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ABSTRACT

Included are ideas, suggestions, and examples for selecting and designing conservation science projects. Over 70 possible conservation subject areas are presented with suggested projects. References are cited with each of these subject areas, and a separate list of annotated references is included. The references pertain to general subject materials, information on how to conduct an investigation or experiment, and information on how to organize an exhibit or demonstration. (PR)

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FOREWORD

The Soil Conservation Society of America, Washington, D. C. Chapter, has encouraged conservation projects at Science Fairs for many years. It has recognized outstanding projects at Area Fairs with certificates.

A series of conservation project suggestions was developed jointly by the Chapter and the American Society of Range Management, National Capital Section. These were published in "Project Ideas for Young Scientists" (Taylor, Knipling and Smith, 1960, 1962).[1/] Later, these same project suggestions were reprinted (with permission) together with some new project ideas, brief introductory material, and some suggested conservation references in "Conservation of Our Renewable Natural Resources--Suggestions for Science Fair Projects in Junior and Senior High Schools" (Agricultural Stabilization and Conservation Service, 1964).

Interest in conservation science fair projects has been continuous. The Chapter decided to update the second publication mentioned above. A committee was appointed and the present bulletin developed. This bulletin is entirely new except for some conservation project suggestions repeated without change from the 1964 publication. It includes some new project suggestions and revisions of some of those published in 1964.

Because of the widespread interest in Science Fairs, and the requests for assistance reaching the Washington, D. C. Chapter, it was decided to request the International Headquarters of the Soil Conservation Society of America, 7515 N. E. Ankeny Road, Ankeny, Iowa 50021, to print and make copies of the publication available for general distribution to other interested groups. Thus, a project of the Washington, D. C. Chapter, Soil Conservation Society of America, has become national in scope.

Soil Conservation Society
of America
April 1970

1/ Citations in parentheses are listed in "Selected References" in the back of this bulletin.

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CONSERVATION SCIENCE FAIR PROJECTS

by

Paul E. Lemmon,[2/] Theodore C. Green,[3/] and Merle S. Lowden[4/]

INTRODUCTION

So, you want to develop a conservation science fair project? Let's see if we can help you get started. You want ideas, suggestions, examples, and some selected sources of information that can be studied. You want to follow some orderly pattern in planning your project and in carrying it out. You want to know how to present your project at the fair.

This brief publication is intended to help you in the following ways:

(1) To select the general scientific field of work and the specific subject matter within that scientific field toward which you will concentrate your efforts.

(2) Find recent publications about natural resource conservation so that you may learn more about the broad, modern concepts of conservation and select the specific conservation matter to which you wish to relate your science fair project.

(3) Obtain ideas and suggestions about kinds of science fair projects that may appeal to you.

(4) Refer you to available publications providing guidance, information and instructions on "how to investigate," "how to observe," "how to experiment."

(5) Refer you to available publications providing suggestions and ideas on how to set up an exhibit or demonstration. (You will recognize that this deals with the art and science of communications.)

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SELECTING THE GENERAL SCIENTIFIC FIELD AND SPECIFIC AREA OF WORK

You will likely be encouraged to develop a science fair project by a teacher or advisor in a particular scientific field. For example:

Chemistry	Statistics
Earth Sciences	Economics
Meteorology	Sociology
Physics	Linguistics
Mathematics	Communications
Agricultural Sciences	Art
Biological Sciences	And many others
Psychology	

It is natural you will select a scientific field in which you are involved in your regular school work. Your advisor and your classmates will be of much help. Your project is likely to be an individual effort extending and expanding your knowledge about a particular subject that you have studied or are studying but for which class time is not available to explore it as deeply as you would like.

For example, you may be studying Biological Sciences. This may be the general scientific field which you select for your science fair project. Suppose you have recently been studying plants, a branch of Biological Sciences we call Botany. You are intrigued with the information you have studied about a particular subject such as the plant cell, solutions and membranes, plant structures of roots, leaves or stems, plant functions such as the ascent of sap in tall trees, or many other items. You will have learned that scientists have studied all of these items and many more. They have developed methods and techniques to learn more about each subject and have discovered and expressed many natural laws and general statements that apply to them. Or suppose you have recently been studying animals, a branch of Biological Sciences we call Zoology. A listing of subjects could be given around which your study may have been organized. You may be intrigued by the information you have studied about any one of them. Do you wish to develop your project along the lines of Botany, the study of plants, Zoology, the study of animals, or some other recognized subdivision of Biology?

First, select the general scientific field within which you wish to work, and then narrow that field down to one of the recognized subdivisions of it.

Having made these choices, you are ready to consider the selection of a specific project. In a subsequent section, we have included a list of suggested conservation science fair projects. Each suggestion includes one or more references that expands the suggestion. In every case, the suggested project may be developed in many different ways depending upon your interests, inclinations, imagination and efforts. The references given are only a point of beginning. Most references cite additional papers for study. In addition to the suggested conservation projects, the list of selected references at the end of this bulletin includes some published suggestions and ideas for science fair projects. After you have tentatively selected several specific project ideas you can more clearly express your interests to your advisor and others in seeking help.

Remember, you are learning about the vast amount of scientific information that has already been discovered. You are not expected to discover new basic truths or natural laws although, as you advance in a career of science, you may be in a position to do so.

Final selection of a project should be guided by: (1) Your curiosity and profound interest in a specific subject; (2) the time and energy you wish to devote to exploring a subject and in developing a project; (3) the availability of equipment and materials; and (4) many other factors. Your own interests and curiosity about a subject should determine your final choice because without it you are not likely to develop an outstanding science fair project.

Then too, you will want to relate your project to conservation in a tangible and easily explained manner. Once you have narrowed down the alternatives to a choice between several possible projects that appeal to you, your advisor can easily refer you to many references for your study. The next section will be helpful in relating your project to conservation of natural resources.

We hope you are beginning to get the idea your science fair project is going to involve a major scientific field, plus general scientific information from many allied fields, plus conservation. For example, a project may involve: Biology, general science and conservation; Chemistry, general science and conservation; or, Physics, general science and conservation.

LEARNING ABOUT NATURAL RESOURCE CONSERVATION

You may have been surprised, when thinking about conservation of natural resources, at the list of general scientific fields given at the beginning of the preceding section. Can all these be related to conservation? The answer is yes! It would be difficult to indicate a scientific field that is not somehow related to the conservation of natural resources. That is what makes a conservation science fair project more interesting than just a science fair project. It gives you the opportunity, yes, requires you, to understand the relationships of the most basic natural law or scientific truth to something that is of vital concern to each individual. That is, its relationships to the conservation of natural resources. A conservation science fair project is a means of illustrating practical application of scientific information you have been learning about in your science courses.

Of course, you need to learn more about the servation of natural resources along with your orts to develop the scientific parts of your ject. This is where the list of selected erences at the end of this bulletin will be help.

There are thousands of publications on con- vation that you could read. But we know you l not be able to read more than a few. Text- ks and other books are written to assemble, anize and summarize the vast amount of infor- ion in most scientific fields, including con- vation. A good textbook on conservation is a d place for you to start your study about servation of natural resources. A number of se are available as you will find when going ough the card catalog of a good library. We e confined our reference listing to only a such books. These are not necessarily the t or the only good ones, but they are some of most recent and appear to adequately sum- ize the kind of information you should ob- n.

Drawing from one of the publications in the erences listed (Munzer and Brandwein, 1960) find conservation to be defined as "the wise , intelligent development, and efficient man- ment of our natural resources." You will find y such definitions, none of which are superior all respects. The definition just quoted ears to express an attitude or policy in the a of human behavior according to the authors. does this concern everyone? The authors of s definition go on to say that conservation sures within such a policy may be expressed such words as: planning, allocating, sub- tuting, restoring, reusing, recycling, pro- ting, etc. Do these conservation measures cern you?

In your studies you will find natural re- rces variously classified as renewable," n-renewable," "inexhaustible," and "new or be-developed." Can you list examples of er classes? Is this an adequate classifica- n? Are there some natural resources that d explanation before you can properly place m in one class or another?

Now, recall your choice of a scientific ld and the subject matter within that field. the several specific projects you are con- ering be related to conservation? Your final ice of a conservation science fair project t be made to relate your scientific studies h one or more areas of natural resource con- vation.

The listing of selected references includes ms other than books about natural resource servation. These are smaller publications, tly by government agencies, designed to pro- e information about natural resources, their ortance, availability, and conservation mea- es that affect them. Some of these publica- ns are general in scope and cover broad fields natural resource conservation. Others are fined to different kinds of natural resources h as soils, water, forests, and grasslands. code numbers following each citation will assist you in selecting the reference pertinent to your study. Most of these smaller publica- tions are available free or at small cost, as indicated in the citations, and you may wish to obtain copies for your own. Besides the infor- mation they contain for your study, several might be useful as a part of your science fair exhibit or demonstration.

Most of the selected references we have listed refer you to many other books, pamphlets, bulletins, scientific articles, and other sources of information that you can obtain to extend your studies if you desire. Several of our citations are devoted exclusively to list- ings of a large number of selected publications about conservation.

You might as well face it. A scientist must be adept at finding published information about a subject of his interest. He relies on libraries and librarians to help him in this important phase of scientific work. He finds that it is a continuing job to which he must devote time and attention. Libraries are of many kinds; your school library, county li- braries, those of colleges, universities, and many other agencies and organizations, the National Agricultural Library of the U. S. De- partment of Agriculture, and the Library of Congress. Some of these have extensive collec- tions of reference materials and others are limited. However, about any library has facili- ties to obtain references available elsewhere through inter-library loans. Do not hesitate to ask your librarian to assist you in obtain- ing items that you need.

PLANNING YOUR PROJECT

The most important values of your science fair project is the knowledge and experience you gain in properly conducting an experiment, doing scientific work, presenting a report, and in preparing an exhibit or demonstration. Some of the references listed are designed especially to assist you in these matters. If we were to indicate "required reading" for a science fair participant, we would recommend first the small book by Golstein and Brandwein, 1957.

No matter where you obtain instructions for planning and developing your project, you will find the first requirement is a "statement of the problem." This should be brief but should clearly indicate the subject area of your proposed work, the general methods of ap- proach to be used, and the objectives that you plan to achieve. A conservation science fair project will include, in the problem statement, information about how you plan to show the relationships between your scientific project and some phase of natural resource conservation.

A science fair participant does not ordi- narily begin actual work on his project until he has developed a satisfactory problem state- ment and plan approved by his advisor. Besides the problem statement, your plan should include brief information about the research methods, materials, and facilities you intend to use, and the measurements and observations you intend to make. Many scientists say that a successful research project is divided into three parts of about equal importance and complexity, and requiring about equal amounts of time and effort. The first part is "planning." Your library research is a part of this phase. The second part is "doing the research work," and the third part is "reporting the results." From this, you will see that planning your science fair project with your advisor and others is going to require some very careful study and thought. It may require more effort than you originally suspected. Additional efforts, suggested by your advisor, in reworking your plan, in developing the problem statement, and in deciding upon methods, materials, and observations and measurements you intend to make, will be efforts well spent. It will save you much time later and will lead to a far better science fair project. Even the most mature scientist subjects his work plans to detailed reviews by others and appreciates the suggestions and comments he receives.

A condensed step-by-step statement, written in 1969 by Mr. E. G. Sherburne, Jr., Director of Science Service Inc., Washington, D. C., may be helpful in summarizing and highlighting the information presented in this bulletin. The statement is included below with permission.

"Suggestions for Science Fair Projects"

"1. *Decide on a Topic*: Ideas for topics can come from anywhere at any time. Finalists at the 17th International Science Fair said the ideas for their prize-winning projects came from the following sources: magazines, scientific papers, newspapers - 25%; books - 17%; schools and teachers - 13%; and others - 12%." (Other sources are included in the Selected References.)

"2. *Read Widely*: Your success in a science fair project depends largely on how much you know about your subject. Wide reading broadens your understanding of the possibilities and limitations of your project. Search your school library and the public and nearby university, college and specialized libraries for publications in your project field. Librarians are most willing to help you find the magazines, books and other printed matter that you will need."

"3. *Question Others*: Scientists draw heavily upon the knowledge of others in their own and related fields. Acquire the habit of consulting with others about your plans. Often a classmate or adult can point out an error in your thinking or suggest a method which might take you many hours to detect otherwise. Professional scientists and technicians are always glad to help answer your questions if you follow simple rules of courtesy such as querying them when they have the time to answer, and questioning them only when you have done enough reading and thinking to be able to ask intelligent questions."

"4. *Kinds of Projects*: Depending on your grade level and on the rules of your local fair, you may do a number of different kinds of projects. The best kind is the experimental project, where you try to reach conclusions through data obtained in laboratory or field experiments. For younger students, there are also construction projects, where you attack problems of design and materials in building some sort of equipment or device, and collection projects, where biological, geological, or other specimens are collected to study their geographical or other interrelationships. Remember that simply building something or collecting something, without drawing some significant conclusions, will not make a good science fair project. Older students should never undertake construction or collection projects, unless they are of an extremely sophisticated nature."

"5. *Write a Report*: Even though your local science fair rules do not require it, you should write up the results of your work. Your report should contain the following: The purpose of your project (what you were trying to find out or investigate), how you went about doing your project, what you did find out including any key data that you used in coming to your conclusions, any special problems that you encountered, acknowledgements of any major help received, and major help reference sources (books, articles in scientific journals, etc.)."

"6. *Build your Exhibit*: Your exhibit should be a display version of your report. While graphs, photos, data, apparatus, equipment, materials or other things with which you worked may be scattered all over, they will need to be molded into an interesting display. Before you start building anything, be sure to check all the rules about displays for your science fair, including the regulation for size."

"7. *Some Don'ts*: Don't write to some organization to send you everything they have on some subject, or expect them to do your project for you. Don't copy work that has already been done. Don't do a "cookbook" project by going according to step-by-step procedures given in a book or magazine. And don't tackle a project that is so big that you will not get it finished in time."

CHOOSING A PROJECT TITLE

A short, eye-catching, project title is desirable. This is usually chosen during the latter stages of your work when you are developing a report, preparing an exhibit, or setting up a demonstration. This is part of the final third of your project. Some of the selected references will be of help in this phase of your work. The project title cannot fully convey the scope of your project but it should be carefully and thoughtfully chosen to be suggestive of your project contents. This is important to officials organizing and classifying projects for science fairs and in arranging them for competition. *Conservation* projects should be identifiable readily from the title in order to assure their appropriate consideration. Such identification does not eliminate a project from classification and competition in a basic scientific field in addition to the conservation category.

Even though this bulletin is directed specifically to those interested in conservation science fair projects, your efforts and the information contained in this bulletin may apply to other student research efforts; for example, ordinary student project work, Future Scientists of America Clubs, Science Clubs of America, NASA-NSTA Youth Science Congresses, Junior Academy meetings, the Science Talent Search for the Westinghouse Science Scholarships and Awards.

SOME CONSERVATION PROJECT SUGGESTIONS

Causing People to Become Conservationists

Conservation of our renewable resources takes many forms. It is practiced by the farmer who runs his crop rows on the contour instead of in convenient straight lines, by the timber owner who does selective cutting and reforestation, by the factory owner who keeps his mill wastes from polluting streams, by school children and scouts when they plant trees or develop wildlife shelter, by all of us through tax supported conservation programs.

Conservation does not just happen. It is the result of someone's labor. That means someone must want it done. To get conservation done the farmer or the lumberman, the mill owner or the teacher, the scoutmaster or the taxpayer must be made aware of the importance of conservation to him. He must want to get it done and learn how to go about it. This might apply to a class in school or to your county government, as well as to an individual.

How to cause people among such groups to become conservationists--to stimulate individual or group or civic action--offers a big challenge in the field of conservation education today. It is a challenge to the best skills in the graphic arts, the various mass information and news media, the whole broad range of the art of teaching and convincing.

There are many interesting conservation science fair projects to be developed under this general project title. For example:

(a) Block diagrams as tools in resource inventories.

These require unique knowledge and graphic skills. They are three-dimensional drawings that are commonly used in published soil surveys, geological bulletins and other reports. They illustrate features of the landscape such as shape, location and position of a natural soil body in relation to topography, drainage, elevation, geological formations and to other kinds of soils in a way that is not possible on ordinary maps. Such diagrams, when skillfully done, provide information not readily understandable by other methods of communications. What kind of diagrams can you develop to illustrate natural resources in a specified area for a science fair project:

References

Lobeck, A. K. 1924. *Block diagrams and other graphic methods in geology and geography*. John Wiley and Sons, New York. In libraries.

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Katz, Hyman H. 1949. *Technical sketching and visualization for engineers*. Macmillan Co., New York. In libraries.

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Anonymous, 1948. *Techniques*. Higgins Ink Co., Brooklyn, New York.

Anonymous, 1953. *Technical illustration*. Higgins Ink Co., Brooklyn, New York.

Thornbury, William D. 1954. *Principles in geomorphology*. John Wiley and Sons, New York. $10.50.

Lobeck, A. K. 1956. *Things maps don't tell us*. Macmillan Co., New York. $5.95.

Lobeck, A. K. 1939. *Geomorphology*. John Wiley and Sons, New York. $13.50.

(b) Interpreting soil maps for different conservation uses.

Soil maps show the extent and location of different kinds of soils. Besides the soil maps, a published soil survey includes interpretations and detailed soil information that help conservationists and others use soils according to their capabilities and treat them according to their needs for conservation and improvement. The interpretations tell which soils of an area are *high*, *intermediate*, or *low* in potential productivity for different crops. They tell which soils are *well suited*, *moderately well suited*, *poorly suited*, or *generally unsuited* for such non-farm uses as developmental sites for buildings, playfields, golf courses, septic tank disposal areas, etc. They indicate, by ratings, the relative hazards and limitations that may be expected when using each different kind of soil for a specified use. Such things as erosion, flooding, excessive wetness, steepness, rockiness and stoniness, droughtiness, low fertility, clayiness, and the like are economically important in use of soils for different purposes. Such ratings are usually expressed as *severe*, *moderate* or *slight*.

Starting with a recently published soil survey (see the project title "Soil Profile Effects" for reference list of nearby recently published soil surveys) you can prepare on transparent overlays, colored maps showing areas with different degrees of general suitability, or areas with different degrees of specified hazards and limitations for specified conservation uses. Colors are very helpful and interesting for these interpretive maps. For example, red can denote *severe* hazard and limitations. It is a common color signifying danger, or on the highway, "stop." Yellow may be used to denote *moderate* hazards and limitations. Yellow normally signifies caution - you can expect some problems. Green is a conventional "go ahead" color. Here, we would expect to find little or no hazards or limitations to the specified use being summarized on your map. Such interpretive maps are not generally a part of published soil surveys but they are very helpful in getting people to understand and use the information that is contained in a resource inventory such as a published soil survey. A series of such interpretive maps as colored overlays to the soil map in a soil survey would make a very good science fair project.

Reference

Bartelli, L. J., A. A. Klingebiel, J. V. Baird, and M. R. Heddleson [eds.], 1966. *Soil surveys and land use planning.* Soil Sci. Soc. Amer. and Amer. Soc. Agron. 677 South Segoe Road, Madison, Wisc. 53711 (Especially Chapter 10 and Plates 13-17).

(c) Creating conservation awareness through pictures, cartoons, comic strips, and posters.

You've heard the old adage, "one picture is worth a thousand words." This is certainly true and there are many people who learn more about natural resource conservation through these channels than from any other means of communication. Have you ever seen a comic strip that presents a conservation story? Somebody developed these and it took a lot of imagination, knowledge, and skill. Have you ever eaten at a restaurant where you spent 10 or 15 minutes studying and enjoying the interesting place-mats the waitress set before you? Usually these depict historic events or tell about scenic attractions important in the area. Why couldn't these tell a resource conservation story? Someone needs to use a lot of imagination, conservation information, and artistic skill in developing them. Don't you think the development of a series of natural resource conservation place-mats could be a helpful contribution? It is likely that you may develop skills that will lead to a very interesting, profitable and worthwhile vocation. Certainly, the development of such a series would make an excellent science fair project.

References

Howard, E. F. Corporation, 1954. *Who lives on the forest farm? - Jackie Davis learns how birds and animals find food and shelter among growing trees.* Southern Kraft Division, International Paper Company, Mobile, Alabama.

Mercer, Howard Corporation, 1951. *The crop that did not fail.* Southern Kraft Division, International Paper Company, Mobile, Alabama.

Anonymous, (undated). *The fight to save America's waters - a Mark Trail adventure in public health and conservation.* Public Health Service, U. S. Health, Education and Welfare Dept., Washington, D. C.

Anonymous, (undated). Five booklets entitled: *The story of soil; The story of plants; The story of meat animals; The story of grass; The story of poultry.* Swift and Company, Agric. Res. Dept., Chicago, Ill.

Anonymous, 1959-1967. Seven booklets entitled: *Help keep our land beautiful; Making a home for wildlife on the land; Food and the land; The wonder of water; The story of land; Dennis the menace and dirt; Working together for a livable land.* Available from the Soil Conservation Society of America, 7515 N. E. Ankeny Road, Ankeny, Iowa 50021. Price 25¢ each to 9 copies with decreasing cost for larger quantities.

Establishing Sodded Turfs for Conservation

Sodded turfs are established for many conservation jobs, e.g. to protect yards, banks, golf courses, playfields, etc. The kind of seedbed preparation best adapted to receive sod, kind of sod for different uses and areas, time of sodding and methods of application, substratum characteristics on which sod is placed, subsequent care and treatment, and many other matters are all of importance for successful establishment and growth. How can you compare the relative effectiveness of rooting and growth between different substrata materials and treatments? This project utilizes a simple quantitative method that can be developed and illustrated for a science fair.

Reference

King, J. W. and J. B. Beard, 1969. *Measuring rooting of sodded turfs.* Agr. Jour. 61(4): 497-498.

Organic Mulches for Conservation

Organic materials in and on the soil have long been recognized as important elements of the soil environment. They retard soil erosion, slow down water runoff, help maintain good soil tilth, aeration, and fertility. They improve water intake rates and increase available soil moisture supplies. They insulate the soil against heat and cold and retard unnecessary water evaporation. Much is known from research and practical experience about these matters. Artificially supplied and naturally grown organic mulches provide some of the best conservation treatments applied to the land. Many kinds of mulches and techniques are required for the multiplicity of uses and areas where these treatments are needed. Many simple controlled experiments can be developed to test, evaluate, and illustrate these kinds of conservation measures in the field, in the laboratory or around the home. The following references provide a few illustrations that may help you select and develop a specific conservation science fair project. For instance, the results of mulching for moisture conservation might be demonstrated in a garden by putting peat, straw, or grass clippings around two or three rows of beans. Do the mulched rows produce more? What is the effect if part of the beans is irrigated or watered frequently?

References

Diseker, E. G., E. C. Richardson, and B. H. Hendrickson, 1963. *Roadbank erosion and its control in the Piedmont upland of Georgia.* U.S. Dept. Agric., Agricultural Research Service ARS 41-73.

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Chepil, W. S., N. P. Woodruff, F. H. Siddoway, and D. V. Armburst, 1963. *Mulches for wind and water erosion control.* U.S. Dept. Agric., Agricultural Research Service ARS 41-84.

Chepil, W. S. et al, 1960. *Anchoring vegetative mulches.* Agric. Eng. 41(11): 754-755, 759.

Swanson, N. P., A. R. Dedrick, H. E. Weakly, and H. R. Haise, 1965. *Evaluation of mulches for water-erosion control.* Trans. Amer. Soc. Agr. Eng. 8(3): 438-440.

Allison, F. E. and M. S. Anderson, 1951. *The use of sawdust for mulches and soil improvement.* U. S. Dept. Agric. Circular No. 891.

Lingg, A. W. and C. J. Whitfield, 1957. *Stubble-mulch farming.* U.S. Dept. Agric. Bul. 1166.

U.S. Dept. Agric. 1957. *Soil, the Yearbook of Agriculture.* (See "stubble" and "stubble-mulch.")

Yamada, H., J. Miller, and J. Stockton, 1963. *Desiccated grass mulch increases irrigation efficiency for cotton.* Calif. Agric. 17(11): 12-13.

Reducing Evaporation from Water with Chemicals

Engineers impound water made available in nature through precipitation. The next great challenge is to put the water to effective use. Evaporation losses from impoundments in the 17 western states exceeds the useable water storage capacity of all California! An important conservation measure being investigated involves the use of chemicals that establishes an evaporation resistant barrier on the water surface. What are these chemicals? Are they harmful to plants and animals? What are the methods that may be used in applying them? What are the technical, biological and economic implications of such a proposed conservation measure? Can you devise and conduct a simple controlled experiment to test the effectiveness of some suggested chemicals to reduce evaporation from water surfaces?

References

Michel, Curtis, 1963. *Evaporation control: A new tool for water management.* Jour. Soil and Water Conserv. 18(6): 223-229 (Cites 44 additional references)

Osborn, J. F., J. Letsey, and N. Valoras, 1969. *Surfactant longevity and wetting characteristics.* Calif. Agric. 23(3): March

Roberts, W. J. 1961. *Reduction of transpiration.* Jour. Geophys. Res. 66(10): 3309-3312.

Rietveld, W. J. and L. J. Heidmann, 1969. *Influence of antitranspirants on water use, growth characteristics, and relative drought resistance of Ponderosa pine seedlings.* U.S. Dept. Agric., Forest Service, Research Note RM-151. 7 pp.

Soil Profile Effects

The proper management of a soil is often influenced by conditions beneath the soil surface. Soils of the Piedmont area, for example, are often underlain by granitic-type rocks such as granite, gneiss, or micaschist. Soil at the surface may be of good tilth, underlain by rotten rock which rests on hard rock.

On the coastal plain, impeded drainage with mottled subsoils occurs frequently and may affect the use or results of use of the soil. Flat areas of the coastal plain frequently develop pan formations. The breaking of these is sometimes necessary for conserving water, but may be too expensive for general farm practice.

What happens to water infiltration and retention on different types of soil? Consider the same amount of rain on different types. Consider the same amount varied as to length of time or fall.

What happens when one attempts to grow conservation cover on different types of soil? On soils that have been manipulated to change the nature of the profile? Various crops and various types of treatment with the same crop might be recorded.

References

Any modern textbook on soil science.

Flocker, W. J. and H. Timm, 1969. *Plant growth and root distribution in layered sand columns*. Agron. Jour. 61(4): 530-534.

Recently published county soil surveys available in major libraries or from the U. S. Government Printing Office, Washington, C. C. such as:

Matthews, E. D., E. Z. W. Compy, and J. C. Johnson, 1961. *Soil survey of Montgomery County, Maryland*. U. S. Dept. Agric., Soil Conservation Service in cooperation with Maryland Agric. Expt. Sta. (See, Soil Conservation Service, 1969. *List of Published Soil Surveys*. U. S. Dept. Agric., Soil Conservation Service, Washington, D. C. 20250. April. From this list, you can select and obtain a copy of a recent soil survey for an area near you.)

Learning About Soils by Making a Collection of Soil Monoliths

Biological scientists have found that collecting and preserving plant and animal specimens is one of the best ways to learn about them, e.g. plant collections, insect collections, seed collections. The same methods are used by soil scientists to learn about soils. You can't collect an entire soil that occurs as a natural body on the landscape, but you can collect and preserve representative samples of soil profiles from vertical banks or the walls of dug pits. Two kinds of soil monoliths are described in the references--full scale or natural size, and micromonoliths. We suggest the latter but techniques are similar.

These samples, appropriately identified with the soil name, labeling of the several profile layers with texture, structure, thickness, reaction PH, relative amounts of coarse fragments, and other information, will provide needed information to help you recognize different kinds of soil. The major characteristics responsible for soil performance when used in different ways--for production of cultivated crops, growing trees, shrubs, grasses and legumes, for engineering purposes such as foundations for roads, buildings, playfields, and as septic disposal fields, etc., will be obvious.

We suggest you begin your project by obtaining a recently published county soil survey for an area accessible to you. (See the project title "Soil Profile Effects" for a reference list of recently published soil surveys in nearby areas.) It may be possible for you to spend several hours in the field with a local soil scientist employed by the Soil Conservation Service or the State Agricultural Experiment Station. He can identify the soils by name at a number of convenient locations and you can return later at your convenience to make the soil monoliths and obtain needed detailed information for labeling them. Referring to the published soil survey will help you in describing and labeling your monoliths. Soil monoliths make an excellent science fair display especially if they are supported by additional information about capabilities for different uses and about hazards and limitations in difference conservation uses. The published soil survey will provide this kind of information.

References

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Antibiotics

The micro-organisms that produce the "wonder drugs" such as penicillin live in the soil, as well as in modern laboratories where they are put to work to produce antibiotics for medicinal and agricultural purposes. But are micro-organisms the only ones that produce antibiotic substances? What is the role of these antibiotic substances in the soil? Are they defense mechanisms against certain plant diseases or insects? Do they influence the development and growth of possible plant competitors? If so, can they be increased or encouraged, or can their influence be minimized, by particular conservation or management measures to accomplish specific objectives? Many experiments can be devised to study these interesting and important problems.

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Modifying Soil-Water Relations with Chemicals or Soil Stabilization with Chemicals

These closely related project titles may involve many different types of conservation measures, for example: reducing soil erosion from watersheds or from exposed banks; reducing wind erosion from soils; treating soils to promote water yield for storage and use; sealing soil surfaces to effect water impoundments; stabilizing roadbed materials. Research has been reported where many chemical measures have been explored but knowledge is still quite incomplete. Such chemicals or substances as sodium chloride, calcium chloride, gypsum, lime, cement, bentonite, resins, polyvinyl alcohol, asphalt, and lignin products have been used. Many simple experiments may be developed to learn more about these research projects and to test the effectiveness of different chemicals or substances on a variety of different substrata for different conservation uses. Such projects are easily related to conservation but practicable uses of such measures require intensive economic evaluations.

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Reducing Evaporation from Soils with Chemicals

Plant growth is often retarded because of insufficient supplies of soil moisture. This is especially true in dry, desert areas with low rainfall, but it is often a periodic problem in areas with sufficient total rainfall. We know that water is lost from the soil by evaporation and many techniques have been studied to reduce this wasteful loss of needed moisture. Treating soils with certain kinds of chemicals has been suggested and tried by scientists. What are these chemicals? Are they harmful to plant and animal life? What are the technical, biological and economic implications of such a conservation measure? Can you devise and conduct a controlled experiment to test the effectiveness and practicability of such a proposed conservation practice?

References

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Hydrophobic or Nonwettable Soils

Scientists were puzzled by their "dusty tracks in the mud" as they crossed freshly burned watersheds after fall and winter rains. Studies indicated this phenomenon to be associated with the presence of certain kinds of plants that appear to produce organic chemicals responsible for nonwettability in soils. Do you have, and can you identify nonwettable soils in your locality? Can you develop, by artificial treatments, nonwettability in soils similar to that found in nature by the scientists? An extract of plant materials with the NH_4OH solution has been used. Can you find any differences in soil wettability after applying standardized extracts from different plants or organic matter available for your study? Assuming you are successful and can make flats of soil nonwettable (or that you have a natural source of nonwettable soils available for your study) do you find the nonwettable soil throughout your soil sample or concentrated in a band at a certain depth? Can the amount and location of the nonwettable soil layer be altered by applying more extract, a wetting agent, heat, pure water? Can you devise and perform experiments with different materials (wetting agents) designed to eliminate or minimize nonwettability in soils? Would a successful treatment have any practicable application in conservation? Can you make a simple device for measuring soil temperature at different depths under a fire such as a wildland fire? Can you devise and perform experiments to study the effects of heat on soil nonwettability? Or other properties and characteristics of the soil? What are some of the implications of these studies in conservation of natural resources?

References

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Effects of Air Pollution on Plants

Air pollution by toxic substances such as that generated by many industries, motor vehicle exhaust, and leakage from storage, is harmful to man, animals, and plants. Some toxic air pollutants are chlorine, sulfur dioxide, carbon monoxide, ozone, peroxyacetyl nitrate (PAN), ethylene, and fluorides. Can you devise a simple controlled experiment to expose pot-grown test plants to polluted air under different conditions and study the effects? A small gasoline motor may provide a source of exhaust fumes. Other toxic gases are available commercially in cylinders controlled by valves or they may be generated chemically. Plastic laundry bags supported on frames may make individual treatment chambers. Many simple, safe, controlled experiments are possible to study this important problem dealing with the environment and related to natural resource conservation.

References

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Weaver, E. C. 1968. *Environmental pollution experiments.* The Science Teacher 35(4): 24-27.
Woodruff, N. P. 1969. *Control of airborne pollutants.* Great Plains Agric. Council Publication No. 34. Vol. 1. Kansas State University, Manhattan, Kansas.

Effects of Fire on Seed Germination

Fire is often used to stimulate regeneration of certain desired forest species or to encourage desired understory plants for wildlife uses and for livestock grazing. Even under controlled management, results of burning are often erratic and unpredictable. What are the effects of heat produced by such burning on seed germination of selected important species? Is there a difference between dry and moist heat? The amount and kind of seed dormancy may be related to heat treatment. What are they and how can they be tested in conjunction with an experiment to test heat treatments on seed germination? How does this relate to natural resource conservation? Many experiments can be developed to shed light upon this broad and little known subject. The reference cites other publications that will be helpful.

Reference

Cushwa, C. T., R. E. Martin, and R. L. Miller, 1968. *The effects of fire on seed germination.* Jour. Range Mgmt. 21(4): 250-254.

Seed Germination Related to Conservation

Seed germination experiments can be done with simple equipment. Seeds of many plants are readily available or can be obtained with advanced planning. Work can be carried out almost any time of the year.

Basic environmental factors that affect seed germination are: water, oxygen, temperature, and light. These factors operate together in predictable and often unpredictable ways depending upon the species, variety, and conditions. Chemical and physical treatments may be used to increase or decrease seed germination depending upon the species and objectives. Illustrations can be developed to show how the information is important in conservation of natural resources.

References

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Root Growth Studies

Conservationists need information about the influences of environmental factors and their modifications on root growth of plants. Many techniques have been used. They are generally time-consuming and laborious, such as root excavations of field-grown plants or soil-removal from the roots of plants grown in containers. Usually the test plants are destroyed in the process, thus preventing a continuous study of root development of the same plants under standardized conditions. A simple procedure of growing plants in glass-faced boxes has been used. Using this technique, root development may be studied continuously over time. Studies may include different kinds of plants or mixtures of plants to learn about root competition. Effects of many different environmental treatments, such as using different soils and different physical and chemical treatments, may be incorporated into a controlled experiment for an interesting conservation project.

Reference

Larson, M. M. 1962. *Construction and use of glass-faced boxes to study root development of tree seedlings.* U. S. Dept. Agric., Forest Service. Rocky Mountain Forest and Range Expt. Sta., Research Note No. 73. Fort Collins, Colorado.

Shade Tolerance in Plants

Some plants grow better in shade than others. Can you classify common plants in your locality according to their relative shade tolerance? Information about the relative shade tolerance of different plants is important in many ways: e.g. selecting turf grasses for shaded areas; determining the value of understory species in forest stands as forage for domestic animals and for wildlife uses; management of forests to encourage regeneration of desirable tree species. What factors need to be controlled in developing an experiment to test relative shade tolerance of plants? How can you develop a relatively simple procedure for testing shade tolerance? These and other questions lead to many science fair projects for which implications to natural resource conservation may readily be developed. The reference cites a number of other publications that may be helpful.

Reference

Wood, Glen M. 1969. *Evaluating turfgrasses for shade tolerance*. Jour. Agron. 61(3): 347-352.

Differential Response of Grass and Legumes to Nitrogen and Phosphorus Fertilizers

An important phase of conservation is the selection of fertilizer treatments favorable to the desired vegetative cover. Nitrogen stimulates grass growth while having less effect on legumes. Rooted propagules (portions of growing plants) of uniform size of grass and alfalfa, from a single plant each, will provide a striking demonstration of these relationships when grown in gallon cans and given different fertilizers. For best results each treatment should be in duplicate and the experiment should continue at least two months. Suggested fertilizer rates: 200 lbs. N, or 100 lbs. P per acre. Check with biology teacher as to treating all cans with K. Growth curves can be obtained by periodic measurement of plants by Crider's technique.

Reference

Crider, Franklin J. 1955. *Root-growth stoppage resulting from defoliation of grass*. U. S. Dept. Agric. Tech. Bul. 1102.
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Effects of Water Table Depth on Growth of Plants

Can a simple controlled experiment be developed to study the effects of water table and related phenomena on the growth of plants? The references (each citing other relevant research) describes studies with trees and grasses in greenhouse tanks with sloping soils of different kinds to control the water table. The plants were selected to represent different growth requirements and the soils to represent different major characteristics. The methods can be adapted for a science fair project using your own choice of plants and soils. Control of various habitat factors during the experiment is discussed. Results can be related to conservation of natural resources.

References

Mueller-Dombois, D. 1963. *Techniques for studying soil-water-growth relations on artificial slopes*. Forest-Soil Relationships in North America (Edited by C. T. Youngberg), Oregon State Univ. Press., Corvallis, Oregon. pp 153-161. $8.00. In major libraries.
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Sims, H. P. and D. Mueller-Dombois. 1968. *Effect of grass competition and depth of water table on height growth of coniferous tree seedlings*. Ecology 49(4): 597-603.

Reducing Evaporation from Plants with Chemicals

More water escapes from our continent through small pores in plants than from all other ways combined. This is called plant transpiration. Is all this loss of water necessary? Can it be reduced in the interest of conservation? This problem is complex with many ramifying implications. Scientists are learning about chemical treatments that may be used to reduce this important source of water-loss. What are these chemicals? How can they be tested for conservation uses? Many simple controlled experiments may be developed to study various aspects of this important problem.

References

Waggoner, P. E. and J. E. Pallas, Jr. 1968. *Saving the water spent by plants*. U. S. Dept. Agric., Yearbook of Agriculture, pp 213-217.
Gale, J. and A. Poljakoff-Mayber. 1965. *Antitranspirants as a research tool for the study of the effects of water stress on plant behavior*. UNESCO Arid Zone Research 25: 269-274.
Waggoner, P. E. and J. D. Hewlett. 1965. *Test of a transpiration inhibitor on a forested watershed*. Water Resources Research 1(3): 391-396.
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Davenport, D. C., R. M. Hagan, and P. E. Martin. 1969. *Antitranspirants - uses and effects on plant life*. Calif. Agric. 23(5): 14-16.
Davenport, D. C. 1966. *Effects of phenylmercuric acetate on transpiration and growth of small plots of grass*. Nature 212(5064): 801-802.
Lopushinsky, William. 1969. *A portable apparatus for estimating stomatal aperature in conifers*. Pacific Northwest Forest and Range Experiment Station, U. S. Dept. Agric., Forest Service, Portland, Oregon.

orest Measurements

Growth and yield of forest stands are usualy determined by making certain physical measureents of individual trees. Some of the items measured are: height, age, diameter, basal area, umber of trees per unit of area, crown length, rown spread, stem volume and stem weight. asal area is the cross-sectional area of stems t breast-height (4-1/2 feet), expressed as quare feet per acre. This is a convenient and lmost universally-used measurement related to tand density, size of individual trees, and ther items.

Until about 20 years ago, foresters layed ut plots of designated sizes and measured the iameters of individual trees with a caliper or iameter tape. Then, by laborious computations etermined the basal area. A new principle has volved that has revolutionized forest measureents. This is called "point sampling," "plotess sampling," and by other names. A measureent requires only a few seconds. The references describe this new method. They describe wo simple instruments by which this measurement ay be made--home-made angle gauges, or small, alibrated, inexpensive wedge prisms.

An interesting project may involve basal rea measurement of several different forest tands using older methods as compared with hose made by the newer method. The use of this easurement in determining effects of various orest conservation treatments, such as thinning nd selective harvesting, can be pointed out to ake this a conservation project.

References

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'ood

What is wood? How is it formed? What funcions does it perform in the growth of trees? hat are some of the characteristics of wood important to man? Does wood from different kinds f trees differ? Can trees be identified from amples of their wood? What are some of the uses f natural and processed wood? Many projects can e developed to study wood and illustrate answers o these and other questions. These projects can e related to natural resource conservation.

References

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Fire Retardants and Suppressants

Believe it or not, fire is one of nature's most important conservation phenomena! We challenge you to develop this thesis in line with a modern and comprehensive concept of natural resource conservation.

Fire can be beneficial: to reduce bulky, inflammable materials that are in the way or are a nuisance; to produce heat; to prepare certain kinds of seedbeds; to reduce certain disease and pest hazards. Fire can be detrimental: destroying forests; destroying forage and cover on grass and brush lands; destroying houses and other structures.

Scientists and many other people have provided a vast amount of knowledge about fire. They have shown how to make things burn faster and how to treat things to retard burning. They have provided sophisticated methods of generating and maintaining fire as well as methods for retarding and extinguishing fire. In other words, much effort has been devoted to helping man understand this common phenomenon so that he may use it to his advantage. Since fire is such an all-pervasive phenomenon in our lives, can't we develop science fair projects to learn more about this knowledge and demonstrate some of the things we know?

Take the matter of fire retardants. Did you ever fire-proof your Christmas tree? Have you noted that some items around the home do not burn easily although on first appearance they would be expected to burn rapidly: for example, drapery, curtains, clothing, certain kinds of paper products? It is likely the manufacturers have gone to great lengths to render these materials more valuable to man by eliminating some of the hazards to his well-being due to accidental fire. Have you ever thought of extinguishing a fire, such as a wildfire in the forest, by spraying a fire retardant on it from the air or the ground? Could a fire prevention measure, such as a firebreak through a forest or a grass and brush area be developed by fireproofing strips of vegetation in strategic locations?

These questions deal mostly with the use of chemicals and substances that retard burning. What are these chemicals and materials? How are they applied and at what rates? Do they perform satisfactorily on all kinds of inflammable materials under different conditions? Can you develop a simple controlled experiment to test the effectiveness of a series of suggested chemicals or substances by using them as fire-proofing treatments on shavings or twigs taken from a Christmas tree? Carefully plan your experiment and document your tests and observations. Then, set up an exhibit to demonstrate your findings at a science fair. Take the necessary precautions to guard against accidental fire and injury.

References

Hardy, D. E. 1967. *The fire retardant development plateau.* In Western Forest Fire Conditions published by the Western Forestry and Conservation Association, American Bank Bldg., Portland, Oregon. (Eleven references are cited)

National Fire Protection Association Committee (M.S. Lowden, Chairman) 1967 (2nd ed.) *Chemicals for forest firefighting.* Published by National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts 02110. (Numerous references are cited)

Drake, G. L. Jr., and L. H. Chance. 1968. *Flame-retardant fabrics safeguard your life.* U. S. Dept. Agric., Yearbook of Agriculture, Washington, D. C. 20250. pp 279-283.

Eickner, H. W. 1968. *Wood can protect you from fire.* U. S. Dept. Agric., Yearbook of Agriculture, Washington, D. C. 20250. pp. 321-324.

Interception and Distribution of Rainfall under Forest Stands

Less rainfall reaches the soil under a forest canopy than in the open. Factors affecting this are: kind of trees, condition of forest stands (age, size, density, etc.), climatic conditions (amount and intensity of rainfall, temperature, humidity, wind, evaporation), topography, and other items. How does this natural phenomenon affect forest growth, understory growth, soil-water recharge of underground supplies, soil and water conservation? How can you set up a simple experiment to learn about this matter in a forest stand accessible to you? The first two references describes methods for doing this. You can make your own equipment. The third reference cites 61 scientific publications for further study bearing on the subject.

References

Voigt, G. R. 1960. *Distribution of rainfall under forest stands.* Forest Science 6(1): 2-10.

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Helvey, J. D. and J. H. Patric. 1965. *Canopy and litter interception of rainfall by hardwoods of eastern United States.* Water Resources Research, Vol. 1, No. 2, Second Quarter, Amer. Geophys. Union, Washington, D. C.

Control of Stump Sprouting

Good forestry often requires the elimination of weedy or undesirable trees. Many kinds of trees and shrubby species sprout profusely after cutting thus rendering control measures by cutting only partially effective. Stump treatments with various herbicides have been used to reduce sprouting on cut stumps. What are these chemicals? What are the best methods of application? When is the best time of year for such treatments? What is the relative effectiveness of different chemicals? What species of woody plants appear to be most troublesome due to stump sprouting? Other conservation measures require the complete control (elimination) of existing woody vegetation in order to be completely effective. What are some of these conservation measures? Have you been plagued with persistently resprouting trees, such as black locust, in your lawn, hedge, or flowerbed, arising apparently from the roots of a nearby desirable shade tree? Can you devise a simple controlled experiment to test the effectiveness of several suggested chemicals to eliminate this troublesome problem?

Reference

Leonard, O. A. and A. H. Murphy. 1964. *Stump sprout control.* Calif. Agric. 18(4): p. 7.

Controlling Weeds that Compete with Planted Tree Seedlings

Can the use of selective weed sprays or general contact herbicides be used in place of mechanical treatments, such as cultivation or hoeing, to reduce weed competition and improve survival and growth of planted tree seedlings? The reference describes some field experiments dealing with this important and complex problem. Many such experiments may be conducted to study various aspects of the proposed project. These can include use of different kinds of test plants and weedy competitors, different kinds and amounts of spray materials, different dates and methods of application. Relating your experimental results to practical conservation objectives will lead you into many interesting ramifications of this general subject.

Reference

Brown, J. H. and K. L. Carvell. 1962. *Grass control around planted tree seedlings.*

Jour. Soil and Water Cons. 17(1): 76-77

Insects and Conservation

Some of our most important crops depend upon insects for pollination. Insects are an important link in the food chain of many animals. Some insects are harmful to man and his various pursuits while others are beneficial. How do insects relate to the subject of conservation of natural resources? Experiment 98, dealing with insect behavior, in the reference will guide you into an interesting conservation science fair investigation. Many other investigations are included in this book that may suggest other science fair projects.

Reference

Kalmus, H. 1960. *101 simple experiments with insects.* Doubleday and Company, Inc., Garden City, N. Y. (This reference is also cited in the section on selected references). $3.95.

Conservation Education

Knowledge of the part soil and water resources play in our living is an important responsibility of citizenship. Conservation of these important resources is taught in many schools today. Some people have a better chance to observe and learn the effects of these resources on living because of their surroundings or their friends and family.

But too many students still grow up without sufficient knowledge of the importance of protecting and improving the land from which we get most of our food and much of the material for our clothing and shelter.

How much do the students in your class or your school know about conservation? Do farm-raised students know more about it than those who have lived only in the city, or in the suburbs? What do they know most about--Soil? Water? Forests? Wildlife? What phases of conservation education need more attention in your school?

A survey or questionnaire, with the results plotted to show the answers to some of these questions, would make an interesting and valuable science fair exhibit.

References

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U. S. Department of Agriculture. *Our American Land.* Agr. Info. Bul. 321 (SCS).

Value of Conservation Practices

Conservation of land and water resources--especially through construction of lakes and ponds, establishing or preserving woodlands, maintaining meadows, and preventing stream channel erosion--adds materially to the attractiveness of the countryside and to the facilities for recreation. These measures may make the land more productive and more valuable. Building ponds and doing other things for conservation, however, cost money, sometimes a great deal of money. Studies to determine what these measures are worth to the landowner and to the community in comparison to what they cost would be very valuable in helping people decide on the kind of conservation program to undertake.

References

U. S. Department of Agriculture. 1958. *Land, the yearbook of agriculture.* Washington, D. C.

Upchurch, M. L. 1957. *Longtime investments in soil management, Soil, the yearbook of agriculture.* U. S. Department of Agriculture. pp. 441-50.

Ciriacy-Wantrup, S. V. 1951. *Dollars and sense in conservation.* Calif. Agr. Expt. Sta. Cir. 402.

Suburban Soil Erosion

Cutting all trees and bringing all lands to new grades in suburban building developments is very contrary to good soil and water conservation practices because during the development period and for years thereafter the soil has little or no protection from water erosion.

1. Show two areas on opposite sides of a stream or on different streams, one denuded, the other with houses among the trees and with cleared areas for gardens.

2. Show differences in stream turbidity (color and load) after a rain when the area is wooded, as compared with a denuded area, either bare or recently seeded or sodded.

References

J. H. Stallings. 1959. *Soil Conservation.* Prentice-Hall, Inc., Englewood Cliffs, N. J. $9.95.

J. H. Stallings. 1957. *Soil Use and Improvement.* Prentice-Hall, Inc., Englewood Cliffs, N. J. $7.56

Urbanization and Conservation

One of today's most critical conservation problems is the effect of rapid expansion of cities into farm areas, with resultant loss of good food producing land, increased floods and sedimentation, reduction of recreation areas, etc. Cities must expand, of course, as our population grows. But there are ways of selecting land best suited for urbanization and then handling it in ways to minimize the ill-effects of urbanization.

An exhibit showing a land area before and after urbanization under good practices and under bad practices would be very informative.

References

U. S. Department of Agriculture. 1967. *Know the soil you build on.* Agr. Info. Bul. 320.

U. S. Department of Agriculture. 1967. *Sediment.* Agr. Info. Bul. 325.

Soil surveys and land use planning. Soil Science Society of America, 677 South Segoe Road, Madison, Wisconsin.

U. S. Department of Agriculture. 1963. *Soil conservation at home.* A213 244, USDA Yearbook of Agriculture. *A place to live.*

Value of Plant Residues

Several small plots could be set up in the garden or backyard to study the value of plant residues (leaves, straw, etc.) as an aid for (1) conserving moisture, (2) improving soil tilth, (3) building up soil fertility, or (4) other soil and water conservation benefits.

One of the plots could be kept cultivated so no vegetation would grow. Different kinds of plant residues could be applied to the others; e.g. leaves on one, clippings from the lawn on another, and peat, barnyard manure, or combinations of residues with commercial fertilizers on still others.

The purpose of this project would be to learn how plant residues can be used to improve soil conditions and conserve moisture. The results of the year's observations could be shown by charts and demonstrated at the Science Fair.

Reference

Stallings, J. H. *Soil, use and improvement.* 1957. Ch. 10 and 15. Prentice-Hall, Inc., Englewood Cliffs, N. J. $7.56.

Cross-Slope Cultivation

Garden plots could be used to determine the effect of cross-slope (contour) cultivation on runoff and soil erosion. The plots should be near each other on the same kind of soil and the same steepness of slope. One plot would be cultivated across the slope and the other up and down the slope. Some device for catching and measuring the runoff water and soil lost from each plot would provide data for comparing the effects of the two methods of cultivation. Observations on a contour-farmed field during a rain would supplement the plot data. The results could be illustrated at the Science Fair by models in small boxes.

References

Stallings, J. G. 1957. *Soil, use and improvement.* Ch. 13. Prentice-Hall, Inc., Englewood Cliffs, N. J. $7.56.

U. S. Department of Agriculture. *Teaching soil and water conservation.* PA-341. Washington, D. C.

U. S. Department of Agriculture. 1957. *Soil, the yearbook of agriculture.* Washington, D. C. 784 pp. See p. 290, "Erosion on cultivated land," by B. D. Blakely, J. J. Coyle and J. G. Steele.

Water

Water is probably the most critical natural resource in our country today. Where it is available, in what quantity and quality determines whether agriculture can expand, whether new industries can be located, and even affects the growth of cities.

Man's use of the land affects the behavior as well as the supply of water. A challenging science fair exhibit might be built around what man can do to improve the quality and quantity of water for a community. This might be a graphic description of watershed management, including erosion control and flood prevention, control of pollution and sedimentation, development of water storage, reduction of evaporation losses, and many other factors of good water and watershed management.

Check with local offices of the Department of Agriculture to see if there is a watershed protection and flood prevention program underway in your area. If so, the plans and progress of this project will provide a good basis for your study.

References

U. S. Department of Agriculture. 1955. *Water, the yearbook of agriculture.* Washington, D. C.

U. S. Department of Agriculture. *Water facts.* PA-337, Soil Conservation Service, Washington, D. C.

U. S. Department of Agriculture. *Teaching soil and water conservation.* PA-341, Soil Conservation Service, Washington, D. C.

Conservation of a Small Watershed

If the conservation problems were corrected on enough small watersheds (the drainage basins of small streams), big conservation problems (floods, water shortages, dust storms, extensive soil loss or deterioration, etc.) would be solved. These problems are important to both rural and city people. Making citizens (youth and adults) aware of the problems and possible solutions is the first step. There is a miniature watershed on practically each school ground or nature trail. Why not identify the conservation problems on one, plan their solution, and carry out the plan on the ground? Then why not make and exhibit a model of that watershed, along with a poster listing and picturing the conservation practices installed?

References

U. S. Department of Agriculture. 1955. *Water, the yearbook of agriculture.* Washington, D. C. (e.g., pp. 151-218).

U. S. Department of Agriculture. 1957. *Teaching soil and water conservation.* PA-341, pp 28-30.

A Rurban Watershed -- Rock Creek in the Nation's Capital. 1959. Allis-Chalmers Mfg. Col.

U. S. Department of Agriculture. 1963. *Water intake by soil.* Misc. Pub. 925.

The Hydrologic Cycle

The continuous circulation of water in nature, through the processes of evaporation and condensation, is known as the hydrologic cycle, and is essential to life on this planet. The process can be materially influenced by the way man uses and cares for his land. Therefore, it is important for everyone to know what happens in this cycle and what we can do in soil conservation and land use programs to avoid wasting water and damaging the soil.

A model, diagram, or series of drawings or photographs describing the processes involved and the effect of land use on the hydrologic cycle could present a highly important and valuable story. The construction of a really effective exhibit of this kind offers a challenge to the inventive as well as the scientific-minded student.

References

U. S. Department of Agriculture. 1955. *Water, the yearbook of agriculture.* Washington, D. C. 751 pp. (See esp. p. 41, "From ocean to sky to land to ocean," by Ackerman, Coleman, and Ogrosky.

Foster, E. E. 1952. *Rainfall and runoff.* Macmillan Co., Inc., New York. In major libraries.

U. S. Department of Agriculture. 1967. *Conservation and the water cycle.* Agr. Info. Bul. 326.

Farm Ponds for Conservation and Use of Water

Rainfall is often quite below average in many areas. In these years, the wells or farm streams may not produce enough water to supply all needs for home and livestock. Many farmers have built dams across small watersheds to catch rainwater which otherwise would run off to the ocean. Generally, a relatively small area, say 4 acres, is sufficient to supply enough water for a livestock water pond. (These ponds may provide much good recreation too.)

Ponds need to be quite large to provide enough water for irrigation for field crops. Ten to 15 acres or even more may need to be in the watershed. But a garden can be irrigated by the water saved by even a relatively small pond.

Significant charts and graphs could be developed assuming varying seasonal deficits of rainfall from the Washington area average and showing:

1. Acre-feet of water storage in ponds needed to replace the deficits.
2. Watershed areas needed to collect rainfall runoff in those ponds (remember water losses).
3. Acres of apple orchards that could be sprayed during a normal spray season from such ponds.
4. Number of cattle or other types of animals for which such ponds would supply adequate water for drinking, for washing of equipment, etc., for a specified number of months.
5. Capacity of a pond needed to provide supplemental water for an average (specified size) lawn or garden.

Reference

U. S. Department of Agriculture. 1955. *Water, the yearbook of agriculture.* Washington, D. C. (See "irrigation," "ponds," "reservoirs," "livestock water needs," etc.).

Water Conservation for Cities

More and more water is being used both by agriculture and by cities. Irrigation is expanding in the more humid areas. Water consumption is expanding even more rapidly in the urban areas. Many cities already have taken water formerly used by agriculture. Some have had to impose water rationing on their citizens. The job of providing increased quantities of water and of maintaining or improving quality of water for cities is increasing and becoming more costly. Could you make a study that would reveal the future needs for water both for agriculture and for urban uses in your area? Such a study would be very valuable for planning for future water supplies.

You could secure estimates of agricultural uses of water in the past from the Bureau of the Census. Estimates of urban uses, both for industrial purposes and for human consumption, could be obtained from the planning commission or other city officials. You could develop charts showing water consumption in the past by type of use and you could project these into the future on the basis of trends in population.

Reference

U. S. Department of Agriculture. 1955. *Water, the yearbook of agriculture*. Washington, D. C.

The Leaky Faucet

Most homes and apartments at one time or another have a leaky faucet. The amount of water lost from one leaky faucet could be measured. This figure could then be used to estimate the amount of water lost from this cause during a year in all the homes in the city, state, or nation. Charts could be developed showing how much this water cost, or how valuable it would be if saved and used for growing gardens and crops, filling swimming pools, cooling factories, or other purposes.

References

U. S. Department of Agriculture. *Water facts*. PA-337. Soil Conservation Service, Washington, D. C.
U. S. Department of Agriculture. 1955. *Water, the yearbook of agriculture*. Washington, D. C.

Measurements of Soil Moisture

Water in the soil is an important element in the hydrology of a watershed. Soil is one of the principal natural reservoirs for the storage of the water that falls on the land as rain, snow, or other forms of precipitation. Measurements of the moisture in the soil help answer many questions about the hydrology of an area.

Instruments are available for measuring the moisture in the soil in place. Electronic devices can be used to make a continuous record of the measurements and/or to transmit them to a central location.

Some of the problems that can be studied by measuring moisture in the soil are:

1. Effect of plant cover on water intake. Install soil moisture instruments in two areas of a similar soil with different plant cover (or one bare area); install or use data from rain gauge nearby. Calculate the increase in moisture content of the soil resulting from each rain; compare amount or rate of gain (intake) of the two plots. How does this affect runoff from the area?

2. Effect of different kinds of vegetation on evapotranspiration. With instrumentation as described in item 1, compare rates of moisture depletion on the two areas after rains that saturate the soil. Calculate the moisture-storage capacity of the soil and its possible effect on runoff.

References

Blanc, M. L. 1959. *Soil moisture reporting*. Weekly Weather and Crop Bul. 46(13): 7-8. Mar. 30. U. S. Weather Bureau, Washington, D. C.
Lassen, Leon, H. W. Lull, and Bernard Frank. 1952. *Some plant-soil-water relations in watershed management*. USDA Cir. 910. Washington, D. C.
U. S. Department of Agriculture. 1955. *Water, the yearbook of agriculture*. Washington, D. C. pp. 41-51 "From ocean to sky to land to ocean"; pp. 151-159 "How much of the rain enters the soil?"; pp. 362-371 "How to measure the moisture in the soil."
(The above publications list additional references)

Soil Aggregate Formation

Soil that is crumbly is said to be "well-aggregated." This kind of soil structure is better for farming than cloddy or lumpy soil. We know that soil growing grass or trees usually is better "aggregated" than soil that has been in cultivation for a time. But exactly how or why this happens is not too well-known. It is believed that water, soaking into the soil from a well-vegetated surface, carried with it in solution organic matter that helps to create this situation. Studies of the action of soil micro-organisms in connection with the organic matter in the capillary water, and possible effects of positive and negative charges on clay particles in the soil, would make interesting and useful projects.

References

Baver, L. D. 1956. *Soil physics*. Ch. 5. John Wiley & Sons, Inc., New York. In libraries.
Stallings, J. H. 1957. *Soil conservation*. Ch. 5 and 6. Prentice-Hall, Inc., Englewood Cliffs, N. J. $9.95.

Nitrogen-Fixation by Legume Bacteria

Nitrogen is indispensable to life processes.

Although 80 percent of the air is pure nitrogen, this element is useless to plants and animals unless it is combined in some form to make it available. Many leguminous plants used as cover crops for soil and water conservation, have a special relationship with bacteria which cause and live in nodules on the roots of most legume plants and bring about this combination, commonly called nitrogen-fixation.

This fixation and its effects can be shown by growing leguminous plants aseptically; and inoculating with pure cultures, crushed nodules or commercial preparations. Some strains of the bacteria are symbiotic with only certain groups of legumes. Different strains may range from highly effective "fixers" to actual parasites, on the same legume. Growing a legume in sterilized soil, in soil from a field in which the legume is growing well, with different strains of nitrogen-fixing bacteria or with the same strain, exposed at the time of inoculation to differing amounts of heat or drying, can demonstrate differences which are highly significant in growing these soil-conserving legumes.

References

Erdman, L. W. 1959. *Legume inoculation.* What it is. What it does. USDA Farmers Bul. No. 2003.

Virtanen, A. I. 1950. *The biological fixation of nitrogen and its significance for agriculture.* Proceedings of Eighth Congress of the Nor. ic Assn. of Agr. Res. (Copies available from USDA, ASCS, CV.)

Soil Bacteria, Nitrogen, and Humus

Many bacteria essential to higher life live on dead organic material and change it, making humus, an essential of good soil, an essential to plant growth and therefore to conservation. These bacteria can do this only when enough nitrogen is present for them to live and function. These organisms, too small to see by the unaided eye, are key operators in soil management and therefore to human life itself.

What happens to organic matter such as peat moss or leaf mold mixed with garden soil, treated with different levels or types of nitrogen fertilizer and a fixed amount of water? What happens to organic matter under (a) desert-like, (b) artic-like, and (c) topic-like conditions? What if the soil used in the mixture is (a) acid, (b) neutral, or (c) alkaline? What happens to plants seeded in the soil under the different conditions being observed? Care must be taken to keep careful control--one of which might be to have the organic matter and soil sterilized at the beginning of the experiment and kept moistened by distilled water.

References

U. S. Department of Agriculture. 1957. *Soil, the yearbook of agriculture.* (e.g. pp. 151-165).

Gibson, T. 1951. *Recent progress in soil bacteriology.* In World Crops, Vol. 3, No. 4. (Copies available from USDA, Agr. Cons. Program Serv.)

Waksman, S. A. 1952. *Soil microbiology.* John Wiley & Sons, Inc., New York, N. Y. In major libraries.

Plant Ecology

Ecology is the study of the relation of organisms to their environment and to one another. An important phase of plant ecology is the effect of changing soil environment on the plant life it will support at a particular time. Knowing what kind of soil environment is most favorable for a particular plant or tree is important in planning soil conservation and good land use. The effect of changing soil conditions on the growth of plants might be the subject of an interesting study in plant ecology.

References

Daubenmire, R. F. 1959. *Plants and Environment.* John Wiley & Sons, Inc., New York. $7.50.

U. S. Department of Agriculture. 1957. *Soil, the yearbook of agriculture.* Washington, D. C. 784 pp. (See esp. p. 38)

Stallings, J. H. 1957. *Soil conservation.* Ch. 7, 8, and 11. Prentice-Hall, Inc., Englewood Cliffs, N. J. $9.95.

Identification and Evaluation of Grasses by Their Vegetative Characteristics

Identification of grasses by vegetative characteristics is often essential in evaluating pastures, lawns and conservation plantings. Grow seed of known grasses in flower pots or flats and make field collections. Determine characteristics that distinguish common grasses. Display drawings of characters used to differentiate species, mounted specimens and growing seedlings. What characteristics make grasses valuable as soil-binding and moisture-conserving plants? Exhibit could include pressed, dried specimens, as well as the growing plants and charts.

Reference

The identification of 76 species of Mississippi grasses by vegetative morphology. 1952. Mississippi Agriculture Experiment Station Technical Bulletin 31.

How Seeds Travel

It is well-known that seeds of importance in soil and water conservation are widely dispersed by wind, water, birds, and other animals. They have special organs adapting them for the different forms of hitch-hiking, as the parachute-like hairs of the thistles and dandelions, the hard light hulls on the seeds of littoral plants, and the hooks and glands that adhere to hair or skin. Every seed, as goes the song of the boll weevil, is "looking for a home." Relatively few of the millions of seeds find a proper spot for their germination and growth to a plant, but when this happens by nature's chance, they have found their home and perhaps helped solve a conservation problem. This process the botanist calls ecesis (from Greek), a short word but laden with meaning. Wherever we live, new or wayfaring plants can be found. To the inquiring mind the kind of soil and site they grow in and the types of seeds they bear--the different types make a good exhibit--are clues for the scientific detection of their identity, origin, and how they got there.

Observe an area of earth that was bare a year or two ago, chart its plant population, where the plants probably came from, how they got there (related to the different types of seeds) how many kinds, and how they compare with those in a nearby undisturbed area.

References

Ridley, Henry N. 1930. *The dispersal of plants throughout the world.* L. Reeve & Co. Ltd. In major libraries.
Any illustrated encyclopedia, "*Seed.*

Effects of Competition on Plant Growth

Greater productivity may be realized along with proper soil conservation if optimum stand densities are received from plantings.

Competition occurs whenever two or more plants make demands for water, light, or nutrients in excess of the supply. Interesting results may be secured by planting different numbers of seeds in a series of pots or green house flats. The same species might be used throughout, or different species might be used. Results can be evaluated in terms of height, weight, fruit or flower stalk production, and recorded by photography, charts, or tables.

Reference

Weaver, J. E. and F. E. Clements. 1938. *Plant ecology.* McGraw-Hill, New York. $12.00. In major libraries.

Effect of Major Elements on Growth of Kentucky Bluegrass

On many soils it is essential that proper fertilization be done to maintain an adequate desirable plant cover. Such cover is needed to conserve the soil as well as maintain high production.

Plant Kentucky bluegrass seed in one series of pots filled with subsoil and in a second, filled with garden soil. Possible treatments might include no fertilizer, a complete fertilizer (10-10-10) nitrogen only (ammonium sulfate or ammonium nitrate), phosphorus only, and potassium only. The complete fertilizer treatment and the single fertilizer treatments should be comparable with respect to the amount of nitrogen, phosphorus and potassium applied. Harvest two replications and display two. Measure roots and tops and include weight if possible. Study could be supplemented by fertilizer experiment on a small portion of a home lawn.

References

U.S. Department of Agriculture. 1948. *Grass, the yearbook of agriculture.* Wash. D. C.
H. B. Musser. 1950. *Turf management.* McGraw-Hill Book Co., Inc., New York. $10.95. In major libraries.

Effect of Clipping on Root Development

The amount of top growth removed from plants and the frequency of this removal has a great deal to do with root growth and consequently the ability of plants to absorb nutrients and moisture from different soil depths.

Grow seedlings in pots and subject them to various clipping treatments, including height of cut and frequency (daily, weekly, etc.). Measure root development, amount of top growth, etc. It would be desirable to include more than one species, e.g., annual ryegrass and Kentucky bluegrass. This study could be supplemented by a height of clipping test on a home lawn. Photographs taken in the spring and fall and sod samples dug in the fall would be useful in reporting on a home demonstration.

References

U. S. Department of Agriculture. 1948. *Grass, the yearbook of agriculture.* Wash. D. C.
H. B. Musser. 1950. *Turf management.* McGraw-Hill Book Co., Inc., New York. $10.95. In major libraries.

Influence of Mowing and Grazing on Grasses

Conservation use of pasture and range plants is necessary to keep them in good high producing condition. To demonstrate this, plant grasses such as crested wheatgrass, meadow fescue, bromegrass or others in near-gallon cans filled with soil and with perforated bottoms to facilitate drainage. Grow in full sunlight. Clip the plants weekly at heights of 1/2, 2 and 4 inches for a period of 8 to 12 weeks. At the end of the period, submerse the cans of soil in water for 24 to 48 hours. Remove soil and plants from cans and gently wash soil from roots to show the effect of height of cutting upon root development. Results may be displayed by mounts of plants, photographs, charts, etc.

Reference

Weaver, I. E. and F. E. Clements. 1938. *Plant ecology*. McGraw-Hill, New York. $12.00. In major libraries.

How Grass Grows

Grass, like other green plants, grows by manufacturing food through the process of photosynthesis in the green leaves. If too much of the foliage is removed, as in mowing a lawn, growth is slowed down and sometimes the plants are killed.

To determine the effect of foliage removal on growth of grass, study two plots of lawn mowed at different heights. Mow both plots on the same day, cutting one with the mower set as low as possible and the other as high as possible. Before each mowing, record observations on the density and vigor of the grass, height or length of blades, presence of weeds, and other features that indicate the condition of the lawn. The results of these observations continued for several months could be shown on charts and illustrated by samples of the sod from the two plots.

Reference

Crider, F. J. 1955. *Root-growth stoppage resulting from defoliation of grass*. USDA Tech. Bul. 1102., Washington, D. C.

How Much Water Does a Plant Use

The amount of water used by plants is important in determining species to be used in plantings, especially where the water supply is limited.

The water requirement of grass can be determined by carefully following relatively simple procedures. Gallon confectioners' cans make suitable containers. The plants should be started as cuttings and after rooting must be grown for two or more months in a known amount of soil, and all water applied must be measured. Loss of moisture by evaporation from the soil surface can be greatly reduced by a surface mulch or cover. The dry weight of plant material produced is divided into the weight of water used to obtain the water requirement.

References

Keller, Wesley. 1953. *Water requirements of selected genotypes of Orchard-grass*. Agronomy Journal 45.

Keller, Wesley. 1954. *Water requirement of Dactylis glomerata L. in the greenhouse as influenced by variations in technique and their interactions*. Agronomy Journal No. 46, No. 11.

Selective Action of Herbicides on Weed and Forage Plants

Plant rows of seeds of oats, red clover, and ladino clover 1/4 inch deep in each of 4 pots or near-gallon cans. In three of these pots scatter over the surface a mixture of seeds of broad-leaved plants such as rape, mustard or lettuce to represent broad-leaved weeds and lightly cover with soil. Grow the plants in full sunlight for a period of 3 weeks. The pots having a mixture of legumes, oats and plants representative of weeds should be given differential treatment at this time: (a) Spray one pot at a calculated rate of 1 lb. of 2,4 dichlorophenoxyacetic acid (2,4-D) per acre, (b) spray a second pot at a calculated rate of 1 lb. of 4-(2,4-dichlorophenoxy) butyric acid (4-(2,4-DB)) per acre, and (c) give no spray treatment to the third. Continue to grow plants in full sunlight for an additional period of 3 to 6 weeks.

This demonstration will show the effect of broad-leaved plants in competition with legume seedlings, in comparison with the weed free condition. Also, the 2,4-D spray treatment will eliminate both weeds and legumes and leave the oats relatively uninjured while treatment with 4-(2,4-DB) should remove the "weed" species without injury to the legumes or oats. What are the principles of selectivity?

Herbicidal chemicals can be obtained from commercial companies such as Amchem Products, Inc., Ambler, Pa.; Dow Chemical Co., Midland, Mich.; Chipman Chemical Co., Roundbrook, N.J.; and others. It is important that chemicals be applied to the foliage of the plants at the rates of application recommended.

Reference

Ahlgren, Klingman, and Wolf. 1951. *Principles of weed control*. John Wiley & Sons, Inc., New York. In major libraries.

Wildlife Habitat

Field borders between cropland and woodland are often unproductive and badly eroded. Crops do not do well close to the trees because trees take the moisture or make too much shade. Hence, there often is a "no-man's land" at this point on the farm. If this border is planted to shrubs, especially those that bear fruit or berries, it will provide excellent food and cover for wildlife and will attract song and game birds, rabbits, and other animals. In addition, the shrubs will protect the land from erosion.

A season's wildlife count, comparing fields that have planted edges or borders with those that do not, will reveal interesting and useful information about the effect of this conservation practice on wildlife populations. It may also reveal facts about food preferences, nesting habits, and other wildlife behavior.

You can get help from your county agent or local offices of the U. S. Department of Agriculture, in locating fields where such comparisons might be made. Be sure to get permission of the farmer, too.

References

U. S. Department of Agriculture. *Making land produce useful wildlife.* Farm Bul. 2035.

U. S. Department of Agriculture. *More wildlife through soil and water conservation.* Agr. Info. Bul. No. 175.

Establishing Wildlife Areas

Most farms have out-of-the-way corners of land that are difficult, costly, or impossible to farm. These frequently can make good wildlife areas for birds to nest in if they can get access to other areas for safety. A good stand of grass and bushes provides cover. These are especially fine if a source of food is also provided, or is close by as in grain fields. But such shelters for wild game should take into account the birds or animals and their predators. Such areas ought not to become "traps" by reason of their isolation from other habitat.

There are many backyards and wooded corners that might make good places for birds to nest or rabbits to hide. Check your neighborhood for likely places. Are there grasses and bushes for the rabbits? Are the trees the kind that would discourage cats from climbing? (Cats are notorious bird predators if the birds have no place to keep out of reach.) What is the significance of field borders? What food plants are most desirable and can be planted?

Establish or maintain such areas and exhibit photographs and specimens of such habitat and plants. Existing areas may be identified and included.

References

Habitat Improvement and other Publications of the National Wildlife Federation. Washington, D. C.

Bird Habitat Publications of the National Audubon Society, 1130 Fifth Avenue, New York, N. Y.

Pond and Marsh Management for Waterfowl

Pond environments with continuously stable levels may lose much of their utility to waterfowl through the disappearance of many of the more desirable kinds of waterfowl food plants. Periodic reduction of the water level or even complete drainage and refilling often restores the capability of the pond to produce preferred food and cover plants. This process often occurs under natural conditions in areas of low rainfall, such as the pothole country in the Dakotas, Minnesota, and the Prairie Provinces of Canada. On federal, state, and other areas managed for waterfowl, deliberate manipulation of water levels are carried out periodically to insure maximum sustained use of these lands and water by wildlife. To maintain highest fertility of the waters, however, the timing of the "draw-down" is important, for the nutrient content of the water varies with the season. Thus, unless timed properly, drainage of impoundments may dissipate nutrient elements from the pond. Changes in pond vegetation and other factors may be determined and exhibited from photographs, charts, specimen collections, etc.

Reference

Cook, Arthur H. and Charles F. Powers. 1958. *Early biochemical changes in the soils and waters of artifically created marshes in New York.* New York Fish and Game Journal. pp. 9-65.

Martin, A. C. and F. M. Uhler. *Food of Game ducks in the United States and Canada.* Research Report 30, U. S. Fish and Wildlife Service, USDI. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 308 pp. $0.75.

Stream Pollution and Fish Conservation

River or other stream pollution by sewage and industrial wastes destroys fishing and other recreational resources. Showing the facts and helping the public to understand them can be a constructive conservation project and Science Fair exhibit. For example:

1. Model showing a "combined" sewer during heavy runoff of stormwater, emptying into the river. This will require running water, color and open topped pipes. Benefit from

correction of this system: Recreational use of river will be safe at all times. At present it is unsafe because of periodic overflows of sewage after rains.

2. Picture exhibit of a sewage treatment plant showing primary and secondary treatment facilities and operations. Information regarding capacity and other facts should be included. Benefits: As city grows, additional solids must be removed since these solids use up oxygen in the river which fish require to live. Elimination of odor in the river.

3. Two fish tanks. One equipped with oxygen supply and live fish. One without oxygen supply and dead fish. Benefit: Oxygen in water is required for fish to live. Also unsightly and smelly scum develops on water without oxygen.

Sources of Information and Assistance

Interstate Commission on the Potomac River Basin, 203 Transportation Building, Washington, D. C.

Division of Sanitary Engineering, District Building, Washington, D. C.

U. S. Public Health Service, Division of Information, Washington, D. C.

Do Earthworms Help to Conserve Soil and Water?

Soil "aggregation" (crumb structure that is not readily broken down by rain) and soil channels made by macro-organisms are important to soil and water conservation. Earthworms improve the stability of some soil aggregates in water and, at the same time, make holes which increase water infiltration. Interesting experiments could determine the effects of earthworms on different soil properties and their possible influence on soil and water conservation.

A simple study of earthworms in action may be made as follows: Fill a container half full of loose black earth with several earthworms in it. Then add on top of that about half as much white sand or sawdust Follow that by a half-inch of corn meal. Moisten daily with a small amount of water at house temperature. (If a glass container is used for easier observation, place inside a paper bag for darkness.) Record observations daily. Later, make studies of the composition of the sand or sawdust and earth layers, earthworm population, etc. Another container with a different mulch on top, or another kept at a different temperature, would provide interesting comparisons.

References

C. S. Slater and H. Hopp. 1948. Soil Science Soc. Amer. Proc. 12: 508-511.

C. S. Slater and H. Hopp. 1949. Jour. Agr. Res. 78(10): 325-339.

U. S. Department of Agriculture. 1957. *Soil, the yearbook of agriculture.* p. 164.

Insects and Wildlife Conservation

To understand the maze of interrelationships existing in wild populations challenges the ingenuity of our best ecologists. Any altering or control measures applied to insects can further complicate the picture and offer a very interesting and challenging field of study. Insect counts before and after the application of insect control measures, can indicate which kinds of birds or other animals have had their food supplies altered. For example, learn when the county will carry on "fogging" operations to control mosquitos or will spray to control certain tree insects. Take counts of various insects on plants in the sprayed area (1) before and (2) a day after (Caution: If planning to apply any insecticides, remember that some are very dangerous to man and other warm-blooded animals.)

References

C. H. Hoffman and J. P. Linduska. 1949. *The Scientific Monthly.* LXIX: 104-114.

U. S. Department of Agriculture. 1952. *Insects, the yearbook of agriculture.* pp. 669-731.

Insects and Soil and Water Conservation

Many insects are important in the breakdown of organic matter and in making holes in the soil, which increase water infiltration. Interesting research might classify the different insects and other arthropods in forest floors or cultivated fields and tabulate their effects on the soil. The Berlese funnel and brine flotation method may be used to determine insect population.

Population counts before and after spraying might also be of interest. Does spraying change the amount or kind of activity going on in the soil? (Caution: Some insecticides are very dangerous to man and other warm-blooded animals.)

References

C. H. Hoffman, H. K. Townes, H. H. Swift, and R. K. Sailer. 1949. *Field studies on the effects of airplane applications of DDT on forest invertebrates.* Ecological monographs 19: 1-46.

U. S. Department of Agriculture. 1952. *Insects, the yearbook of agriculture.* (e.g. pp. 79, 291-292).

U. S. Department of Agriculture. 1957. *Soil, the yearbook of agriculture.* p. 163.

Methods and Economics of Reducing Erosion on Farmland

There are mechanical ways of reducing soil erosion on hilly land, such as terrace systems, contour farming, stripcropping, etc., and there are vegetative methods, models, drawings, photographs, etc., may be used to illustrate these

Yet many family gardens--both vegetable and flowering--lose much of their topsoil (and therefore ability to produce) from erosion. Do the gardens you know about have little rivulets running downhill between the rows or plants where the soil has eroded away? Over a few weeks a check on this can be made by getting some 18-inch stakes and painting about half-way down and driving the stakes into the soil as far as the paint. Put the stakes about three or four feet apart. After each rain or a number of rains; draw a string between two stakes at the former surface level and see how deep the rivulets are.

How much top soil has been lost? Estimate the average depth of the erosion and how many eighth's of an inch the thickness would be if smoothed out evenly. From this, compute how heavy the soil is--how many tons per acre have been lost--as conservationists do. How much decrease in yields might result? How much harder would it be to make an income on eroded land?

Estimate the soil and yield losses in different types of relatively clean cultivated land uses and in a grassy area of similar topography.

References

Conservation and *Erosion* in any encyclopedia.

Foster, A. B. and A. C. Fox. 1957. *Teaching soil and water conservation--a classroom and field guide.* USDA PA-341. pp. 19 and 20.

U. S. Department of Agriculture. 1957. *Soil, the yearbook of agriculture.* (e.g. pp. 390-307).

U. S. Department of Agriculture. *Terracing for soil and water conservation.* Farmers Bul. 1789.

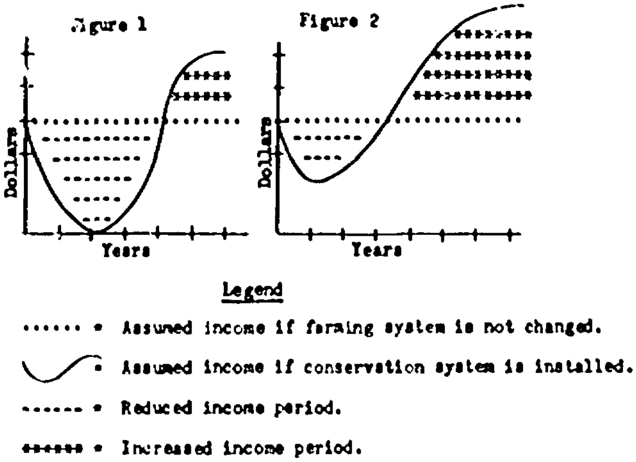
U. S. Department of Agriculture. *Will more forage pay?* Misc. Bul. 702.

U. S. Department of Agriculture. 1961. *How to control a gully.* F-2171.

Mathematics of Installing Conservation Farming Systems

The cost of conservation practices and frequently a lower farm income for a period of years are facts that discourage farmers from doing needed conservation work. The effect on income might look something like Figure 1. Alternatives might make the effect like Figure 2 or some other pattern.

How can a farmer calculate whether he can "afford" to carry out a conservation system? Two or three alternative cropping and livestock



systems might be assumed. Assumptions of stable prices and increases in crop yields, for example, of from 20 to 35 percent (2 to 5 percent per year) over a period of years might be made under various conservation systems of management. Optimum use of lime and fertilizer would be important. The federal government will share the cost (about 50 percent) of certain conservation practices and bear certain technical service costs. The family minimum living cost may require the borrowing of money. How much and when? Charts, graphs, and mathematical formulas and computations can be used. Models of a farm before and after treatment can illustrate systems and practices.

References

U. S. Department of Agriculture. 1957. *Soil, the yearbook of agriculture.* (e.g. pp. 367-376, 411-450). U. S. Department of Agriculture. 1958. *Land, the yearbook of agriculture.* (e.g., pp. 316-338).

Ball, A. G., E. O. Heady, and R. V. Baumann. 1957. *Economic evaluation of use of soil conservation and improvement practices in western Iowa.* USDA Tech. Bul. No. 1162.

Ciriacy-Wantrup, S. V. 1951. *Dollars and sense in conservation.* Calif. Agri. Exp. Sta. Cir. 402.

U. S. Department of Agriculture. *What is a farm conservation plan?* PA. 629 (SCS); *Credit in use and conservation of agricultural resources.* 1957. Agri. Info. Bul. No. 172; and *Agricultural conservation program national bulletin* and a related ACP unpublished paper *Conservation farming pays--when?*

SELECTED REFERENCES
(Annotated)

The numbers following each citation indicate the subject-matter content according to the following codes:

1 = How to conduct experiments, do scientific work, and present reports, exhibits, or demonstrations of results.
2 = Conservation of natural resources - General.
3 = Conservation of renewable natural resources - General.
4 = Conservation of renewable natural resources - Soil.
5 = Conservation of renewable natural resources - Water.
6 = Conservation of renewable natural resources - Forests.
7 = Conservation of renewable natural resources - Grasslands.
8 = Conservation of renewable natural resources - Wildlife.
9 = Suggestions and ideas for science fair projects.

American Association of Colleges of Pharmacy, 1963. *Pharmaceutical science project handbook.* American Pharmaceutical Association, 2215 Constitution Avenue, N.W., Washington, D. C. 20037. 32 pp. 25¢.

Certain fields of pharmaceutical science, defined in this booklet, deal with the search for new drugs, many of which come from specialized plants of limited availability. All major fields deal in some way with problems of health sciences. The booklet provides a source of pharmaceutical science project ideas, some of which are related to conservation of natural resources. A number of science projects are outlined under each of four major fields with background information, supplies needed for the project, procedures, discussions, and selected references. (9)

American Chemical Society, 1969. *Cleaning our environment--the chemical basis for action.* A Report by the Subcommittee on Environment, Committee on Chemistry and Public Affairs. American Chemical Society, 1155 Sixteenth St., N.W., Washington, D. C. 20036. 249 pp. $2.75.

This publication is written especially for laymen (legislators, administrators and others) who deal with environmental pollution problems at one or more steps removed from direct involvement such as a particular science and technology. Two goals have been achieved by the long list of distinguished scientists on the committee that prepared this bulletin. (1) They have set down an objective account of the current status of the science and technology of environmental improvement; what is known and how it is being used; what must be learned and how it might be used. (2) They analyzed the information thus assembled and have recommended a number of measures that, if adopted, should help to accelerate the sound development and use of that science and technology. Following a brief but enlightening summary that includes 58 of 73 recommendations, the material is presented in detail in four sections: The Air Environment; The Water Environment; Solid Wastes; and Pesticides in the Environment. Each section provides a comprehensive laymen-oriented, discussion, well organized under appropriate subheadings, to provide an exhaustive account. Each section includes the recommendations and an extensive list of cited literature on the subject. Anyone interested in environmental pollution would do well to begin his studies with this bulletin. (2)

Anonymous, 1962. *Adventures in biology.* Board of Education, City of New York. Publication Sales Office, 110 Livingston Street, Brooklyn, N. Y. 11201. 289 pp. $1.50.

Provides suggestions, procedures and source references for nearly 200 projects answering biological questions. Twenty-seven of these are classified as ecological or conservation. Each project includes additional suggestions for related topics. Contains a comprehensive bibliography including 59 Turtox Service leaflets available from General Biological Supply House, Chicago, Illinois on such subjects as: preserving botanical specimens; embedding specimens in transparent plastic; growing plants in nutrient culture media; collection and culture of earthworms and other Annelids; hydroponics--growing plants in nutrient solutions without soils. (1, 9)

Anonymous, 1965. *Conserving our natural resources--a 4-H leader's guide.* U. S. Department of Agriculture PA-614. Washington, D. C. 42 pp.

This bulletin was prepared by a committee of federal and state agencies and industry groups. It is for the purpose of providing a better understanding of our nation's renewable natural resources through an integrated approach to conservation. It provides an understanding of the relationships between living things and their environment. Discussions including soil, water, forests, grasslands and wildlife point out the interrelationships between them. A special section on references includes films, textbooks and pamphlets. This bulletin is available from the U. S. Government Printing Office, Washington, D. C. or from offices of the Federal Extension Service, Forest Service, Soil Conservation Service, or the Fish and Wildlife Service. (3, 4, 5, 6, 7, 8)

Anonymous, 1967. *Selected references on forests and related natural resources.* U. S. Dept. Agric. Forest Service FS-39. Washington, D. C.

An updated list of selected references available from the U. S. Government Printing Office, Washington, D. C. or from offices of the Forest Service. (2, 3, 4, 5, 6, 7, 8)

Anonymous, 1967. *Trees of the forests--their beauty and use.* U. S. Dept. Agric., Forest Service PA-613. Washington, D. C. 24 pp.

This pamphlet tells about trees. It gives background about our forests and how they have changed. It tells about the National Forests--what they are and how they are managed. Characteristics of various trees and their uses are described. Ten special areas in the National Forests are described as places to go and learn more about trees and forests. Available from the U. S. Government Printing Office, Washington, D. C. for 25¢ or from offices of the Forest Service. (6)

Allen, Shirley W. and J. W. Leonard, 1966 (3rd ed.). *Conserving natural resources--principles and practices in a democracy*. McGraw-Hill, New York. 432 pp.
A comprehensive textbook on natural resource conservation including classification into resource groups with individual discussions, methods of resource management, legislation, etc. Bibliography at end of each chapter. (2, 3, 4, 5, 6, 7, 8)

Barr, George, 1958. *Research ideas for young scientists*. Whittlesey House, McGraw-Hill Book Company, Inc., New York. 142 pp.
This is an intriguing small book describing many research ideas not repetitious of those ordinarily suggested. The material is organized under the following headings: electricity and magnetism; transportation; sound and light; the human body; weather, water; insects; plants; distance; time; science in your home. Each section is terminated with suggestions entitled, "more to find out," and a short listing of "books to read." Kinds of research ideas presented are illustrated by such topics as: "is it warm under the snow;" "can you control the evaporation of water?"; "can you read by firefly light?"; "do all vines twine the same direction?". Imagination and background in conservation will be needed to use the ideas in developing acceptable conservation science fair projects, but reviewing this book cannot help but stimulate ideas. (9)

Bennett, Hugh Hammond, 1939. *Soil conservation*. McGraw-Hill Book Co., Inc., New York. 993 pp.
This book is the "classic" on soil conservation. There is a later book (1955) by the same author and publisher entitled *Elements of Soil Conservation*. (2, 3, 4, 5, 6, 7, 8)

Berman, William, 1963. *Experimental biology*. Sentinel Book Publishers, Inc., New York. 128 pp. paper-back. $1.00.
As indicated on the cover, this excellent book on experimental biology is a road to research in plant cancer, aquaculture, enzymes, metabolism, photosynthesis, chromatography, phagocytosis. Detailed and illustrated instructions and techniques are given for preparing cultures, solutions, slides, using manometry, making tissue extracts, extracting chlorophyll, and for photomicrography. The exercises are developed around special science projects with many suggestions for expanding the investigations. (1, 9)

Boy Scouts of America. Merit Badge Library. New Brunswick, N. J. 08903.
This is a series of clearly presented, well prepared, illustrated and periodically updated booklets, written by authorities in their fields. They are designed especially for Scouts and Explorers in meeting merit badge requirements. Separate booklets cover many phases of science, art, technology, vocations, sports, recreation, communications, conservation of natural resources, etc. For example, booklets are available on *Agriculture* (1960), *Bird study* (1967), *Botany* (1964), *Conservation of natural resources* (1967), *Forage crops* (1965), *Forestry* (1959), *Soil and water conservation* (1968). Selected booklets are useful in relating scientific projects to conservation of natural resources. Each booklet lists selected references for further study and lists the other booklets in the series. Available in libraries, bookstores, suppliers of Boy Scout equipment, or from the publisher at 50¢ per copy. (2, 3, 4, 5, 6, 7, 8, 9)

Carvajal, J. and M. E. Munzer, 1968. *Conservation education--a selected bibliography*. The Interstate Printers and Publishers, Inc., Danville, Illinois. 98 pp.
An annotated bibliography, published for the Conservation Education Association, listing United States publications from 1957 through 1966. A few earlier "classics" are included, mostly without comments. Citations are classified by subject categories and the suggested reading levels. (2, 3, 4, 5, 6, 7, 8)

Concepts in Science Series. Harcourt, Brace and World, Inc., New York, Chicago, Atlanta, Dallas, Burlingame. (Especially the following items.)

Brandwein et al, 1966. *Concepts in science: 6--teacher's edition*. $3.80.
This 440-page, hard-backed book contains an introduction for teachers and 54 investigations. Each unit contains well described and illustrated investigations followed by a series of questions to promote individual study.

Brandwein et al, 1966. *100 invitations to investigate*. $21.00, wholesale.
This is a set of 100 ungraded laboratory cards providing background information, illustrations, and guides for pupil's independent investigations in the biological and physical sciences. Packaged in a stury case, pupils in grades 4 through 9 can pursue their own interest in a particular area of science, independent of their regular classroom work and their teacher. A single box, which can serve one or more classrooms, contains: (1) an introductory card; (2) a sample investigation

card; and (3) 100 investigation cards separated into three approximate degrees of difficulty. Intended as a self-sufficient enrichment program for the *Concept in Science Series*, *100 Invitations to Investigate* can also supplement any other elementary school science textbook series.

Brandwein et al, 1968. *Life: its forms and changes*, $4.35; *Matter: its forms and changes*, $4.35; and *Energy: its forms and changes*, $4.95.
These three books, also a part of the *Concepts in Science Series*, are designed especially for junior high schools. They are organized into units of study, each unit contains a number of illustrated and described "apprentice investigations" followed by suggestions for "an investigation on your own." (1, 9)

Dasmann, Raymond F. 1969. *An environment fit for people--the new meaning of conservation.* Public Affairs Pamphlet No. 421. 381 Park Ave., New York 10016. 28 pp. Price 25¢. (Published in cooperation with the Conservation Foundation, 1250 Connecticut Ave., N.W., Washington, D. C., where it may also be obtained.)
This pamphlet is an excellent, modern, mature, and general presentation of conservation according to the following definition: "The rational use of the environment to achieve the highest quality of living for mankind." The material is organized under the following headings: the meaning of conservation, ecology and conservation; population and environment; conservation in cities--air pollution, water pollution, solid wastes, urban open space, city planning; conservation and rural lands--soil erosion, conservation of rangelands, forest conservation; wild creatures and wild places; the marine environment; outlook and action. (2, 3, 4, 5, 6, 7, 8)

Driscoll, Richard S. 1967. *Managing public rangelands; effective livestock grazing systems for National Forests and National Grasslands.* U. S. Dept. Agric., Forest Service AIB-315. 30 pp.
A photographically illustrated pamphlet that presents range management objectives, rangeland conservation practices, and kinds of grazing systems with information about their advantages and disadvantages. A selected bibliography lists other publications for further study. The information is brief, simply written, and will give a science fair participant some general background to relate his project to rangeland (grassland) conservation. Available free from the U. S. Forest Service, Washington, D. C. 20250. (7)

Foster, Albert B. and Adrian C. Fox, 1957. *Teaching soil and water conservation - a classroom and field guide.* U. S. Dept. Agric., Soil Conservation Service, Washington, D. C. PA-341. 30 pp.
As the title states, this publication is a classroom and field guide. The material is presented as 22 conservation activities such as: Compare soils by growing plants in them; how much sediment does a stream carry?; how does crop cover affect soil loss?; make splash boards to study splash erosion. Simple experiments and demonstrations are explained and illustrated. These help students set up their own investigations to more fully understand the basic concepts of each activity. Each activity is accompanied by a discussion on "interpretations" that leads the student to a broader appreciation and understanding of the subject matter. This publication may be obtained free through a local Soil Conservation Service office or from the national office in Washington, D. C. (4, 5, 6, 7, 8, 9)

Fox, Charles E. 1967. *Conservation activities for young people.* U. S. Dept. Agric., Forest Service, Washington, D. C. 20250. 21 pp.
This booklet suggests many potential conservation science fair projects. Numerous questions and statements, organized about suggested field excursions, are presented to extend students' observations and curiosity. The suggested field excursions sample all phases of renewable natural resources. Twenty-eight simple demonstrations or experiments are described briefly, each of which will direct students to specific conservation science fair projects of their own. Lists of "other subjects to explore further," "exhibits and collections," and "subjects to write and talk about" provide additional suggestions. May be obtained free from offices of the Forest Service. (9)

Frandsen, Waldo R. 1960. *Grass makes its own food--for growth--for forage--for good land use--for soil conservation.* U. S. Dept. Agric., Soil Conservation Service, Agriculture Informational Bulletin No. 223.
An 8 x 15 inch sheet folded to pocket size and giving elementary information about grass. When opened, one side contains a poster-type caricature of a "grass factory" illustrating basic environmental requirements entitled, *How grass makes food for growth.* This folder has been used in classrooms and on exhibits to illustrate rangeland conservation principles. Available free from local or national offices of the Soil Conservation Service or for 5¢ from the U. S. Government Printing Office, Washington, D. C. (7)

Goldstein, Philip and Paul Brandwein (editors) 1957. *How to do an experiment.* Harcourt, Brace and Co., Inc., New York. 192 pp.
This small book is truly outstanding. It tells the junior scientist about scientific methods; how information is obtained; how to carry on an investigation, including choosing and starting the problem, doing the preparatory

work, planning and carrying out the investigation, recording the observations, analyzing results and formulating the conclusions, reporting the investigation and results orally, in writing and as an exhibit. A useful bibliography is included. Every science fair participant should review this book. (1)

Green, Iva. 1958. *Water--our most valuable natural resource.* Coward-McCann, Inc., New York. 96 pp.
An interestingly written, well-illustrated, elementary discussion of water, its sources, uses, and conservation. (5)

Guidry, N. P. and K. B. Frye, 1968. *Graphic communications in science--a guide to format, techniques and tools.* National Science Teachers Association, 1201 Sixteenth St., N.W., Washington, D. C. 20036. 48 pp. $2.00.
This publication guides the reader toward effective presentation of data in illustrations (charts, diagrams, etc.). Different types of charts are described along with the best methods of production and the equipment necessary for professional-looking work. Includes a glossary of terms and a bibliography. (1)

Harrison, C. William, 1969. *Forests (riches of the earth.)* Julian Messner, 1 West 39th Street, New York 10018. 191 pp. $3.95.
"For as long as man has been on earth, forests have been essential to his survival and well-being...from them man has received the materials with which to build his houses, his ships, his tools....forests support the bulk of wildlife and produce the oxygen we breathe. The story of our forests and their enormous variety and manifold uses is a fascinating one, and man has much to learn if he is to preserve their beauty, their wonder and their economic value as one of the greatest of the riches of our earth." This is a recent book whose scope is indicated by the above statements taken from the foreword. Any student interested in developing a conservation science fair project relating to forests as one of the important renewable natural resources, will gain much background information from reading this interesting book. (6)

Kalmus H. 1960. *101 simple experiments with insects.* Doubleday and Co., Inc., Garden City, New York. 194 pp.
This small, hard-back book, written by a scientist at London's University College, and adapted for North American readers, includes a series of simple experiments designed to sample various functions and habitat factors of insect life. Animals and apparatus needed for each experiment are listed. Background information is given for each experiment together with suggested procedures. A short introduction tells about insects as a group of animals. Specific references are cited for each experiment. Available from libraries or from the publisher. (9)

LeCompte, Robert G. and Burrell L. Wood, 1964. *Atoms at the science fair--exhibiting nuclear projects.* U. S. Atomic Energy Commission, P. O. Box 62, Oak Ridge, Tennessee 37831. 52 pp. Free.
This booklet, designed to help young exhibitors, science teachers, project counselors, and parents, offers advice on how to plan, design, and construct successful exhibits. A long list of nuclear science project titles exhibited at the National Science Fair-International from 1950 through 1963 is included. Nuclear energy-related investigations and applications are suggested in the areas of biology, medicine, chemistry, physics, geology, and industry. There is a well-chosen list of suggested references published since 1952 and a list of suppliers of radioisotopes. (1, 9)

McAvoy, R., J. Ayres, J. C. Chiddix and R. E. Diveley, 1959. *Biology projects.* Science Publications, Normal, Illinois. 160 pp.
A hard-backed, small book suggesting 61 biological project areas that may be pursued in the classroom, as individual projects, or as hobby interests. Projects are not described in complete detail but are suggestive of the avenues that might be followed. Projects are organized under; the plant kingdom, the animal kingdom, and general projects. Specific references reporting published research in the suggested subject are not given and no bibliography is included. (9)

McCorkle, J. S. 1967. *Grass-the rancher's crop.* U. S. Dept. Agric., Soil Conservation Service. Leaflet 346. 8 pp.
This photographically illustrated leaflet tells about the importance of grass and grassland conservation. Available free from local or the national offices of the Soil Conservation Service or for 10¢ from the U. S. Government Printing Office, Washington, D. C. (7)

Moore, Shirley (ed.), 1960. *Science projects handbook.* Science Service, Inc., 1719 N. Street, N.W., Washington, D. C., or Ballantine Books, Inc., 101 Fifth Avenue, New York. 254 pp. Paperback, 50¢.
A very helpful, inexpensive, small book giving, in chapters 3 through 12, actual reports by students who have developed projects in many areas of science. The book contains guidance for the student in developing a project and carrying it through competition such as a science fair. There is a 20-page chapter citing references for study. These are organized by subject areas. (1, 9)

Morholt, E., P. F. Brandwein and A. Joseph. 1958. *Teaching high school science: a sourcebook for the biological sciences.* Harcourt, Brace and Company, Inc., New York.
A heavily illustrated book of techniques, demonstrations, projects, experiments, and

references for teaching and learning biology, general science, health, botany, and zoology at the high school level. Includes a 19-page chapter on *conservation: web of life*. (1, 2, 3, 4, 5, 6, 7, 8, 9)

Munzer, M. E. and P. F. Brandwein, 1960. *Teaching science through conservation.* McGraw-Hill Book Company, Inc., New York. 470 pp.

This book, sponsored by the Conservation Foundation, helps science teachers relate general science, biology, chemistry, physics, and earth science to conservation of natural resources. Conservation is defined according to modern concepts and resources are classified as renewable, nonrenewable, inexhaustible, and new to-be-developed. Many well described and illustrated experiments, projects, and exercises are given to lead the student into a more complete understanding and appreciation of basic scientific principles and their interrelationships to the conservation and use of natural resources. An extensive bibliography is included, classified by subject matter, availability, and reading level. (1, 2, 3, 4, 5, 6, 7, 8, 9)

National Science Teachers Association, 1968. *Award winning FSA (Future Scientists of America) science projects.* National Science Teachers Association, 1201 Sixteenth Street, N. W., Washington, D. C. 20036. 30 pp. $1.00.

This publication contains many student reports of actual regional award-winning projects. Scientific areas represented are: biology; chemistry and physics; earth-space science; and miscellaneous. The projects represent all grades from 7 through 12. A prospective science fair participant will profit from referring to these reports. Many reports include discussions of additional investigations that could be made. (9)

McNall, P. E. 1964 (2nd ed.). *Our natural resources.* The Interstate Printers and Publishers, Inc., Danville, Illinois. 280 pp. $4.75.

This book is written for young people to present the story of natural resources and man's dependence upon them. Resources are discussed as "inexhaustible," "exhaustible-irreplaceable," and "exhaustible-replaceable." Attention is given to atomic and solar energy and to more conventional sources of energy such as coal, oil and gas. Excellent presentations are included about soil, water, minerals, wildlife, trees, and other vegetation, together with discussions about their conservation. Available in libraries or from the publisher. (2, 3, 4, 5, 6, 7, 8)

Patterson, Margaret E. and Joseph H. Kraus. 1957 (5th ed.). *Thousands of science projects.* Science Service, 1719 N Street, N.W., Washington, D. C. 20036. 44 pp. 25¢.

Each of the thousands of science projects reported was completed by at least one student who participated in a science fair or competed in the science talent search of the Westinghouse Science Scholarships and Awards. The project titles are classified in two ways--by broad general subjects, and according to the classification used by the Library of Congress. There are some photographs illustrating how the projects were displayed to the public. Information (descriptions and plans) about how each title was developed is not included and is not available. The list of titles may provide ideas to those in search of a suitable project but a specific project under any title may take many different forms depending upon the individual student. (9)

President's Council on Recreation and Natural Beauty, 1968. *From sea to shining sea, a report on the American environment--our natural heritage.* U. S. Government Printing Office, Washington, D. C. 304 pp. $2.00.

This publication, available in major libraries and from the U. S. Government Printing Office, presents the consequence of man's impact on his environment. "In his single-minded pursuit of particular aims--evolving into the intensive specialization accompanying technological advance--man has often been oblivious to unintended side effects of his actions." The publication presents a national beauty movement defined as, "...a vigorous expansion of traditional concepts of the American conservation movement started by John Muir, Gifford Pinchot, and Theodore Roosevelt." All facets of the subject are covered under; *The Environment* - the urban areas, the rural areas, and transportation; *Sharing Responsibility for Action;* and *Keys to Action* including literature, films, agencies and organizations that can help, "...until the impact of the renewal of the American environment has been felt in every part of the land." (2, 3, 4, 5, 6, 7, 8)

Research problems in biology--investigations for students. Series 1 and 2, 1963, and Series 3 and 4, 1965. Anchor Books, Doubleday and Company, Inc., Garden City, New York.

Each of these four, 160-page, paper back books contain 40 investigations sampling areas of research. The investigations were prepared by biological scientists and present background of current knowledge, suggested approaches to the problem, and appropriate references to scientific literature. Each investigation is an invitation to discovery, emphasizing inquiry and encouraging independent work. (9)

Rosenfeld, Sam. 1965. *Science experiments with water.* Harvey House, Inc., Irvington-on-Hudson, New York, N. Y. 190 pp.

Illustrates, describes and discusses numerous simple experiments with water that clearly presents basic physical phenomena of water and

related subjects. Thought-provoking questions lead students to other investigations. Available in libraries or from the publisher. (9)

Sawyer, R. W. and R. A. Farmer. 1967. *New ideas for science fair projects*. Arco Publishing Company, Inc., 219 Park Ave. South, New York 10003. 155 pp. $3.95.

An excellent book for prospective science fair participants. It explores and explains every aspect of science fair activities: how do you choose a topic?; what are the basic techniques of research?; how do you plan and build a project around your selected topic?; how do you prepare a timetable?; how much will your project cost and how long will it take to build?; who can help you with your research?; how do you enter your project in a science fair?; what types of fairs are there?; what are the rules?; who does the judging and what are the rewards? It includes 22 national fair-winning reports by actual participants, some of which are illustrated by photographs and drawings. These will be helpful to science fair participants. (1, 9)

Science Clubs of America, 1966. *Science activities handbook*. Science Service, Inc., 1719 N Street, N.W., Washington, D. C. 20036. 63 pp. $1.00.

A handbook for teachers, club sponsors, and parents of science-interested youth. Includes information from many sources helpful in encouraging student scientists. Contains sections about science fairs (national, international, local) with background information about organization, rules, regulations and judging; about the National Science Talent Search; and about many other helpful subjects. (1)

Showalter, V. M. and I. L. Slesnick, 1966. *Ideas for science investigations*. National Science Teachers Assn., 1201 Sixteenth Street, N.W., Washington, D. C. 20036. 58 pp. $3.25.

This is an excellent reference for science fair participants. Part one, containing a chapter for students and a chapter for teachers, indicates how to use the publication. Part two, comprising five chapters, is devoted to "development of investigations." The first chapter of this part deals with selecting and starting the problem. The next three chapters illustrate how three different students developed entirely different and acceptable projects from the same basic project. The fifth chapter of this part deals with reporting the project. Part three presents project suggestions as "ideas for investigation." These are organized into four groups--biology, chemistry, physics, and general. Project topics are stated and discussed briefly. Then, a number of questions or statements are presented about each topic that leads the student into selecting his own specific project for investigation. Part four is a selected reference listing of relatively recent publications organized under the headings "ideas," "techniques," and "information in depth." (1, 9)

Smith, Guy-Harold (ed.), 1965 (3rd ed.). *Conservation of natural resources*. John Wiley and Sons, N. Y. 533 pp. $9.95.

A comprehensive textbook written by many authorities. Contains chapters on specific resources, historical review, evaluations of past activities and future outlook. Bibliography material is included throughout the text and at the ends of chapters. (2, 3, 4, 5, 6, 7, 8)

Soil Conservation Service. 1964. *Water facts - sources - supplies - needs - uses - losses - floods - conservation*. U. S. Dept. Agric., Soil Conservation Service, PA-337. 14 pp.

This pamphlet, issued in 1957 and revised in 1964, provides a brief factual summary of water. A student interested in developing a conservation science fair project about water will obtain background information from this publication that will help him relate a specific project to water conservation. Obtainable free from a local or the national office of the Soil Conservation Service. (5)

Soil Conservation Service. 1964. *Grass in conservation in the United States*. U. S. Dept. Agric., Soil Conservation Service, SCS-TP-143. 43 pp.

A technical publication basic to a broad understanding of the use of grass in soil and water conservation. It includes four main sections written by authorities: grass in soil and water conservation; grass in conservation farming; conservation of private rangeland; new plant materials for conservation farming and ranching. There is an excellent, comprehensive but selected list of publications for further study. The more advanced science fair participant will obtain information to help him relate a project dealing with grass and legumes to conservation of grassland. Available in major libraries or from the U. S. Government Printing Office, Washington, D. C. (7)

Stallings, J. H. 1957. *Soil conservation*. Prentice-Hall, Englewood Cliffs, N. J. 575 pp. $9.95.

This is a general and comprehensive textbook of permanent value. (2, 3, 4, 5, 6, 7, 8)

Strong, Evelyn. 1966. *Science fairs? why? who? helping children learn science*. (A selection of articles reprinted from *Science and Children*.) National Science Teachers Association, 1201 Sixteenth St., N.W., Washington, D. C. 20036.

This publication discusses science fairs for elementary schools. It gives two criteria for selecting children's participation. Suggestions for suitable science projects are given under the following four headings: observations of the environment; demonstration of a basic principle of science; collecting and analyzing data; controlled experimentation. "Worthwhile projects are those which are

problem-centered and in which the process is important--not those which center on showmanship or gadgetry in display." (1, 9)

Taylor, John K., Phoebe Knipling and Falconer Smith. 1962 (rev.). *Project ideas for young scientists*. Joint Board on Science Education, 6113 Trowbridge Place, Oxon Hill, Maryland 20022. 173 pp. $1.25.

This book discusses the purposes and nature of science projects, science exhibits, and science fair activities in the greater Washington, D. C. area. Definitions used in Prince Georges County, Maryland for classifying projects into eleven general subject-matter fields for exhibit are given together with instructions for preparing exhibits and in judging. Numerous project titles are presented with brief, general discussions about how a project may be developed and listing one or more published sources of information that will help the student get started. These projects are organized under 12 areas--zoology, botany, agricultural science, conservation, chemistry, engineering, etc. There is a chapter listing a large number of briefly annotated, unclassified titles suggestive of science projects, and a chapter listing many "just titles." (1, 9)

UNESCO. 1959. *Seven hundred experiments for everyone*. Doubleday and Co., Inc., New York. 221 pp.

Prepared by the United Nations Educational, Scientific and Cultural Organization for world-wide use through translated editions. Chapters cover the following subjects: plants; animals; rocks, soils, minerals, and fossils; astronomy; air and air pressure; weather; water; machines; forces and inertia; sound; heat; magnetism; electricity; light; the human body. Clear explanations and diagrams are provided on how to make necessary equipment and how to perform many experiments to demonstrate "basic principles that govern the world." Appendices include listings of ready references, scientific data and information that may be needed. (1, 9)

Viorst, Judith. 1967. *150 science experiments step-by-step*. Bantam Books, Inc., 271 Madison Avenue, New York, N. Y. 10016. 180 pp. 60¢.

This book is written for young people interested in exploring some of nature's basic laws through the experimental process. It covers the fields of chemistry, physics, biology, weather, and numbers. The experiments, designed for grades six to nine or ten, range from easy to challenging. (1, 9)

Weaver, E. G. (ed.). 1969. *Science experiments in environmental pollution*. Holt, Rinehart and Winston, Inc., 393 Madison Avenue, New York, N. Y. 10017. 40 pp. $1.00.

A booklet of new ideas for investigating pollution problems. Written in the spirit of inquiry, they provide ideas for student or class projects. Projects include physical and chemical tests for such air and water pollutants as fluoride ions, acids, sulfur dioxide, dust, and radioactive particles. Projects dealing with the effects of micro-organisms on solid wastes, such as paper and aluminum foil as well as on detergents and soap are also included. Many helpful diagrams and hints on constructing testing devices are given. Some suggested investigations are very simple and use a minimum of equipment and chemicals. This publication provides projects for junior and senior high schools but some investigations will be too complex for junior high schools. (9)

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