purpose:

This exercise points up the fact that the measurement of biological things i.e. ear length, potato weight, the diameter of corn cob, etc. will plot out as a normal bell curve. This can be later related to the students own performance. Secondarily, it has value in its use of small unit metric system and more importantly gives practical experience in developing a graph.

The exercise is straight forward and can be done either indoors or outdoors. For an outdoor laboratory, students should be instructed to go out into the lawn, field, forest, etc. and pick some organism and measure some part of it, that is, the lengths, widths, or weights of seeds, needles, wings, etc. or the number of seeds in a fruit, or height of a plant species in an area. Collect measurements from a sufficient number of organisms. These measurements should be tabulated and a distribution made showing the number of the measurements that are the same, that is, their frequency. The measurement values are then plotted on the horizontal axis and the frequencies on the vertical.

A more ambitious study of the normal curve which includes some aspects that would appeal to a more advanced or sophisticated group would be a combination study including the comparison of an animal's physical characteristics and its environment.

While digesting the data concerning the measurement of some characteristic the adaptation of that feature can be shown to relate to the animal's habitat or niche.

There are many possible species pairs that could be used but frogs and toads make for an interesting study. The catching and handling of live frogs insures lively activity.

The two species that are selected should be those that have distinctly different habitats e.g. Rana pipiens and Rana clamitans or R. clamitans and Hyla versicolor or R. Pipiens and Bufo americanus.

After a sufficient number of each are collected, then several parameters could be measured and graphed, e.g. lengths of toes, fingers, feet, forearms or typanium diameters or total body weight. Here a problem will arise since females are generally larger. If the animals are collected at any other time besides in the spring, the juvenile forms will distort the data. This could be all left unsaid and allow the students to discover it. <u>All animals should be treated kindly and released as soon as possible.</u>

One of the more obvious would be coloration and the protection it affords. The ease with which their coloration can be changed to suit the background would also make an interesting study. They could be placed in coffee type cans and the backgrounds could be changed, e.g. light green grass, brown bark, dark green moss or perhaps, one group might want to make a study of pure color effect; providing background of different color construction paper against the inside walls of the can. In addition, other characteristics which may be studied include suction cups on toes, the extent of webbing on hands and feet, toads carotid glands, or jumping speed and distance.

An interesting activity that could be added to this exercise during a class period preceding the collection of the frogs and toads would be the playing of "Voices in the Night", recorded by A. A. Allen, Dept. of Ornithology, Cornell University, Ithica, New York, selecting those frog calls that you would expect to hear in your area and giving students helpful suggestions for recognizing and remembering the sounds such as "finger on a comb", "long trill", "fingers on a balloon", "gulp", etc.

POLLEN STUDY

Purpose:

To illustrate that species of plants that were growing many thousands of years ago can be identified by their pollen grains and that an inference can be made regarding the succession of plants that have existed in a given area.

To help the students realize that pollen can be used to identify plants, they should spend some time previous to the sample collection viewing grains of pollen supplied by the teacher. These could be collected at any convenient time in the field or from a commercial florist and preserved in 10-15% acetic acid, alcohol or dilute F.A.A. solution. Refrigeration could be used for short term preservation.

Collect samples of bottom sediment from a lake or swamp. Only a handful would be sufficient for several classes. As another comparison, collections could be made at several depths.

Materials:

1. Distilled water
2. Potassium or sodium hydroxide pellets
3. Cheese cloth
4. Gentian violet solution
5. Heat sources

Procedure:

1. Place a small sample of sediment in a test tube half filled with distilled water.
2. Allow the sample to become saturated, then shake the mixture and filter it through cheese cloth into a second test tube.
3. Add a small pellet of the hydroxide and a few drops of Gentian violet to the contents of the second tube.
4. Boil the contents very carefully for a few minutes and set aside to cool.
5. Allow any sand to settle and decant.
6. Study samples of the material under the microscope using the high power objective. (The organic debris has more pollen than has the supernatant liquid.)
7. Observe, sketch and count the various types of pollen. Identify if possible.

Reference:

Curtis, J.T., Plant Ecology Work Book, Minneapolis Burgess Publishing Co., 1950

Smith, R.L., Ecology and Field Biology, Harper & Row, Publishers, Incorpor d, 1966.

COMMON HOUSEHOLD MICROORGANISMS

Purpose:

To demonstrate the presence of microorganisms in the household and the inhibitory effect of a fungus on bacteria.

Materials:

1. Petri dishes (sterile)
2. All purpose growth agar
3. Incubator or warm room or box (approximately 37°C. and dark)

Procedure:

Prepare the growth medium, sterilize, and pour into as many sterile Petri dishes as necessary for the class.

Demonstrate to the class the proper procedure for inoculating the growth plate. (See BSCS Green Version for procedure.) Give each student a petri dish which he takes home and inoculates himself. In order to limit excessive duplication, it is suggested that the teacher assign specific areas of the home to each student. Places that might be sampled to obtain cultures are: the crevices in the kitchen stove, the sides of the paper basket, the bathroom sink, the kitchen sink, the backs or arms of padded chairs where the head or hands commonly rest, and in the refrigerator in the meat tray. Other places could be sampled where contamination may be found or thought to be found.

They are brought back to school and incubated at 37°C or left at room temperature for a day or two until some observable colonies of microorganisms appear. There may be molds or bacteria growing on the plates.

Variety should play a role here. The molds that are grown can be transferred to a bacteria plate to see what effect, if any, that the mold has on the bacteria. Bread molds or fruit molds can be grown and the spores sprinkled on the bacteria to see what effect they may or may not have. Caution: since there is the possibility that some of the microorganisms may be pathogenic, observe results through the Petri dish.

Other ideas that could be brought in at this time are: the antibiotic qualities of the molds in connection with disease control, antiseptics to prevent infections, of cleanliness around the home to prevent disease, and of proper preservation of foods to retard spoilage.

GERMINATION OF SEEDS

Following are 16 conditions to be used in testing germination. Two students will complete one test. All tests will be made available to each group, so everyone will have results from all tests. The results will not be apparent for some periods of time -- not the same in all cases. In each test, controls will be necessary and in some cases more than one control will be needed. A discussion period of results should follow the completion of the germination.

1. Salt Concentrations:
Use various concentrations of salt (NaCl) to determine the effect on germination. NaCl from 0 to .5 normal, by 0.05 intervals.

2. Sugar Concentrations:
Use various concentrations of sugar to determine the effect on germination. Sugar from 0 to .5 normal, by 0.05 intervals.

3. Breaking dormancy of Black Locust seeds:
Locust seeds have a very hard seed coat which keeps out H_2O and O_2. To germinate, this seed coat must be broken. Suggestions might be to "score" the seed coat with a small file. Also, soak the seeds in solutions of sulphuric acid -- various concentrations. Try ½ hour in concentrated H_2SO_4. Wash thoroughly afterwards.

4. Beet and mustard seeds together:
This will show a form of chemical inhibition. Plant beets and mustard together, beets alone and mustard alone in the same medium. You might plant mustard or beets with other species, e.g. beans, carrots, radish, corn.

5. Seeds at various depths:
Use several species if you wish. Plant these at various depths in soil and compare results of germination: time, success, vigor.

6. Light regimes:
Use different light regimes to test germination. Suggested would be light intensity, duration, color, cycling light and dark, variations of these. Use your imagination.

7. Temperature regimes:
Use different temperature regimes to test germination. Use temperatures from 40°C to 5°C in 5°C intervals. (40°C, 35°C, 30°C, 25°C, 20°C, 15°C, 10°C, 5°C) Try cycling warm and cold.

8. Clay, sand, silt, stamp sand, coal, fly ash, sawdust:
Test germination with these or other soil materials. Use imagination. Compare any differences found in various materials.

9. Different soil horizons:
Take soil samples from several horizons of the soil profile. Find a road cut if it is difficult to dig a hole. Try to find

the soil in a relatively undisturbed area. Compare germination in various horizons.

10. Water regimes:
Compare germination in soil that has various amounts of water -- saturated soil, wet, moderate and dry.

11. Irradiation:
Test germination with various doses of radiation by X-rays or gamma rays. Possibly various species may be compared for resistance to injury. Dentists or physicians may be willing to help. Amounts of radiation sufficient to kill humans have little effect on seeds. At 10X human lethality, the effect begins to be shown.

12. Time:
Compare the time taken to germinate different species under the same conditions.

13. Chemical warfare in plants:
Make extracts of various plants that may alter germination. Test and compare some of the following with control: goldenrod, cherry, wintergreen, pussywillow, ragweed, red pine, bunchberry, starflower, juneberry or others. Grind 50 grams of fresh leaves with 250 ml. of water. Filter and wash with water to make 400 ml. of extract. Use this as the moistening agent for tests with pure water as control. Soil perlite or vermiculite may be used as the germination medium to hold the liquid.

14. Non-degradable detergents:
Test germination with non-degradable detergents in the moistening medium. Use various detergents and various concentrations, with soil. Use 0.5%, 5%, 10%, and 20% solutions.

15. Bio-degradable detergents:
Use these to compare with non-degradable detergents. Check with group #14 and have some tests done in same manner. Also compare the bio-degradable detergent in relation to time by planting seeds with application of detergent and plant some after detergent has had time to break down, about 1 week. Soil may be used as the germinating medium.

16. Soaps:
Do the same with soaps as with bio-degradable detergents.

ANIMAL INVESTIGATIONS

I. Road Kill Survey

This study lends itself to individual and/or small groups. Assign individuals (group) a specified road or street area. During the course of the study, every road-killed animal is to be recorded. The date should also be recorded. The time of year of the study will influence the species the numbers of animals thus killed. Tabulate results of all the studies. What species is recorded most often? What factors contribute to its higher death rate - numbers, migration pattern, immaturity? Students should correlate habitat with their recorded road-kills. An extension of this investigation could lead to an actual autopsy of several of the animals to try to determine what food the animal had recently eaten and whether it had internal parasites. Disposable rubber gloves should be used as a health precaution.

II. Preparation and Use of Animal Skulls

A further study may include the preparation of animal skulls (mammals in this case) by the students and a series of activities using the skulls already prepared. The method of preparation and possible activities are listed in the following paragraphs.

Mammal Skulls: An Ecological Approach

An interesting and valuable asset to the teaching and study of ecology and related areas of biology such as comparative anatomy or general zoology is a collection of animal skulls.

A collection of species of local mammals can be obtained from hunters, trappers, taxidermists, fur ranchers and local zoos. You may wish to ask students to bring in animals killed by automobiles as in many cases the head is undamaged.

Your collection can become a useful teaching tool as well as an interesting exhibit. The ideas listed below will aid you in beginning your work on this interesting phase of the biological sciences.

Procedure for preparing animal skulls:

1. Remove all of the outer skin and fur from the skull. Place it in a pot of "Rabbit Head Soup" composed of a solution of ½ cup sal soda (washing soda) for each gallon of water. For skulls that come from animals that have a large amount of fat, double the amount of sal soda. The quantity of "soup" needed will depend on the size of the skull being treated.

   Heat the solution and allow the skull to simmer for about two to three hours or until the flesh is quite tender. Check frequently to prevent over cooking as it weakens the skull fissures and the skull will fall apart. The skull has been cooked sufficiently when the flesh on the back of the head begins to fall off the bone.

2. Cool the skull gradually (to prevent teeth from cracking) by slowly adding cold water to the pot. When the skull is cool, remove it from the pot and scrape off the flesh with a paring knife.

   Remove the lower jaw by gently pulling it down and cutting the ligaments which connect it to the skull. Save any teeth that worked loose as they may be easily repaired by gluing after the final processes of preparation.

3. With the aid of a forceps, remove the brain through the hole in the back of the skull. This job will be easier if you run water into the skull, shake it, then pour out the water. After complete removal of the meat and other tissue, rinse the skull with plenty of clear water and allow it to dry.

   In place of steps 1,2 & 3, several alternate methods may be substituted. Actually, the use of insects (for C.) will be less work and give best results.

   a. Place skull in a can and fill with soil but leave open. Bury open can with the skull and mark location. Let the final consumers do the work. Dig up can and continue with step #4.
   b. Place skull on a red ant hill and let the ants strip it of flesh. Continue with step #4, if necessary.
   c. If dermestid beetles or scavanger beetles are available, place the skull in a colony and let them eat the flesh. Continue with step #4, if necessary.

4. A mixture of Magnesium Carbonate and Hydrogen Peroxide (30 volume) should be used for bleaching the skull. The mixture should be made into a thin paste and should be applied with a nylon bristle paint brush. Avoid using a brush with natural bristles as it will most likely be destroyed by the bleach.

   Apply a liberal amount of the paste to the skull and allow it to stand for at least 24 hours. Rinse the dried paste off the skull with water and allow the skull to dry.

   Replace any teeth that have fallen out and glue them with any good clear drying glue. Apply a thin bead of glue to the back of each tooth at the point where it contacts the jaw. This will prevent them from falling out and becoming lost when the skull is being used by students in the classroom.

5. Connect the top and bottom portion of the jaw by drilling small holes near the junction of the jaw bones. Insert a piece of copper wire through the holes in both pieces, bend the ends over and tighten with a needle nose pliers.

Many state conservation departments can furnish you with an identification key for animal skulls. Listed below are some of the more common mammals of North America, their food source, and their tooth formula as published by The Missouri Conservation Commission.

The tooth formula lists the number of each kind of teeth, front to rear, in the upper and lower jaws on one side. For example, one side of the upper jaw of the Opossum has 5 incisors, 1 canine, 3 premolars and four molars: (5-1-3-4). On one side of the lower jaw, 4 incisors, 1 canine, 3 premolars and 4 molars: (4-1-3-4). The total number of teeth is obtained by multiplying the number of both the upper and lower jaw by two and adding them together.

NAME	FOODS	TOOTH FORMULA
White tailed deer	twigs, leaves, nuts, fungi	$\frac{0-0-3-3}{3-1-3-3} = 32$
Beaver	tender tree bark, corn, aquatic plants	$\frac{1-0-1-3}{1-0-1-3} = 20$
Raccoon	fruit, grass, fish, clams, grain, nuts	$\frac{3-1-4-2}{3-1-4-2} = 40$
Opossum	insects, carrion, fruit, grain	$\frac{5-1-3-4}{4-1-3-4} = 50$
Striped skunk	insects, mice, fruit, leaves, grass	$\frac{3-1-3-1}{3-1-3-2} = 34$
Red fox	rabbits, mice, carrion	$\frac{3-1-4-2}{3-1-4-3} = 42$
Coyote	rabbits, mice, carrion, some plants	$\frac{3-1-4-2}{3-1-4-3} = 42$
Woodchuck	leaves, flowers, seeds, fruits, few insects	$\frac{1-0-2-3}{1-0-1-3} = 22$
Eastern grey squirrel	nuts, fruits, corn, bark, buds, seeds	$\frac{1-0-2-3}{1-0-1-3} = 22$
Eastern fox squirrel	nuts, fruits, corn, bark, buds, seeds	$\frac{1-0-1-3}{1-0-1-3} = 20$
Muskrat	aquatic plants, clover, corn grass, clams	$\frac{1-0-0-3}{1-0-0-3} = 16$
Cotton tail rabbit	grass weeds, clover, bark	$\frac{2-0-3-3}{1-0-2-3} = 28$

The following is a list of experiments and observations that may be carried on using the finished skulls in the classroom.

1. Preparation of skulls from heads brought in by students or obtained from other people. This should be done as a group project involving four to six students since some may not wish to do all phases of skull preparation. This procedure allows the students to see the general musculature (muscle systems) of the skull and may aid them in determining

the strength of the jaws and in turn help them to determine the food sources of the animal being studied. This is also a good project for your science club or ecology club.

2. Identification of different types of skulls using classification and identification keys.
3. Determine whether the skull is that of a herbivore, carnivore, or omnivore.
4. Determine the specific types of foods eaten by the animal by studying the jaw structure and the types and numbers of teeth.
5. Determine if there is any difference in the skulls of nocturnal and diurnal animals.
6. Study the various types of teeth and numbers of each type found in the skulls.
7. Make a comparative study of the skulls to determine type of habitat and niche.
8. Determine the apparent type of eyesight (keen or poor) from the size of the eye socket in the skull.
9. Study the teeth in an effort to determine the age of the particular animal.
10. Determine the cranial capacity by measuring the amount of fine sand which can be placed in the cranium.
11. Make measurements of the skulls to see if the brain capacity is related in any way to the overall size of the skull.

THE EFFECT OF DYE ON ALGAE

Purpose:

To determine the effect of dye from toilet or facial tissue on algae. Use one brand with several colors.

Materials:

1. algae culture
2. culture dishes - margarine tubs work well
3. graduated cylinders - 10 ml. and 100 ml.
4. jars - 4 liter and 1 liter sizes
5. microscope, slides and cover slips
6. pan - 1½ to 2 quart capacity
7. plant food
8. plastic wrap
9. teaspoon
10. tissue - colored, white (control)
11. medicine droppers

Procedure:

1. Prepare dye extract from each type of tissue by one of these methods:
   a. Short time: place 8 tissues in pan, cover with water, boil for ½ hour, pour off liquid, store in clean jar.
   b. Long time: put 3 liters of water into a jar, add enough tissue to fill jar, cover, allow to stand at room temperature for 3 weeks, remove tissue.
2. Prepare algae culture (stock)
   a. fill 4 liter jar with water
   b. add two teaspoons of plant food
   c. add algae such as chlorella
   d. cover jar with clear plastic wrap
   e. when there is sufficient growth to give a green color, culture is ready for use
3. Prepare nutrient solution: ½ teaspoon of plant food (Hyponex or other water soluble plant food) to one liter of water.
4. Fill culture dishes (margarine tubs) with various concentrations of dye extract. Suggested concentrations: 10% (10 ml. dye to 90 ml. of water), 30%, 50%, 70%, 100% and water only. Label tubs as to concentration.
5. Inoculate each tub with 5 ml. algae (stock) and 5 ml. of nutrient solution.
6. Cover tubs with clear plastic wrap.
7. Place tubs in sunlight.
8. Observe 2 or 3 times a week checking for growth.
9. After 2 weeks determine the number of cells/high power field of view using the following procedure:
   a. Thoroughly mix culture dish.
   b. Using a medicine dropper, place 2 drops of the culture on a clean slide.
   c. Place a clean cover slip over the culture on the slide.
   d. Place the slide on the stage of a microscope and focus under high power. Do not tilt stage.
   e. Using the same slide, count and record the number of organisms in 5 different high-power fields of view.

f. Calculate the average number of organism/field of view and record the density with the corresponding concentration.
g. Repeat the above procedure for each concentration.
h. If the field of view is too crowded for accurate counting, make a dilution of the culture. Refer to Coliform Bacteria as an Index of Sewage Pollution of Water in this manual for dilution method. Note: Hemocytometers may be used in counting to give more accurate results.

Variations:

1. Make counts of algae periodically during the 2 week period.
2. Determine the effect of the dye extract on other organisms: germination of seeds, grown plants, minnows, other aquatic organisms.
3. Compare brands of tissues.

VERTICAL MIGRATION STUDIES

Purpose:

To study the effect of varying intensities of light on the vertical migration of animals.

Materials:

1. 1000 ml. graduated cylinder
2. Black construction type paper
3. Light source attached to ring stand (goose neck desk lamp, etc.)
4. Live specimens of animals. Examples:
   a. Brine shrimp
   b. Daphnia
   c. Zooplankton
   d. Small fish

Procedure:

1. Wrap the cylinder in black paper. Make a cover of black paper. At each 100 ml. level on the cylinder cut a flap which can be open and shut.
2. Use a light source; attach to ringstand so it can be lowered and raised easily.
3. Fill the cylinder with water and add enough organisms so you can see action during the experiment.
4. Put the cover on to seal out all light.
5. Turn on the light and open the flap at various levels. Open a flap and turn on the light after adjusting it to shine directly into the opening. Expose to light for 10 minutes.
6. Look through the flap and see if there is a concentration of animals in the lighted area. Peek into other flaps briefly to find them if they are not in the light. Repeat at each level and make a record of observations. The investigations could be varied by varying the duration or intensity of light.

Discussion:

1. Is there a difference between different organisms?
2. If there is a difference:
   a. What is the advantage of this difference to each animal?
   b. How does this difference enable the animal to occupy its niche?

USING DROSOPHILIA TO STUDY ANIMAL BEHAVIOR

Purpose:

To study the behavior of an organism in an easy manner using a common, easily cultured laboratory animal.

Procedure:

Prepare a culture of fruit flies (Drosophilia) using standard techniques. Instant Drosophilia Medium, which may be purchased from Carolina Biological Supply, Burlington, North Carolina, is entirely suitable for this exercise. Place the dry medium in a container (a half pint milk bottle works fine) and add an equal volume of water. To this mixture, add a pinch of activated (Fleischman's if you wish) yeast. Flies may be added within a minute or two. If etherized and added too soon the flies will adhere to the "wet" media and increase mortality rate.

Place the male and female flies together in the container with a rubber stopper. Eggs will hatch into larvae in approximately one day. Larvae pupate within 5 to 7 days and the pupae hatch after about five more days. Prepare several tubes of adult flies.

BEHAVIOR

Each student is to be given a tube containing fruit flies. The exact size of the tube is not critical but should not be less than six inches.

The students are left on their own for about ten minutes to observe the flies. The first concern is usually the anatomy of the fly, later its activities. Later still notice that the fly is reacting both to light and gravity.

Many questions can be asked relating to behavior and the answers should be tested experimentally by the students. Some examples are as follows:

How do the flies know which way to go to get to the light?
Test by anesthetizing some flies and under a dissecting scope paint both eyes with a black lacquer. Painted and unpainted flies are put side by side and observed. (Some flies may have only one eye painted.)

Do flies learn to go to the light or are they born that way?
Let some flies hatch in complete darkness. Observe when first presented with light stimuli.

Do flies go toward the light in their natural environment, and if so, what good does it do to the flies?
Student will make several hypotheses concerning this, any or all of which may be correct.

Will flies go toward light of any color?
Have students set up lights of the same wattage and cover them with different colors of cellophane such as red, green and blue. Observe the fly's reaction to these stimuli.

Would flies walk faster toward a brighter light?
Mark the tube with a wax pencil at measured intervals,

and time the travel of the flies. Test different wattages of light at different distances from it.

What good does it do the flies to climb up, rather than down, and do they do this in their natural environment?

Again, students will make several hypotheses concerning this.

Do flies learn to climb up or are they born that way?

The same problem exists here as in the question about light.

If they are subjected to both influences at the same time, that is, if they are forced to "choose" between going up and going toward the light, which one will they choose?

Hold the tube near a light bulb, one end pointing at the bulb about six inches away. Slowly move the tube around the bulb to a vertical position, in such a way as to keep the light direction constant, but change the tube's inclination with respect to gravity. At which point do they become "confused" and make the "choice"?

Do flies react to temperature differences?

Set up a cage with a light bulb at one end. Do the flies "select" an optimum temperature?

Do flies react to humidity?

Set up a cage with a wet sponge at one end and anhydrous Calcium chloride at the other. Do the flies select an optimum humidity?

How do flies react to food odors?

A similar set up as that above can be used for this. Use bananas, apples, etc. Cut off the antennae of some flies. Does this make any difference?

Based on an experiment found in Laboratory and Field Studies in Biology: A Sourcebook for Secondary Schools, C. A. Lawson, Ed. Mimeographed, undated.

A CLASSROOM EPIDEMIC

Purpose:

To demonstrate the spread of germs in a community by direct contact with an infected person.

Materials:

1. Petri dishes (sterile)
2. gum drops
3. tomato juice agar (15ml/Petri dish of agar)
4. culture of Lactobacillus acidophilus
5. glass marking pencils
6. Q-tips (sterile)
7. incubator

Procedure:

Step 1 - Have every student wash his hands thoroughly.

Step 2 - Place each student's name on the blackboard, leaving two columns after each name. (Have the same chart put on paper.)

Example:

Name	Shake I	Shake II
John P.		
Albert S.		
etc.		

Step 3 - Give every student a small closed Petri dish with a gumdrop in it. One gumdrop should be innoculated with the Lactobacillus acidophilus.

Step 4 - Give every other student a regular Petri dish containing agar. Have them mark on the bottom of each dish, with a glass-marking pencil, a large Roman numeral I and their names.

Step 5 - Now give every student a regular Petri dish with agar. Half the class will have two. Each pupil marks these with his name and a Roman numeral II.

Step 6 - Have each student take his gumdrop and squeeze it between his hands and wipe his hands together so that they are thoroughly sticky.

Step 7 - Now let each student take a turn shaking hands with another. Write down each student's name and with whom he shakes hands.

Example:

Name	Shake I	Shake II
John P.	Jane L.	
Albert S.	Marcia H.	
Bill A.	Dick F.	

Step 8 - Let each student with a Petri dish marked I pick up a Q-tip, smear his hand, and then smear the agar of Petri dish I. Tell the students to smear lightly so that they don't break the agar. (Remember only half the class has these dishes.) Collect the Number I Petri dishes and put them in a box or wire basket. Turn them upside down, so that the bottoms will not drop out when they are picked up.

Step 9 - Repeat the handshake procedure. List them under Shake II.

Example:

Name	Shake I	Shake II
John P.	Jane L.	Bill A.
Albert S.	Marcia H.	Jane L.
Bill A.	Dick F.	Marcia H.
Jane L.	etc.	etc.

Step 10- Have each student smear his hand with a clean Q-tip and then smear the agar on Petri dish II.

Step 11- Collect the closed Petri dishes marked II and place them in the box with the other.

Step 12- Place the box of Petri dishes on a shelf or dark area that is room temperature or slightly warmer (70-80° F.).

Step 13- After approximately five days, you will notice colonies on some of the Petri dishes.

Step 14- Give each student a duplicated copy of the handshake chart.

Step 15- Give each student his own Petri dish or dishes.

Discussion:

1. What student had the "infected" gumdrop?

2. What percentage of the class came in contact with the infection?

3. How are infectious diseases spread from person to person?

4. Has modern society made it easier for the spread of disease? If so, how?

5. Do you think density dependent diseases should be a concern for the world today?

CHAPTER 8

HUMAN ECOLOGY, POLLUTION AND POPULATION

Human Ecology and Social Values

Social Implications and Public Opinion

Population Problems

Air Pollution: Measuring Solid Particles

Air Pollution: Effects on Certain Materials

Excessive Pollution by the Automobile

Collection of Windblown Particles

Coliform Bacteria as an Index of Sewage Pollution of Water

Decomposition Rate of Solid Waste (Biodegradibility)

Examination of Areas of Solid Waste Disposal in a Small Town

Litter Survey

Setting Up a Glass Recycling Station

What You Can Do About Pollution

HUMAN ECOLOGY AND SOCIAL VALUES

Introduction:

If we as teachers are not able to bring students to a realization of their own ecological roles and cannot convince them to judge their own lives by the ecological principles they have learned, then we have failed mankind and we have failed the whole earth. Some very basic concepts underly our existence and the existence of all other organisms.

1. The Earth contains a finite supply of matter organized into vulnerable combinations in precious proportions.
2. The entire structure of life is built upon the ability of the green plants to capture and store energy from the sun.
3. The Earth contains a finite amount of space which living things can occupy.
4. Survival of man may be made possible, for a time at least, by adaption of man to an almost completely manmade environment.
5. Since space on Earth is finite, then much other life must perish if man occupies the space. "Man cannot live by bread alone;" he has partners on this Earth. Should they perish?
6. Survival of man by technology alone may well result in the steady degradation and ultimate destruction of what we call the "Human Spirit".

Activity:

Opportunities and subject matter for activities having to do with value judgements in this context will present themselves at different times and in different ways to different teachers. This is one attempt:

A camping trip is an excellent opportunity which may be utilized in having students experience, in microcosm, some of the decisions which must be made by individuals and communities, from the simple to the complex, in the process of meeting basic human needs.

Indoor activities preceding the trip may include discussion of some of these points:

a. What are the basic human needs?
b. What definition will you use for basic?
c. Of the things considered to be needs by our society today:
    1. which are subsistence needs?
    2. which are artificial needs?
    3. which are actually psychological needs rather than physical ones?
    4. what effect does artificial stimulation of consumption as practiced by our society have upon our concept of needs? (Do students understand what artificial stimulation of consumption is? Can they cite examples?)
d. Can students place values on the needs listed in (c) in relation to the effect of each on:
    1. the individual?

2. society as a whole?
3. the resources of the earth?
4. the environment
   a. natural
   b. man-made?

Final answers to these questions will probably not be agreed upon, but the major goal here is to initiate thinking in these areas and to develop an awareness in the students as to what is actually happening around them.

Outdoor Exercise with Indoor Follow-up:

A small group tent-camping (preferably in a place that is a non-developed campground) may act as a small settlement, determining the ways in which their basic needs will be met. (Example: shelter, food, heat, waste disposal.)

Compare the decisions made in meeting the needs in this temporary settlement and their short and long-term effects with the ways that the same needs are met in a small permanent community and in a large city. (One way of doing this would be to construct charts, as below, for each type of settlement.)

NEED	HOW MET	SOURCE	EFFECTS ON ENVIRONMENT	
			Natural	Man-made
Shelter				
Food				
Heat				
Waste Disposal				
Water				
Others				

This activity may be continued in any direction suggested by the way that the charts are completed. The examples in Part II may take any other direction you wish or terminate a classroom experience, but hopefully will continue in the students' thinking and perception of their daily experiences.

Discussion Topics:

1. In a time of severe stress for basic human needs, would a highly industrialized and organized society such as that

in the U.S. be likely to survive or function better than a society in an "underdeveloped" country?

2. Is it better to "buy American" than to buy foreign made goods? Consider long range and short range aspects as well as influences on people in various places.
3. Approximately 6% of the people on Earth live in the U.S. They consume at least 40% of the basic resources used each year. Is this ecologically sound?
4. The population in the U.S. has doubled during the last 40 years and is on its way to doubling again. Energy consumption is doubling every six years. Is this ecologically sound?

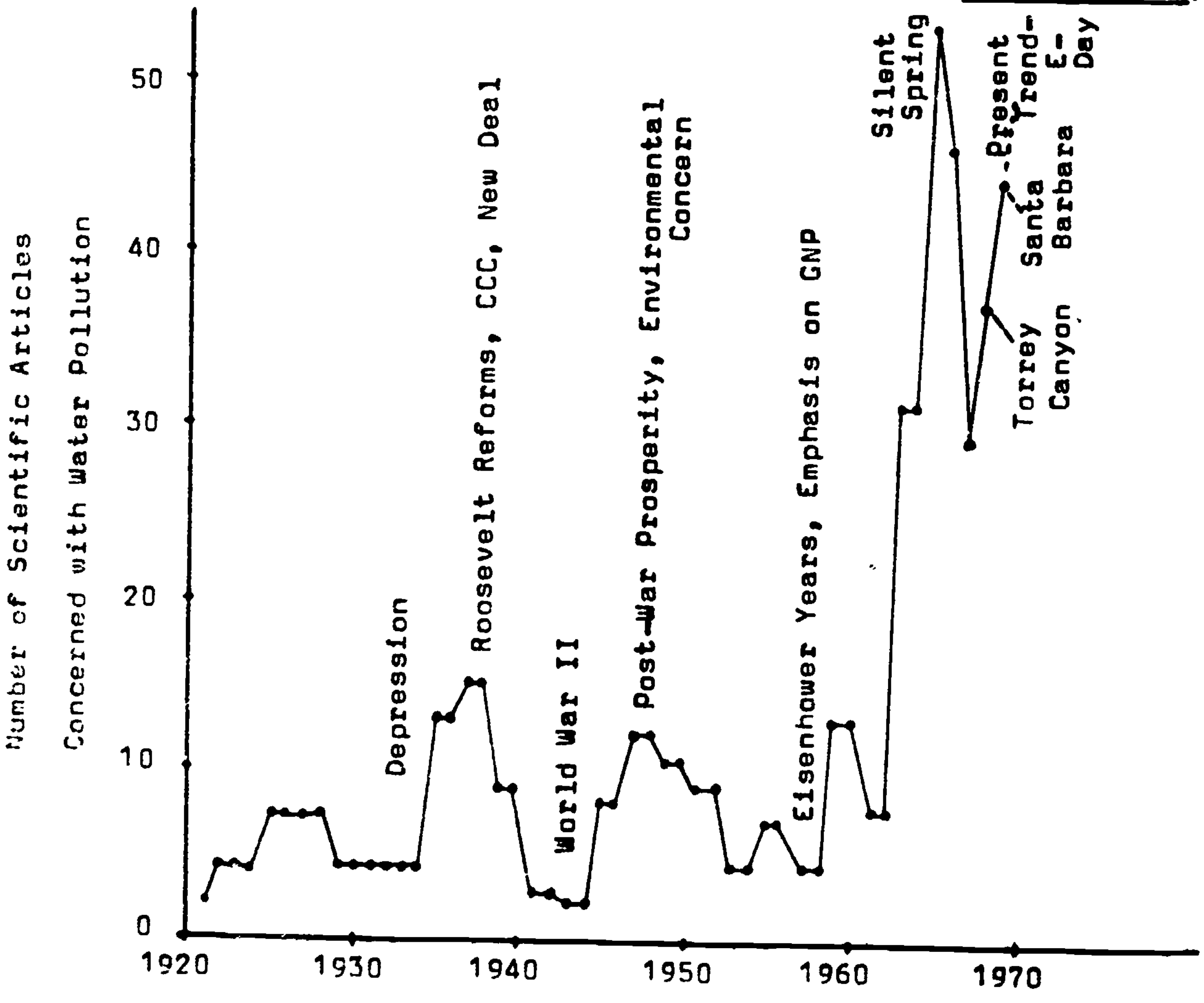
SOCIAL IMPLICATIONS

Introduction:

We are a society that concentrates on production and consumption. We regard pollution mainly as someone else's problem. At times, popular sentiment may be aroused by certain eco-happenings. If an assumption can be made that the number of periodical listings for a specific heading are related to public sentiment, then the listings can serve as an index of popular sentiment. See fig. 1.

Activity:

If the above assumption is reliable, then the number of scientific articles listed can be polled on the vertical axis while the year of listings can be plotted on the horizontal axis. With the graph completed, the fluxuations can be correlated with socialogical-economical-political-ecological aspects of our country and the world. An example of this would be less than five articles under the heading of "water pollution" during the depression and a high during the Johnson administration, emphasis on beautification, and Silent Spring.



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POPULATION PROBLEMS

Geometric Population Growth

The present doubling period of the world human population is about 37 years. The basic causes of environmental problems are the products of man, his technology, and his increasing population density.

Methods:

1. A paper cup with two small objects (corn or beans) in it can represent the earth and its infinite capacity.
2. Place ten paper cups in a row on the desk.
3. In the first cup, place two of the objects. In the second cup place twice as many as in the first. Continue with the remaining cups by doubling the number of objects which were placed in the preceding cup.
4. Observe the increase in the numbers of objects, and compare this to human population.

Suggestions for discussion:

1. Remind the students that the investigation represents a model of human population growth.
2. What are the limitations concerning the number of people the earth will support?
3. Are there areas of the world where human population densities are considered a serious problem? (Consider an individual's stress on the environment-- greater in America than in India?)
4. Is there an ideal population density for the earth?
5. What long-range problems will we face if we overpopulate the earth?
6. Does this geometric population increase apply to other species of organisms? (could this be shown as a demonstration e.g. Drosophila?)

Modifications or variations:

1. The students may consider the population growth occurring in his own city, county or state. For information, contact local governmental agencies or census bureau. (Consider doubling city population with stress on facilities.)
2. If a computer or calculator is available, a student may develop a tape showing a geometric increase using number 2 as a starting point.
3. What are the requirements for a city?

   Plan a city of ten thousand "from scratch". Consider the requirements for such a city. What are all the needs of the people of the city? Take into account housing, public buildings, industry, roads, recreation, waste problems, and the like. Consider what would happen if a new industry settled in your town and its population doubled?

AIR POLLUTION

Introduction:

Gases compose our atmosphere but many other materials may be interspersed in the air. Airborne solids take many sizes and shapes. The smallest particles defy gravity and remain suspended due to the bombardment by the molecules which comprise air. The largest particles gradually settle to the ground due to the pull of gravity. Larger particles range in size upward from 44 microns (1000 microns = 1 mm.). Dust particles range upward and downward in size from about 1.5 microns. The materials found in the air will vary according to the nature of the area.

Purpose:

To measure the amount of solid material deposited in different locations in and around the community.

Materials: Water-Antifreeze technique

1. 4 jars with an inside mouth diameter of 15 centimeters
2. Distilled water
3. Ethylene glycol antifreeze - any brand.
4. 20 mesh screen wire
5. Fine wire or heavy cord
6. Wash bottle
7. Hot plate
8. Asbestos pad
9. Stirring rod
10. Evaporating dish
11. Balances accurate to milligrams

Procedure: Water-Antifreeze technique

1. Set out 4 jars about ½ full of distilled water plus ethylene glycol antifreeze - 50-50 at each location where dustfall measurements are desired. Examples: street corner, top of school building, farm, indoors, top of hill, near an expressway, park. The antifreeze should not only prevent freezing but also prevent growth of organisms.
   a. Exposure should be in an open area.
   b. Jar should be 15 cm. or more from the ground to avoid wind contamination from the ground.
   c. The fine-mesh screen should be fastened securely over the mouth of the jars with cord or wire to keep out insects and large contaminants.
2. Leave jars exposed for 30 days.
   a. In summer the jar should be visited every 3 days, adding more solution when necessary. Do not let jar dry out.
   b. In winter use more antifreeze.
   c. Check solution level in jars after rains. Accurate results cannot be obtained if the jars overflow. Save any solution poured out because it will contain some particles.
   d. Record daily weather conditions for use in interpretations of results.

3. After 30 days bring the samples into the laboratory and evaporate most of the solution.
4. Wash down the sides and the bottom of the jar with distilled water.
5. Transfer the sample, a little at a time, to a weighed evaporating dish. Do not heat so hot that carbon particles (soot) are burned. Heat gently and slowly, under a hood, to avoid splattering. Vapors of ethylene glycol should not be inhaled.
6. When it is cool, weigh the sample and the dish to milligrams and subtract the weight of the dish from the combined weight of the dish and sample. Record jar location and weight of material.

Calculations:

1. Calculate the area of the open mouth of each jar. Area of a circle is (pi) (r^2).
2. Determine the dust fall in $mg/cm^2/30$ days. To determine mg per cm^2, divide mg of solid by area of jar opening in cm^2.
3. To convert $mg/cm^2/30$ days to tons/square mile/30 days, multiply by the factor 28.6 tons per square mile.

Materials: Slide-technique

1. Microscope slides, one per location selected
2. Tape, 1¼ wide
3. Petroleum jelly
4. Balance accurate to milligrams
5. Shoeboxes or similar containers to transport and protect apparatus
6. 1 clothes hanger

Procedure:

1. Pull clothes hanger into a long oval
2. Coat one side of a slide with petroleum jelly.
3. Weigh petroleum jelly coated slide to milligrams. Record weight.
4. Attach tape to parallel sides of the elongated coat hanger.
5. Place petroleum jelly coated slide on the sticky side of the tape--petroleum jelly up.
6. Put this into a container (such as a shoebox) to protect it until placed into its specific location. See water-technique for suggested sites.
7. Place slides in various locations for 2 weeks.
8. Again protect the slide by placing it into a container until it can be weighted.
9. Examine microscopically. Can any particles be identified?
10. Calculate the number of tons per square mile per 2 weeks of the particulate matter (increase of weight of slide) using these conversion factors:

    1 gram = 1.102×10^{-6} tons

    1 sq. inch = 2.490×10^{-10} sq. miles

    $\frac{\text{area of slide}}{\text{in sq. miles}} \times \frac{\text{amount of particulate}}{\text{matter on slide in tons}} \times$ tons/sq. mile/2 weeks

AIR POLLUTION (Cont'd.)

Studying the Data:

1. Which area showed the most solid airborne waste, which showed the least?
2. What factors can you suggest that might have caused this difference?
3. Determine the average solid airborne waste per location sampled.
4. Would you expect this average to vary at different times of the year? Why or why not?
5. Were the particles of matter from the immediate area or were they carried some distance? How do you know?
6. Are any particles macroscopic in size?
7. The results of these experiments might be kept each year and comparisons made of the results. Weather conditions and seasonal changes might be considered in these comparisons.

AIR POLLUTION

Purpose:

To determine the effect of air pollution on various materials.

Materials:

1. good quality nylon hose (15 denier)-do not use a no-run nylon
2. cardboard or stiff paper
3. scissors
4. stapler and staples
5. dyed fabric
6. natural rubber
7. lead weights
8. glass containers

Procedure:

1. Cut nylon into squares and place over a piece of cardboard or stiff paper.
2. Make sure the nylon is taut and staple corners.
3. Place one card in a closed glass container to serve as a control, and the others in appropriate locations.
4. Examine the cards weekly for broken threads.
5. Repeat steps 1 through 4 using dyed fabrics. Fabric should be kept out of the sun to prevent fading due to sunlight. Observe weekly looking for fading of the material.
6. Put strips of natural rubber under tension by suspending a lead weight from one end of the strip. Place one weighted strip in a closed glass container as a control. Place several weighted strips in various locations. Observe weekly noting any loss of elasticity, cracking or other degradation.

EXCESSIVE POLLUTION BY THE AUTOMOBILE

Introduction: It is known that exhaust gas from cars is made up of several pollutants, such as carbon monoxide, nitric oxide, nitrogen dioxide, and unburned hydrocarbons.

Car manufacturers are required to produce cars with exhaust devices that keep the pollution level within limits. California was the first state to require special anti-pollution devices on auto exhausts.

The 1970 federal standards call for an 80% reduction in hydrocarbons and 63.5% reduction in carbon monoxide compared with the 1964 levels.

The automobile is one of the sources of serious air pollution. We realize that an anti-pollution device on cars is only one way to the solution. Nevertheless, the more efficient use of cars, as to the number of passengers carried, could help to cut pollution.

Purpose: To determine the passenger car ratio at different locations and different time periods.

Materials: Pencil and paper for recording data.

Procedure: 1. Choose several locations for observing and recording the number of people in each passing car.

a. A busy corner in a city, a road leading to an industrial plant, and the entrance to the school parking lot are locations that could be used.

2. Record on the chart shown under data the number of cars observed in a 30 minute period carrying 1, 2, 3, 4, 5, or 6 passengers.

3. Count cars Monday through Friday only.

Data: Date__________ Time__________ Place__________

1 passenger	2 pass.	3 pass.	4 pass.	5 pass.	6 pass. or more

Age of driver: old________ middle ________ young________

Studying the Data and Discussion:

1. At what time is the number of passengers per car greatest? At what time are they the least?

2. How do the different locations compare?

EXCESSIVE POLLUTION BY THE AUTOMOBILE (Cont'd.)

3. Does the day of the week affect the number of passengers per car?

4. Record any special events in your community that might affect the results.

5. What explanation can you give for the variance in number of passengers at different times of the day?

6. What excuses are used by individuals for not wanting to ride with others?

7. What advantages can you give for more riders per car? What disadvantages?

8. Do you notice any differences between teenagers and adults in car usage?

9. In your opinion has the number of passengers per car increased or decreased in the past few years?

10. What prediction would you make concerning the future number of passengers per car?

11. What methods would you suggest for the greater utilization of car space?

12. If this study is carried out at a school where parking is a problem, how would you initiate a plan for improving the situation?

COLLECTION OF WINDBLOWN PARTICLES

Introduction:

This experiment will enable you to find that there are solid particles of different sizes in the air being moved by the wind. Dust is released from grinding, drying, and other processes, and may cause ill health and nuisance problems.

Purpose:

To show that solid particles are air borne and how to measure the relative amounts, to determine differences in size of these particles and the major wind direction in the area during testing time.

Materials:

1. Adhesive paper 2 inches (or more) by 10 inches (Fassons Pli-A-Print R-135 may be used. Adhesive paper obtainable from Fasson Products Division of Avery Paper Co., 250 Chester Street, Painesville, Ohio.)
2. Glass jar (quart size).
3. A base to fasten (screw, nail) jar lid to.
4. Spray can of clear lacquer.
5. Bioscope or surface illuminated microscope.
6. Compass

Procedure:

Attach jar to lid and place in a flat and safe area. A flat school roof would be excellent. The base should be 2 feet by 2 feet for stability. Make sure the area is free from obstructions if at all possible. Put the strip of adhesive paper around the jar with sticky side out overlapping the ends so it will stick together and form a cylinder. One strip of masking tape perpendicular to the adhesive strip will make it stay in place better. Mark the north, south, east and west sides of the paper. Leave the adhesive paper exposed for seven days. At the end of seven days, spray the paper strip with clear lacquer. This will seal particles so that none will be lost or gained while studying paper. After allowing clear lacquer to dry overnight, remove from jar and observe in the laboratory to determine particle type, size and density. To determine density, use a standard scale. (Photographic standard for particles per square inch obtainable from Technical Associates for Industry, Inc., P. O. Box 116, Park Ridge, New Jersey 07656; cost about $5.00 per standard.) Observe under bioscope or illuminated microscope to determine the relative size and density of the particles from the different directions under the magnification.

Observation:

1. Did you accumulate particles on the sticky paper?
2. From what direction did you accumulate the largest number of particles?
3. With the exception of insects which are self-propelled, from which direction did the largest particles come?

COLLECTION OF WINDBLOWN PARTICLES (Cont'd.)

4. From which direction did the smallest particles come?
5. List the different colors of particles on the tape.
6. Is there a relationship between the color and size of particles?
7. Compare the abundance of particles from the different directions with the pictoral scale to determine the approximate number of particles per square inch.
8. From what direction did most of the insects on the tape arrive?
9. Check wind direction and speed recorded daily by the weather bureau. Is a correlation of particle abundance with wind direction and velocity possible?

Studying the data:

1. Do you think the air we breathe contains particles as abundant as the tested air?
2. Do you think that solid particles in air pose a hazard to health?
3. Do you think that some of the observed particles could be organic matter containing viruses or bacteria?

Teacher suggestion:

An alternate method would be to place microscope slides on each side of a square box and on the top. Put vaseline on these slides.

References:

Air Pollution Experiments for Junior and Senior High School Science Classes, Air Pollution Control Association, 4400 Fifth Avenue, Pittsburgh, Pennsylvania 15213, Price $1.00.

COLIFORM BACTERIA AS AN INDEX OF SEWAGE POLLUTION OF WATER

Introduction:

Coliform bacteria represent a group of organisms that live in the intestines and indicate presence of untreated sewage. If sewage is present in water the number of bacteria per milliliter is directly related to the amount of sewage pollution.

Purpose:

To determine the number of bacteria per milliliter in a sample of water suspected of sewage pollution.

I Presumptive test:

Materials:

1. Water sample (s)
2. Single strength lactose broth (13 grams lactose/1000 ml. distilled water)
3. Pipettes; 1 ml. and 10 ml. with bulbs
4. Test tubes; 13 x 100 mm. and 22 x 175 mm. or any similar combination
5. Nonabsorbent cotton

Procedure:

1. Prepare 2 single strength lactose broth tubes per sample
2. Put inverted smaller test tube into lactose broth
3. Plug larger tube with nonabsorbent cotton
4. Autoclave at 250°C, 15 lbs. for 15 minutes; be sure to have a very slow release of pressure--this will cause the smaller inverted tube to fill with broth
5. Inoculate one test tube with 1 ml. of the sample, the second tube with 0.1 ml. of the sample
6. Incubate for 24 to 48 hours at 37°C
7. Presence of gas in the inverted test tube is a positive presumptive coliform test
8. Length of bubble may be measured to compare relative amounts of gas production (usually works best after 24 hours)

II Confirmatory coliform test:

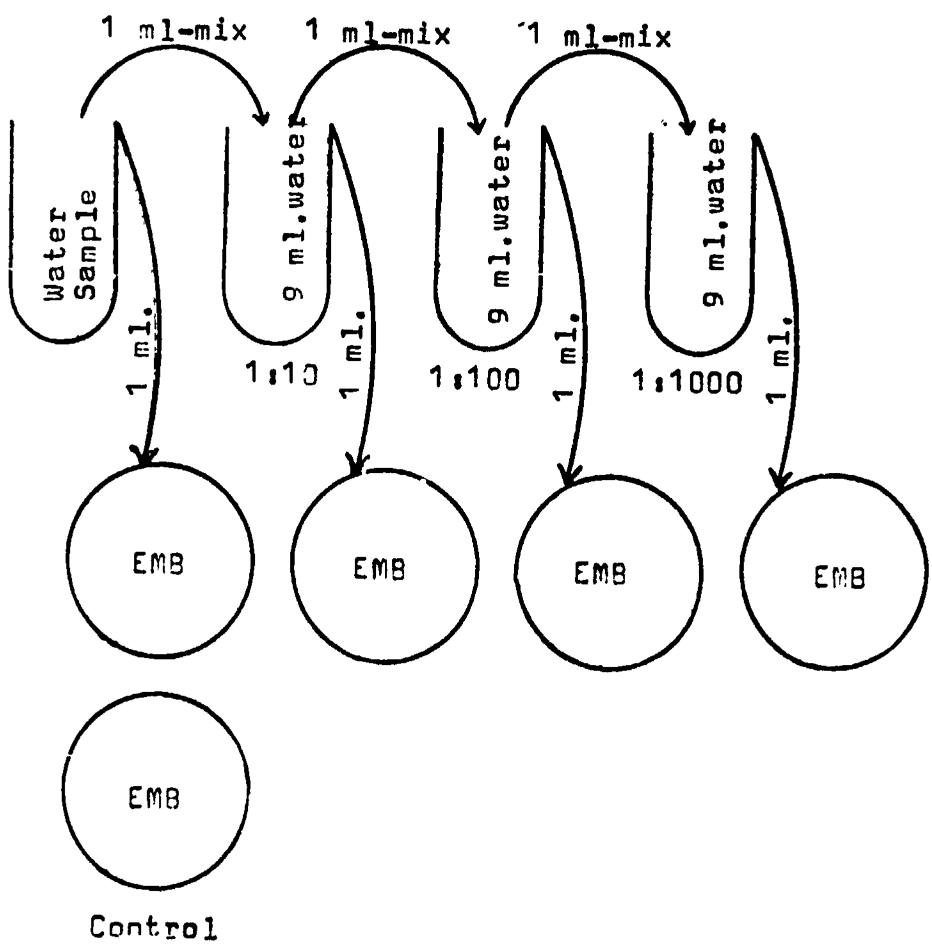
Materials:

1. Sample of water
2. Eosin-Methylene Blue Agar (selective media for coliform bacteria) 15 ml./Petri dish
3. Sterile water blanks (3)
4. Sterile Petri dishes (5)
5. Autoclave
6. Inoculation loops
7. Sponge and disinfectant (Lysol)
8. Sterile pipettes (3) If pipettes are not available, eye-droppers may be used if calibrated first
9. Thermometer
10. Incubator

COLIFORM BACTERIA (Cont'd.)

Procedure:

1. Each group of students should have three tubes of 9 ml. sterile distilled water (each tube should be plugged wih cotton) and five sterile Petri dishes.
2. Number the tubes 1,2,3, and the Petri dishes 1,2,3,4,5.
3. Swab the table with a sponge soaked in Lysol.
4. Shake the bottle containing the water sample and make serial dilutions of the sample as follows; 1:10, 1:100, 1:1000 (See flow chart)
5. Transfer 1 ml. of tube 1 to Petri dish #1 containing EMB agar.
6. Transfer 1 ml. of tube 2 to Petri dish #2 containing EMB agar.
7. Transfer 1 ml. of tube 3 to Petri dish #3 containing EMB agar.
8. Transfer 1 ml. of the water sample to Petri dish #4 containing EMB agar.
9. Invert the Petri dishes and incubate at 37°C for 48 hours.
10. Make a direct count of the number of colonies for each plate and multiply the number by the dilution factor to figure the number of bacteria per milliliter in the original sample.
11. If colonies exceed 300, more dilutions should be carried out to insure a more accurate count.



COLIFORM BACTERIA (Cont'd.)

COLIFORM BACTERIAL COUNT

Dilution	Colonies/plate	Bacteria/ml.
none		
1:10		
1:100		
1:1000		
Control		

Questions:

1. What is the dilution of the material in test tube 1?
2. How many more times dilute is the solution in tube 2 than in tube 1?
3. Which source has given the greatest number of colonies per plate? the least?
4. Would it be possible to get colonies if further dilutions were carried out to 1:1,000,000?
5. How many cells were transferred from each plate of the tubes?
6. If 10 bacteria per milliliter of water is considered the maximum number of bacteria that potable water can contain, what conclusions could you make about the water collected?
7. What are coliform bacteria and why are they used to decide on the potability of water?

Teacher Aids:

1. Refer to the BSCS Yellow Version; Second Edition Lab Guide for an explanation on microbiological techniques pp. 63-68.
2. EMB Media (class size of 28) Selective media for coliform bacteria

Peptone	10.0 gm.
Dipotassium phosphate	2.0 gm.
Agar	15.0 gm.
Distilled water	1,000 ml.

Mix and dissolve ingredients by heating. Make up any loss due to evaporation with distilled water. Dispense in amounts of 100 ml. into bottles of flasks and sterilize for 15 minutes at 121°C.

Before using melt the agar and add aseptically 100 ml. of:

a. Lactose, sterile 20%	5.0 ml.
b. Eosin Y, sterile 2% solution	2.0 ml.
c. Methyl blue, sterile .325 solution	2.0 ml.

Mix well, and pour into sterile Petri dishes. Allow the poured plates to harden and dry before transferring sample to plates.

or
EMB agar 37.5 gms.
Distilled water 1000 ml.

3. According to Standard Methods for the Examination of Water the maximum number of bacteria per milliliter is 10 per milliliter for potable water.

References:

Standard Methods for the Examination of Water, 10th ed., American Public Health Association, New York, New York 1955.

Biological Science, An Inquiry Into Life, (Lab Guide), Harcourt Brace and World, Inc., 1968.

DECOMPOSITION RATE OF SOLID WASTE
(Biodegradability of Solid Waste)

Introduction:

Man has been throwing away solid waste since the beginning of cultures but he can no longer afford to throw these wastes away.

Purpose:

To determine whether different solid waste materials decompose in varying lengths of time.

Materials:

Balance, rule, shovel. To check on different decomposition rates use a variety of substances. A sample list follows:

1. tinfoil
2. aluminum foil
3. cardboard waxed milk carton
4. plastic bottle
5. newspaper - one sheet and 20 sheets in a stack
6. napkin
7. saran wrap
8. waxed paper cup
9. styrofoam
10. facial tissue
11. flashlight battery
12. regular cardboard
13. glass bottle
14. nylon hose
15. plastic bag
16. steel vegetable can (misnamed tin can)

This list of materials may be modified, but you should try to have some soft and some hard materials.

Procedure:

You will be burying the above listed materials at a teacher designated spot. Weigh and measure the materials before burial and after digging up (if then possible). After weighing and measuring, place all substances 8 inches under good top soil. The area should be well marked because the materials are to remain buried 30 days or more. It should be well watered twice a week unless rainfall is sufficient. Bury a similar collection in a plastic garbage bag under both conditions.

When the material is dug up after 30 days or more, make all appropriate observations and measurements and record.

Studying the Data:

1. What materials lost the most weight?
2. Did any material gain weight? Why?
3. Did any material increase in thickness?
4. What materials remained unchanged?
5. What physical factors might have contributed to decomposition?
6. What biological factors might have contributed to decomposition?
7. Is this method of waste disposal preferable to burning?
8. What are some potential hazards to this type of disposal?
9. What will happen to the unchanged material in the future?
10. Should all solid wastes be buried? Explain.

Conclusions:

What are the waste materials that might be recycled?

DECOMPOSITION RATE OF SOLID WASTE (Cont'd.)

Suggest ways of reducing the volume of wasted materials in our society. What will be the consequences of continuing to discard an ever increasing amount of waste materials?

EXAMINATION OF AREAS OF SOLID WASTE DISPOSAL IN A SMALL TOWN

Introduction:

Solid waste tells a story about the culture of an area. Looking at this waste demonstrates that different material on earth decomposes at different rates. In the future these waste deposits may become valuable for their metals and minerals.

Purpose:

To find out how people spend their money. What do they throw away? What problems does the waste create? How long does it take different kinds of waste to break down into useable materials? Is there a need for recycling some materials: metal, glass, plastic?

Materials:

1. Notebook
2. Pencil
3. Meter stick
4. Geology hammer
5. Shovel
6. Box for collecting articles or samples of articles
7. Tin snips

Procedure:

1. This may be done by individuals, small groups, or an entire class. If done by the entire class, sample collection, data, and observation should be recorded immediately. If carried out by an individual or small group, samples of different aged materials should be collected for observation by the entire class.
2. Depending on methods of disposal, determine where oldest, middle age, and recent samples are dumped. The age of dumps can be determined by certain products popular at a given time, by old license plates, by certain kinds of packaging that might date an area or from city records if available and dumping was done systematically.
3. Start with the youngest area of the dump, using the geological hammer or shovel to get the materials.
4. Proceed to the middle aged area and repeat. Do the same for the oldest area.
5. Check for material downstream if near a stream.
6. Estimate to nearest 10% by volume the amount of different materials. (Example: 20% glass, 40% metal, 10% rubber, etc.)

Record all materials by name, kind of material, approximate time in dump, percentage of deterioration, number of each kind, size of each kind, whether buried or in open, amount of water in area (dry, damp, wet), whether oxygen can get to material, animals observed or evidence of animals, plants observed.

Do the same for each of the 3 age areas selected. If one or a small group does the study, bring small samples back to the laboratory. If material is very small, collect entire sample, but if large, use tin snips for getting a small sample. After returning to the laboratory, wash up and then:

1. Classify and divide material into four groups according to the amount of deterioration. Plot these on a bar graph according to:
   a. materials like new
   b. materials that can still be identified but that show partial deterioration or erosion
   c. material that can still be identified as organic or inorganic, but that is well deteriorated
   d. humus and particulate matter that cannot be identified
2. Prepare lists showing number and kind of materials which would stay in area and those that would float away if flooding occurred.

Studying of the data:

Interpretation of graphs and list:

1. In which area is there more waste per person? Why?
   a. Could burning allowed during part of these years account for differences?
   b. Could the cultural change in packaging make differences?
   c. Could a more affluent society buy more at one period than another?
   d. Could buying habits have changed?
   e. Are any waste products found in some layers and not in others; if so, what kinds are missing?
2. Do all materials break up at the same rate?
   a. Does the kind of metal used make a difference?
   b. Should industry be allowed to use materials that won't decompose?
   c. How does moisture affect deterioration?
   d. What effect does oxygen have on deterioration?
   e. Should we use a different method of waste disposal? Why?
3. Do all materials stay in the area?
   a. What materials leave the area?
   b. Will materials leaving the area cause harm to streams? How?
   c. Should fences be used to retain material?
   d. Should materials be crushed to prevent floating? Would this work for all materials?

Conclusions:

1. What conclusions can you draw concerning the deterioration of waste products?
2. Can you suggest uses of any of these waste products?
3. What alternate methods of disposal can you suggest?
4. What prediction can you make for the future if this method of waste disposal continues?

For further work:

1. Using the material found in the dumping area, see if you can

trace a change in the culture. An example of this would be discarding of useable material which indicates a period of affluency.

2. Take several samples and bury in the ground for varied periods of weeks, varied moisture. Dig up and check for deterioration from time to time throughout the year.

A second or third trip to the dump may be necessary to satisfy the responses to several of the above questions.

LITTER SURVEY

This activity gives a litter pick up campaign a scientific flavor. Instead of just collecting litter along the roadside or in a park, record the amount and type of litter found. This could be an annual project in which year to year comparisons could be made or it could be done in a shorter period of time (one month) to show the rate of littering.

Publicity of this activity by local newspaper, radio and T.V. makes for even more interest on the part of the students and informs the public of what your class is doing to combat the "throw away syndrome".

Summary Table for Class

Item	Non-Returnable				Returnable			
	glass	metal	paper	plastic	glass	metal	paper	plastic
Beer								
Soda								
Liquor								
Milk								
Other								

Note: Be safety minded. Warning signs should be used where the traffic is heavy.

Suggested Activities:

Calculate the amount of litter per mile; calculate what percentage of the litter collected was cans, bottles, etc. After the survey has been conducted several times over the same area, calculate the rate of littering. Homework-conduct an opinion an opinion poll on the project to see if interest has been aroused.

Data Table for Individual Teams

		Non-Returnable	Total	Returnable	Total
Glass	beer				
	soda				
	liquor				
	milk				
	other				
Metal	beer				
	soda				
	liquor				
	milk				
	other				
Paper	beer				
	soda				
	liquor				
	milk				
	other				
Plastic	beer				
	soda				
	liquor				
	milk				
	other				

SETTING UP A GLASS RECYCLING STATION

The problem of increased landfill use and indestructability of the glass container has given impetus to glass recycling programs by many organizations. Recycled glass can be used for glassphalt road material, road beds, bricks, building blocks, glass wool insulation, vitrified sewer pipe, reflector material, grit for chickens and glass containers. This recycled glass at present is bringing one cent per pound. The funds of which could be used for various projects.

The following are a few guidelines for setting up a glass recycling program in your school or community:

A. Literature:
   1. The Glass Container Manufactures Institute (GCMI), 300 Madison Avenue, New York, N. Y. 10017, has an extensive array of free literature about glass plants throughout the country which recycle glass. Send for a listing.
   2. Coca Cola Bottling Company also has literature. Contact the local Coke representative for information.
   3. Rodale's Environment Action Bulletin, 33 E. Minor St. Emmaus, Pa. 18049 is a weekly bulletin which has information. Price is $5.00 for six months.

B. Organization of the group involved:
   1. Try to work through the student council in the school. Organizations can be a committee, club, etc. of interested students and faculty members.
   2. Try to work through the school or a civic group to take advantage of liability insurance.

C. Mechanics for a station:
   1. Set up a station at a school, shopping center, gas station or a centrally located area with a large area of pavement.
   2. Have at least one adult at each of the stations. (Preferably a teacher.)
   3. Supply each person with gloves and goggles. Most labs have goggles and many stores will donate gloves for such a program. The vinyl coated work gloves tend to be the safest.
   4. Decide on a specific date which does not change for each month, e.g. second Saturday. Do not have rain dates, water is not a deterrent. Ice and snow may be hazardous however. In such an instance set a snow date.
   5. Set specific times for the program. 9 - 12:00 noon seems to be a good time because of shoppers on Saturdays.
   6. Inform the public to separate the glass into clear, brown and green glass, free of food and metal. Labels may remain. This is a relatively easy task.
   7. In conjunction with the above, flood the community with radio, television, newspapers, posters, flyers and other forms of communication. Many civic groups are very receptive to publicizing projects.

8. Depending on the plant to which the glass is being taken, storage and transport of the glass may be handled in a variety of ways:
   a. Clear glass (the greatest volume generally) can be loaded into a large dump truck (14 cu. yd.) by just tossing the glass in. Colored glass can be loaded into another truck.
   b. The glass may be loaded into barrels placed on a flatbed truck. The barrels should be arranged in a fashion to facilitate emptying all of one kind together. Glass can be broken into the barrels if space is needed, however, the barrels become extremely heavy.
   c. If more than one station is being used but only one or two trucks transport the glass to the recycling plant, the clear glass may go into the dump truck. Colored glass can be loaded into barrels at the same time. A flatbed with a lift can be used at the station to haul the colored glass in the barrels and shuttled along with the clear glass which could go into the dump truck. Any other arrangements of barrels or trucks can be made to accomodate any situation. The trucks can usually be obtained from a conservation-minded trucking firm for the day. If not, try to get a rented one. The rental obviously depletes the profits, however.
9. The trucks weight minus the weight of the truck and the glass is known as the tare weight and can be found by weighing the truck at a weigh station before and after loading.
10. Have an area set aside for bottles which have twist off lids and appoint a crew to work on the removal and storage of the lids. Save the lids for aluminum recycling.
11. Set aside an area for all the paper which will be left with the glass. Usually a scout troop or church will take paper for recycling. A small pickup truck is very useful.
12. Have a crew ready to police the area when the trucks leave.
13. Assign someone to check the station at night for bottles left after the time period.
14. Always have a first aid kit on hand.
15. Publicize the results.
16. <u>VERY IMPORTANT</u>: Do not forget to send a note of appreciation from the organization to those people in the community who helped with the program.

WHAT YOU CAN DO ABOUT POLLUTION

With the environmental problems we already face in the United States, you no longer have to be a coal miner to have sooty lungs. Surveys show that some metropolitan dwellers breathe in pollution that is equal to smoking two packs of cigarettes a day.

Some scientists warn that the combination of air and water pollution, along with increasing population, food needs and power requirements, is rapidly driving us toward major disasters.

Faced with such awesome problems, what can each of us or our families do about our ecology and pollution problems? Here are suggestions offered by environmental scientists:

AIR POLLUTION

1. Don't smoke. Why inhale additional poison and add to the two-pack-per-day pollution you already may be getting?
2. Keep your home furnace clean, adjusted properly and operating efficiently.
3. Keep your automobile tuned for efficient combustion. Have the following checked periodically and adjusted or replaced: carburetor, fuel pump gaskets, timing, blow-by valves, fuel tank, filler tank cap gasket, oil filter, spark plugs, cooling system and air-pollution control devices.
4. Operate your automobile properly. Avoid quick stops and starts: avoid idling the engine when stopping for a long time: avoid racing the engine.
5. Use public transportation, ride a bike or walk when possible.
6. Gasoline-powered tools, such as lawn mowers and snow blowers, should be kept adjusted and in top condition. Use a hand mower if you have a small lawn.
7. Do not burn paper, trash or garbage.
8. Do not burn leaves or garden cuttings. Put in containers for pickup by disposal service. If you wish to compost the organic matter, do it so that smells and mess are avoided.
9. Store garbage and rubbish in a covered, watertight receptacle. Keep covered at all times.
10. Make sure that your garbage is ready for regularly scheduled pickup. Do not allow accumulation by forgetting to put the containers at the curb.
11. Household dust collected by mops or vacuum bags should be disposed into a receptacle to avoid dispersion into the air.
12. Apartment dwellers should carefully obey incinerator regulations concerning types of refuse and operating procedure.
13. Open areas in your yard should be put into lawn or artificial cover to minimize dust blowing.
14. Keep your property clean, including sidewalks and curb areas.
15. Avoid outdoor spraying or spreading of chemicals such as insecticides, weedicides, lime or paint on windy days. Use pesticides only as a last resort.
16. When having an outdoor barbecue, prepare the fire properly to avoid excessive smoking. Do not burn paper dishes, cups and refuse in charcoal burner.
17. Properly care for pets to keep animals healthy and to

prevent spread of waste, hairs, etc.

18. Water and waste should not be allowed to accumulate and become stagnant.

19. Electric power is furnished in large part by burning coal or oil. Use less electricity and avoid wasting it - turn down your furnace thermostat when possible, and avoid unnecessary use of lights, air conditioning, TV, power appliances and equipment.

20. Avoid littering - especially don't dump fine debris such as shavings or dust into the open air. Put litter bags or containers in your car, den, meeting room, backyard, etc.

21. Carry out garbage on camp or hike trips for proper disposal if there is no acceptable way to dispose of it at the site.

WATER POLLUTION

1. Avoid wasting water: turn off faucet when through using water, don't flush toilet unnecessarily, fix leaks promptly.

2. Don't put heavy paper, clothes, rags, disposable diapers, grease and solvents into water disposal systems. These can disrupt disposal system.

3. Use white toilet tissue - dyes pollute water systems.

4. Don't fertilize your lawn excessively - runoff following rains pollutes our streams and water table.

5. Use dishwashers and automatic washing machines as sparingly as possible, preferably for full loads.

6. Use low phosphate detergents.

7. Don't use full amounts listed on detergent boxes in dishwasher and clothes washer.

8. Help eliminate cesspools and septic tanks by voicing support of regional sewage-disposal systems.

9. Don't use local lakes, creeks or rivers for dumping cans, old tires, trash or dead animals.

10. Participate in local drives to clean up polluted waterways and haul junk out of rivers and lakes.

GENERAL

1. Do not use long lived pesticides, such as DDT, Dieldrin, aldrin, endrin, heptachlor, chlordane and lindane - they kill wildlife and unbalance nature.

2. Plant trees and shrubs to attract birds, so less spraying of insecticides is needed.

3. Help with school programs to promote poster-making, literature distribution, assembly discussions and exhibits aimed at environment improvement.

4. Join a local antipollution group that will exert pressure on factory officials to avoid polluting the air and waterways, and on manufacturers to use reusable or recycable packaging.

5. Become familiar with local pollution ordinances and don't hesitate to report violations to local officials.

6. Share your information about pollution with your friends, family and co-workers.

7. Write to state and Federal officials and legislators about: (a) Enforcement of current pollution laws, and passage of new stronger laws and stricter fines. (b) Prohibition of dumping raw sewage, oil, herbicides and garbage in all bodies of water,

including the ocean.

8. Send copies to several officials who might be concerned and list all to whom it is sent. This often sparks more interest because each official wants to avoid being criticized by other officials. Write to a "middle" official with copies to superiors and subordinates.

9. Finally, have a permanent personal antipollution campaign. Remember, we are all contributors to the problem. That candy wrapper you drop on the sidewalk may be one of millions dropped that day if everyone else is as careless.

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CHAPTER 9

PERMANENT OUTDOOR FACILITIES DEVELOPMENT AND USE

USING THE OUTDOORS AS CLASSROOMS
To the teacher

Most states have outdoor center camps associated with State Park or Recreational Area facilities. They are well equipped to be used by school groups, even in excess of 100 students. Many schools have developed the concept of the outdoor school and will rent the facilities from the Department of Natural Resources and use them to educate the student in the wise use of our natural resources and to inspire respect for living things. These facilities are available for short week-end trips or are also available for extended periods. As an example, scout groups usually gear their period to a week-end. School groups will often develop a program to have the student at camp for one week.

The advantages of using these facilities is that it offers the student an excellent opportunity to get outdoors to see and study nature first hand. If the students are housed in cabins, you are assured of safe, reliable housing regardless of weather conditions. The cabins have electricity and heat and could be used for emergency instruction if the weather became too undesireable. A mess hall centrally located, solves the problem of where to eat. You must remember to provide your own food and cooks. The recreational halls are adaptable for lecturing by resource people or for showing movies during the evening.

The program can be as varied as you care to make it. Remember that you do not walk into a pre-arranged camp program, you develop your own. In some cases, an educational center may have a complete educational program for use by student and teacher. Your stay at camp should involve both instructional and recreational planning but must be well planned and coordinated to keep some activity scheduled for the whole day. There are many opportunities to develop leadership and team responsibilities at camp.

If you are interested in setting up such a program, you should have a committee to work out the various details. The areas of concern should include:

1. Making reservations and getting the necessary permits.
2. Arranging transporation to and from the area.
3. Financing the trip (cost of the camp facilities are approximately 50 cents per student per day.
4. Equipment, including what the group will need and what the individual student will need for the camp experience.
5. Food and menu.
6. Programs or schedule of activities for the stay at camp.

Information on specific areas can be obtained by sending for information from the various Departments of Natural Resources and State Public Instruction Offices.

A field trip is usually arranged to:

1. take advantage of some seasonal feature
2. observe a specific item, either plant or animal
3. illustrate in the field what has been studied in the classroom

USING THE OUTDOORS AS CLASSROOMS (Cont'd.)

What should be done after the field trip depends upon the type of trip involved. It is possible to review the trip bringing out important aspects and other interesting topics. If a camera was available on the trip, show the pictures. Get the reaction of the students to the trip. Their ideas can improve the quality of future trips.

Whether the trip is overnight or not, long or short, it can be agreed that there is excitement and motivation where nature is. This excitement and motivation can be long lasting as it may allow the student to discover the "fun" of learning or to start an interest in nature that will allow for constructive use of leisure time.

OUTDOOR EDUCATION AT A PERMANENT FACILITY

Selection of facilities:

The following considerations should serve as a guide in the selection of any camp facility.

1. educational objectives
2. cost per pupil
3. transportation factors
4. length of stay
5. age and physical abilities of students involved
6. physical facilities available (kitchen, dorms or cabins, fireplace, tent sites, etc.)
7. biological, historical and recreational opportunities available
8. restrictions or hazards of the area (i.e. poisonous plants, poisonous snakes, treacherous terrain, water, etc. should be surveyed)

Many school districts own their own permanent resident outdoor school facilities. Other schools rely on public, private and organizational camp facilities. Churches, Boy Scout, YMCA, etc. often have excellant facilities for school camping and are eager to rent or lease the property for the school year. It is imperative that those responsible for the outdoor experience check the facilities, for the success of the outcome depends a great deal on facilities. Some sleeping facilities are not winterized, thus limiting their use. Other camps may offer excellent eating and sleeping facilities but may lack the type of natural biological community which is necessary to fulfill the outdoor experience. For example, a YMCA camp may be mostly lawn or closely cut grass throughout the area. The site must meet the requirements of the objectives set forth by the teacher. If outdoor experiences are important, then choose a site which will encourage maximum outdoor use.

Pre-Planning

Teachers usually find it wise to plan the experience thoroughly with the students well in advance of the trip. The classroom is usually divided into groups of not more than eight per group. Allow students to feel partly responsible for the success of the experience. The program should be designed with student involvement and participation in the planning. Be careful not to make the program too academic or structured too rigidly. Provide for maximum activity and participation out of doors. In planning an alternate bad weather schedule should be prepared.

Some appropriate camp topics, activities and study areas:

soils	math in the forest
water	collections (non-living materials)
wildlife	food preparation
forestry	flag ceremonies
astronomy	art
gun safety	music - folk dancing
fire control	physical educ. (new activities that can't be done at school)
first aid	

- weather
- compass reading
- map making and reading
- creative writing
- creative dramatics
- leaf blueprints
- insect collections
- Indian lore
- nature crafts
- nature trails
- forest management
- stream studies
- land measurement
- early history of area
- geology

Resource personnel for assistance in your program may be available from the following sources:

- State Department of Natural Resources
- State Department of Agriculture
- local trapper
- commercial fisherman
- refuge manager
- lumberman
- cooperative extension agent
- U.S. Soil Conservation service
- U.S. Forest Service
- National Park Service

(Do not overlook local people in your community that have an interest and frequently excellent knowledge of various subjects, such as bird club members, rock hounds, homing pigeon enthusiast, etc.)

Review with students what the objectives of the trip are. Prepare a list of school equipment and personal equipment which will be taken. Plan activities that will not require the parents to purchase new equipment just for this school trip. The length of stay, time of year and facilities available will determine much of this. The sample list will indicate some items normally needed.

- sleeping bag or bed roll
- towels
- wash cloth
- soap in container or wax paper
- tooth paste & brush
- handkerchiefs
- change of clothing
- extra socks, underwear
- raincoat
- boots for wet weather & hiking
- pajamas (warm ones)
- pencil and notebook
- long-sleeved shirt or blouse
- jeans or slacks
- warm jacket
- comfortable shoes
- caps
- gloves

Students may bring the following articles if they are available:

- compass
- insect repellent (required in many areas)
- camera
- slippers for inside cabin
- flashlight
- autograph books
- binoculars
- needle and thread
- safety pins
- bathrobe

It is suggested that students do not bring the following articles:

- jewelry
- cards
- hatchets or guns
- toys of any sort

food, candy or gum
knives
money
transistor radio
phonograph
TV

Teachers may have to select counselors. Sometimes this responsibility is handled by the principal or outdoor education specialist for the school district. In some areas colleges of education require students to have a pre-supervised teaching experience and are eager to place education majors as camp counselors for school camping. Some school districts prefer to involve a maximum number of their own students and select high school students to help supervise elementary campers.

Sometimes it is adviseable, if not necessary, to meet with the parents after the school administration has given approval for the trip. It is important that parents know this is to be an educational experience and not a recreational camp. Some schools merely inform parents about the program by letter. The following sample letter may be of help:

Sample letter and permission slip for parents -

Dear Parents,

The __________ School District is continually trying to provide better learning experiences for your child. Much of today's curriculum was only at the planning stage a few years ago. The present concern for ecology and the environment and the future of man demands that we give greater emphasis on these areas in our school.

In keeping with this need the __________ School District is sponsoring overnight outdoor education field trips for classes from our school system. ______ grades will participate in the program this year. Length of stay may vary from one night-two days for as long as a week. The class will be supervised by their regular teacher and other supervisory staff. Staff members for this trip will be __________.

The purpose of this resident outdoor school experience will be to provide learning experiences in the following areas:

1. plant ecology
2. animal ecology
3. human ecology
4. local and regional history
5. geology and geography
6. conservation
7. outdoor recreation

This program in outdoor education will be conducted at __________. Meals and lodging will be provided in the resident facilities. The area around the camp lends itself exceedingly well to outdoor study. Most activities will be within a reasonable walking distance.

Camp personnel provide the food service although children may be responsible for serving seconds, returning dishes to the kitchen area, etc.

While at camp, students and teachers will live in dormitory (cabin) like quarters. Blankets and pillows are provided but each person will be required to bring his own linens.

Much of the cost of this program will be absorbed by the school district. However, because of transportation charges, insurance, substitute teachers, etc. there will be a charge of _____ for each participant. This is an important part of your child's educational experience this year and we encourage you to send your child. The trip is not a requirement for completion of his-her work, however in the event your child does not go he-she will report to school as usual for classroom instruction.

\- - - - detach & return lower portion - - - - - -

Before your child can participate it will be necessary for you to fill out the accompanying form and return it to school by ____________.

My son-daughter ____________ has my permission to accompany his class to a residential outdoor education camp during the time period ____________.

Special health problems or considerations which my child has are ______________. Medication which my child takes ____________.

It is my understanding that teachers and or camp staff will administer no medication.

The following weekly schedule is given only to show the possibilities for activities during the week. The subjects covered and/or time allotted for each may vary considerably. Teachers should constantly remind themselves that the schedule is not sacred. Time blocks for any activity may be extended to whatever is necessary or desired. Sometimes fewer activities for a longer period of time works exceedingly well. For some studies 45 minutes may be long enough. Student interest and enthusiasm should determine this.

In some cases the rest periods may be shortened or lengthened or eliminated altogether. As a general rule, students will be too keyed up to utilize rest periods properly, especially during the first day or two. Physically active daily schedules will usually reduce horseplay. Some free time may be given to students near the end of their stay after they have become adjusted to the new type of school. Various types of activities for free time should be discussed with the students before their arrival at camp.

Additional work and time on the part of the teacher is required to provide a quality outdoor education experience for their students. The rewards are received in watching the students enjoy themselves as they discover some of the fascinating wonders found in our great out of doors.

OUTDOOR SCHOOL WEEKLY SCHEDULE

MONDAY

9:00	Staff arrives
10:30	Students arrive
10:45	Teacher and counselor orientation: classroom; Staff Student orientation: dining room; Staff
11:30	Cabin, section, and counselor assignments
12:00	Lunch (sack lunch from home; milk will be furnished)
12:30	Ready cabins, make beds, put away personal belongings: counselors
1:30	General orientation hike: Staff and counselors
3:30	Outdoor recreation: teachers and counselors
5:00	Ready for dinner
5:30	Dinner
6:00	Rest period: counselors
7:00	Indoor recreation and snack: teachers and counsolors
8:00	Ready for bed
9:00	Lights out
9:30	Teachers' and counselors' meeting: dining room; Staff

TUESDAY

7:00	Wake-up
8:00	Breakfast
8:30	Housekeeping
9:30	Section 1 : Animal Life; Lanford Section 2 : Plant Ecology; Dudley Section 3 : Waterlife and Microscopy; Siebel
11:30	Ready for Lunch
12:00	Lunch

12:30 Rest period: counselors

1:30 Section 1: Plant Ecology; Dudley
Section 2: Waterlife and Microscopy; Siebel
Section 3: Animal Life; Lanford

3:30 Section discussions: Teachers and counselors

4:00 Outdoor recreation: Teachers. Counselors' study period.

5:00 Ready for dinner

5:30 Dinner

6:00 Rest period: counselors.

7:00 Indoor recreation and snack: Teachers and counselors

8:00 Ready for bed

9:00 Lights out. Counselors' study period.

WEDNESDAY

7:00 Wake-up

8:00 Breakfast

8:30 Housekeeping

9:30 Section 1: Waterlife and Microscopy; Siebel
Section 2: Animal Life; Lanford
Section 3: Plant Ecology; Dudley

11:30 Ready for Lunch

12:00 Lunch

12:30 Rest period: counselors

1:30 All Sections: Group Project 1; Staff

3:30 Section discussions: teachers and counselors

4:00 Outdoor recreation: Teachers. Counselors' study period.

5:00 Ready for dinner

5:30 Dinner

6:00 Rest period: counselors

7:00 Indoor recreation and snack: teachers and counselors

OUTDOOR EDUCATION AT A PERMANENT FACILITY (Cont'd.)

8:00 Ready for bed

9:00 Lights out. Counselors study period

THURSDAY

7:00 Wake-up

8:00 Breakfast

8:30 Housekeeping

9:30 All Sections: Group Project 2; Staff

11:30 Ready for lunch

12:00 Lunch

12:30 Rest period: counselors

1:30 All sections: Counselors' lesson; counselors

3:30 Section discussions: teachers and counselors

4:00 Outdoor recreation: Teachers. Counselors study period.

5:00 Ready for dinner

5:30 Dinner

6:00 Rest period: Counselors.

7:00 Indoor recreation and snack: teachers and counselors.

7:45 Counselors orientation for final clean-up: Staff member.

9:00 Ready for bed

10:00 Lights out. Counselors' study period.

FRIDAY

6:30 Wake-up - pack bags - clean cabins

8:00 Breakfast

8:30 Final clean-up: duties for each cabin will be posted in advance.

10:30 Student departure

11:00 Staff departure

MEASUREMENT OF FOREST INVENTORY PLOT

The purpose of this lesson is to acquaint students with the:
1. amount and value of timber in a given locality
2. some of the procedures used in forest management
3. costs of harvesting and marketing timber

Materials:
1. string or rope 52.7 feet long
2. diameter tapes and/or Biltmore sticks
3. volume tally sheets

(Items 2 & 3 are available from Forestry Suppliers, Jackson, Mississippi - Nasco, Fort Atkinson, Wisconsin - Wards Biological Supply, Rochester, N. Y.)

Area needed for the study :
Any area with trees over four inch diameter

As a demonstration, drive a stake in the general area you wish to sample and measure a circle with the radius of 52.7 feet. This will comprise 1/5 acre which is the standard size plot used in forest inventory. Students should work in pairs, first laying out a plot, one recording the data while the other is using the diameter tape or Biltmore stick measuring the diameter and number of 100 inch pulpwood sticks (must be at least four inches in diameter inside the bark on the smallest end) or the number of 16 foot logs (must be eight inches in diameter inside bark at the small end) if the tree is of large size. Upon completion of measurement of all trees within the plots tally sheets can be totaled. Multiplication of the number of acres by the appropriate fraction will give you an estimate of the amount of timber in a reasonably uniform stand. (The number of samples taken may be adjusted to the class size.)

Students should determine the local market value of the tree species involved before it is cut (stumpage), the cost of hauling the logs to market, and their value at the market site. With this information the students can compute the stumpage value (value of a standing tree) for the land owner and the value for the logger.

Discussion:

A. How should this land be managed?
   1. clear cutting
   2. no cutting at all
   3. removal of all dead, diseased or hollow trees only
   4. removal of some dead, diseased or hollow trees and some large sound trees
   5. removal of only large marketable trees
   6. use of pesticides

B. Give advantages and disadvantages of each for:
   1. man
   2. the forest
   3. the wildlife

   (consider both the short and long range aspects)

AN EXERCISE IN THE PROPER USE OF A COMPASS AND THE MAPPING OF A PERMANENT OUTDOOR FACILITY

Introduction:

Every school has outdoor facilities of some sort. For some, the facilities may include just the buildings and the surrounding playground area, while others are fortunate enough to have ponds, wooded areas, streams, and other natural features in addition to the buildings themselves.

In order to establish a base for future studies outdoor facilities should be accurately mapped. The two-part exercise which follows suggests ways in which this may be done.

Preliminary Work:

Obtain a copy of every existing may that shows the school grounds and whatever facilities you are going to include on your map. Here is a suggested list of sources for these maps.

principal's office	local surveyor
superintendent's office	realtors
water department	county register of deeds
street department	U.S. Geological Survey
planning board	U.S.D.A. vertical aerial photograph

It takes some time to get copies of maps from the various sources open to you, so plan to do this well in advance. They are of much value when you are doing the actual mapping of your area. Cooperation between teachers often helps. (e.g. mathematics and biology)

Part One: THE USE OF A MAGNETIC COMPASS

Materials:

graph paper, protractors, compasses, 10 stakes (to be used as markers in outdoor exercises)

Procedure:

1. The fundamental operation of a compass should be explained and demonstrated to the class. Many biology texts have no information on this subject, so you may find it helpful to "ditto off" a fact sheet for your students.
2. Classroom exercise: Here is one way to lead the student on a "desk" field trip during which he plots his movements.
   a. Fold a sheet of notebook-size paper into four equal parts and indicate the four compass points along the folds (Fig. 1)

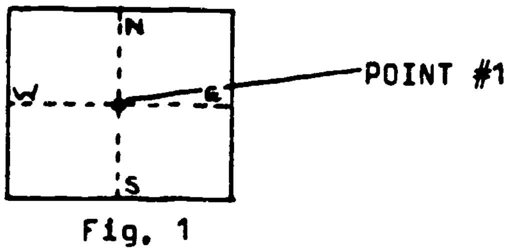

Fig. 1

AN EXERCISE IN THE PROPER USE OF A COMPASS AND THE MAPPING OF A PERMANENT OUTDOOR FACILITY (Cont'd.)

b. Begin the trip in the center of the page. (point #1.)
c. Direct the class to go 3 cm. due north and plot a point. (point #2.)
d. Then choose at random a direction and distance and have the students plot paths from #2 to #3, from #3 to #4, etc. with the use of a protractor. (e.g. "go 5 cm. 90 east to pt. #3")
Choose as many points as time will permit. Finally, have the students plot and determine the distance and direction from the last given point back to point #1. Check the accuracy of this last distance and direction with the "master plot" for this exercise.

Several such exercises may be placed on index cards for student practice. Include a variety of plot points as to number to fit the time available for practice.

3. Outdoor exercises with the compass: Use whatever area you have available, such as the football field, the parking lot or the sidewalk.
   a. Space 10 numbered stakes (1-10 on colored tape) at chosen positions in the area. Space them far enough apart to eliminate crowding as students attempt to determine the distance and bearing between them.
   b. Before leaving the classroom, divide the class into groups for as many compasses as are available; 2-3 persons per group is a good size for this activity.
   c. Each group should have a compass and a listing of numbers 1-10 or colors, in a mixed order beginning with #1 and ~~ending with #1.~~

e.g.	123456789,10,1	group a.
	235791468,10,2	group b.
	6,10,98517326	group c.

   (no two lists should be the same)
   d. Outdoors, the students begin at their assigned number and then go to the next number on the list. This tends to eliminate overcrowding at any one area.
   e. Each group must determine the bearing and distance to the next point. Distance may be measured in meters by pacing.
   f. This outdoor activity generally takes 30-40 minutes. Collect the data from each group at the end.
4. Follow-up inside:
   a. Using the technique as applied in 2a and b, assign a scale and have each group plot the points they obtained on a sheet of graph paper. It is very important that all student groups start at the same

point and have north in the same direction on their graph paper.

b. After all the points are plotted, collect the papers and place them in a pile. Place the master on top of the pile and drive a nail through the pile at each point. This will show the accuracy for each group. Students are generally anxious to try again after they see how they have done in relation to the rest of the class.

End of Part One: CONCLUSIONS: Once the techniques above are mastered, the compass can then be used to accurately map the school facilities.

Part Two: Suggested further work in mapping if desired by instructor.
MAPPING THE PERMANENT OUTDOOR FACILITIES

Materials:

every existing map which shows the facilities
vertical aerial photograph
manila folders
3 x 5 index cards
camera (for prints and slides)

Procedure:

Have the class form temporary committees to map the entire school grounds ...(approx. 1-2 months) or ... plan to map those areas which are of most importance to you now... In any event, here is a list of possible committees and some guidelines for each.

MAP DRAFTING COMMITTEE

goal - To make a large scale base map from which other types of maps can be made at a later date. This map should show as accurately as possible: boundaries, buildings, roads, walks, utility lines, fences and other permanent features such as rock outcroppings, hills, etc. Keep lettering to an absolute minimum in order to leave large blank areas for entering the data, keys and illustrations on the more specialized maps to be made from it.

A smaller scale base map should be made from it by reducing it to fit on 8½ x 11 paper.

MIMEOGRAPH COMMITTEE

goal - To cut a mimeograph stencil of the small scale base map so that it can be run off inexpensively as needed for work sheets

AN EXERCISE IN THE PROPER USE OF A COMPASS AND THE MAPPING OF A PERMANENT OUTDOOR FACILITY (Cont'd.)

MAP FILE COMMITTEE (optional)
goal - To make shallow shelves for storage of the large maps, flat.

RECORDS COMMITTEE
goal - To set up headings for 8½ x 11 manila folders in a file, including TOPOGRAPHY, MICRO-CLIMATES, SOIL, WATER, VEGETATION, WILDLIFE, HUMAN USE. Folders behind these can be set up as the need arises. Eventually, there should be a folder for each species of plant and animal investigated on the school grounds.

PHOTOGRAPHY COMMITTEE
goal - To take both black-and-white and color photos of the present condition of the use and misuse of the school grounds as a start to the actual survey.

LIBRARY COMMITTEE
goal - To compile references useful for identifying local plants and animals, for experiments with soil and water on the school grounds, for maintenance of the outdoor laboratory, etc. This should be set up as a 3 x 5 file by subjects. Get help from the librarian.

Help in building an outdoor reference library may be sought from local community organizations such as the PTA, the local garden club, and various sportsmen clubs.

Further information on mapping the school grounds can be found in The American Biology Teacher, Vol. 20, No. 6, October, 1958.

Further suggestions for the use of map and compass:

1. Self-guided field trip where in the items to be identified can only be found by following a map of compass bearings alone.
2. Combine and file for further study both vegetative maps and photos of the mapped area at different seasons of the year.

REFERENCES

There are two excellent bibliographies available, topically arranged and with brief descriptions covering all manner of ecologically useful references:

Conservation Education - A Selected Bibliography, compiled by Joan Carvajal and Martha E. Munzer for the Conservation Education Association. Order from: The Interstate Printers and Publishers, Inc., Danville, Illinois, $2.50.

Science for Society - A Bibliography, 2nd Ed. compiled by John A. Moore for the Commission on Science Education, American Association for the Advancement of Science. Order from: Science Education, 1515 Massachusetts Ave., N.W., Washington, D.C. 20005, $1.00.

A wealth of material has been published by various companies for the Biological Sciences Curriculum Study, listed at the front of any BSCS text.

A highly useful book containing all manner of techniques and teaching procedures for biology teachers:

A Sourcebook for the Biological Sciences, 2nd Ed. by Evelyn Morholt, Paul F. Brandwein and Alexander Joseph, Harcourt, Brace and World, Inc.

Environmental Education Programs are continually being developed by schools, state agencies and companies, some of which are:

A Curriculum Activities Guide to Water Pollution and Environmental Studies, Vol. 1 and 2. Institute for Environmental Education, Cleveland Heights, Ohio 44118.

Environmental Education Activities, Environmental Task Force, University of the State of New York, The State Education Department, Albany, N.Y. 12224.

Environmental Education Objectives and Field Studies, Paducah Public Schools, Paducah, Kentucky.

Educational Products Division, La Motte Chemical Products Company, Chestertown, Maryland 21620 has published five booklets:

- Amos, W.H., Investigating Water Problems
- Amos, W.H., Limnology
- Foth, H.D., A Study of Soil Sciences
- Renn, C.E., A Study of Water Quality
- Renn, C.E., Our Environmental Battles - Water Pollution

Environmental Science Center, 5400 Glenwood Ave., Golden Valley, Minn. 55422. Write for list of available curriculum materials at specific grade levels.

New programs emphasizing Environmental Education are continually being placed on the commercial market. Some publishers and their programs are:

References (Cont'd.)

Addison-Wesley Publishing Company, "The Environmental Studies Series", three 96-page booklets on air, water and noise pollution for middle grades.

Behavioral Research Laboratories, "Principles of Modern Biology", 9 book introduction to ecology/biology in a programmed, self-paced format.

Eduquip, Inc., "Pollution Study Program", set of experiments and laboratory equipment, free catalog.

Houghton Mifflin Company, "Man and the Environment", new ecology-based life science course utilizing games, role-playing, simulation.

McGraw-Hill Book Company, "Our World of Nature" series, catalog.

In most communities there are available to teachers resource people associated with these organizations:

State and Federal:
- U. S. Soil Conservation Service
- County Agricultural Agent
- State University Extension Service
- State Department of Natural Resources or Conservation Department
- State Health Department

Local:
- League of Women Voters (especially air and water pollution)
- Bussinesses, e.g.
  - Telephone Company
  - Power Company
  - Chemical Plants
  - Food Processers (creamery, cannery, etc.)

Local Authorities for:
- Sewage treatment
- Waste disposal
- Rodent control
- Mass transit