ECOLOGY IN HIGH SCHOOL BIOLOGY COURSES IN THE ELEVEN WESTERN STATES

by

JACK WINSTON CARMICHAEL

A THESIS

submitted to

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

July 1949

APPROVED:

[redacted]

Professor of Science Education
In Charge of Major

[redacted]

Head of Department of Science Education

[redacted]

Chairman of School Graduate Committee

[redacted]

Dean of Graduate School

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to Mr. Stanley E. Williamson for his inspiration and guidance throughout the preparation of this study.

Acknowledgment is made to Dr. Henry P. Hansen for his corrective criticism and guidance in all phases of this work concerned with ecology.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONTINUED)

ECOLOGY IN HIGH SCHOOL BIOLOGY COURSES IN THE ELEVEN WESTERN STATES

CHAPTER I

INTRODUCTION

It has been said that "the schoolroom is only significant when it leads us to an understanding of life outside its walls" (9, p.177). Weaver, a nature study enthusiast, says: (13, p.162)

> If a child can help piece together the food-chain story of a great-horned owl's use of the skunk for food and finds that the skunk in turn feeds on turtle eggs, and the turtle relies on berries and mushrooms which are fertilized by the scats or the decomposing owl pellets containing the remains of the skunk, he will soon show an interest in what the "essentials of life" are, as well as an appreciation of why living in the wild is so hazardous for most animals.

The better biology teachers in the secondary schools have always striven towards a vital presentation of subject matter. Many of them have found that a vital presentation can be achieved by emphasizing the ecology of living things. The views of these teachers are aptly expressed by Michaud: (7, p.164-7)

> The most understandable and comprehensive approach to the study of renewable resources (conservation) is ecological and therefore biological because it pertains to living

> things. Every field of living resource management, including the wise use of soil and water, is primarily the application of the science of ecology.
>
> Considering its basic importance, then, there seems to be a definite need to interpret some of the simpler ecological concepts in terms that can be understood by the high school biology student.

Ecology has been defined as the scientific study of the relationship of the organism to the environment. The term "bio-ecology" refers to the study of the relationships of living things with the environment, and includes both the plant and animal kingdoms. Ecology can be more specifically divided into "plant" ecology and "animal" ecology.

Since ecology consists more of the biological sciences (botany and zoology) than it does of the other natural sciences, it has sometimes been defined as "the practical application of biological principles." The importance of ecology in modern society cannot be denied if we list a few of the activities of Man depending on ecology. They include land reclamation, forestry, agriculture, grazing and range management, fish and game management, resettlement projects, land classification and planning, conservation of water resources, landscaping, and the field of medicine through the study of epidemiology.

Ecology has become so important in modern society that a new field of study, human ecology, has been evolved

and books have been written on the subject. That this has happened is probably due to the fact that there are three main factors of ecology important to the individual organism whether it be plant, animal, or human. These factors are: (1) food-getting, (2) preservation of self, and (3) preservation of kind or race (2, p.166-7).

The relationship of ecology to the other fields of natural science is best explained by Clements and Shelford: (2, p.3)

> Ecology is in large measure the science of community populations. It is concerned with natural communities primarily, and has developed a considerable fund of organized knowledge of plant communities and their dynamics, and a lesser body of similar knowledge on the animal side. Because of the synthesis inherent in it, ecology is also to be regarded as a point of view and a method of attack for various great biological problems. Not only does it concern itself more or less with the whole of biology, but also it must borrow largely from chemistry and physics, from climatology, geology, and soil science, and at the same time make basic contributions to the practical sciences of agronomy, horticulture, forestry, grazing, entomology, conservation, etc., to say nothing of education, economics, sociology, and politics. It cannot, and does not, venture to draw a line between the past and the present, and it has as significant a role to play in geological as in modern times.

Purpose and Value of This Study

It is the purpose of this study to show the extent to which ecology is being taught, and to reveal the

methods and materials currently used in the secondary schools of the 11 western states. From these findings will be determined what information or materials are available, what professional preparation is felt to be needed by teachers in the field, and what others in the field are doing to teach ecological principles.

The value of this study lies first of all in its pioneer aspect, inasmuch as it gives a first glimpse of what is being done to teach ecology on the secondary level. Secondly, the information derived, pertaining to methods, materials, and professional preparation, should prove to be of invaluable aid to the teacher training institutions of the various states. For example, the department of science education at Oregon State College might use this information in planning the training of future biology teachers, and in aiding those already in the field by providing summer session field trips, laboratory arts courses, and curriculum workshops to help them better integrate ecology within the biology curriculum.

Location and Method of Approach of the Study

This study is concerned with the secondary schools of the 11 western states. A letter of explanation and a questionnaire* were sent to 200 high schools to determine

*A copy of the letter and questionnaire may be found in the Appendix.

the extent to which ecology was being taught in the individual schools. One hundred questionnaires were sent to widely distributed schools in Oregon, and 10 questionnaires were sent to schools in each of the following states: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Washington, and Wyoming. The results recorded elsewhere in this study are based upon 56 per cent of the questionnaires sent to the high schools of the various states.

Although replies were received from 60.5 per cent of the schools, 5 per cent were omitted because the questionnaire did not apply to their situation or was so incompletely filled out as to be worthless in tabulating the results. Forty per cent failed to make any response to the questionnaire. In compiling the information, it was decided to use the questionnaire because it was too expensive, impractical, and would have taken too long to visit each of the states and personally contact the many teachers.

The questionnaire was checked thoroughly by experts and revised several times before being submitted to the teachers in the various schools. The Oregon School Directory, found in the science education office of the College, was used to obtain the names of biology teachers.

Statement of the Problem

In the teaching of biology, the teacher is faced with two alternatives: (1) To teach with the emphasis on subject matter, or (2) to teach with the emphasis on the practical application of subject matter. Unfortunately, too many teachers choose the first alternative, to the detriment not only of the student, but of biology. One is heartened, however, to learn of the ever-increasing numbers of teachers who are emphasizing the practical aspects of biology through ecology.

This study has been made to determine the place of ecology in high school biology courses of the 11 western states. It is concerned with the following questions: (1) To what extent is ecology being taught? (2) What units or topics comprise the biology course, and what per cent of the total content do they represent? (3) What courses of a biological nature are taught? (4) What textbooks and magazines are used? (5) Is there a sufficiency or a dearth of material on ecology? (6) What methods and techniques are used in teaching ecology? (7) Is ecology taught as a separate topic, or is it integrated into the other topics of the course? (8) What do teachers in the field think of the importance of ecology?

The problem is, (1) to present the findings of the inquiry in an adequate and orderly manner so it will aid

anyone interested in teaching ecology or preparing to become a biology teacher; (2) to study the biology course as it now exists in the secondary schools of the 11 western states; (3) to note what the schools could do to promote the advance of ecology in the biology program; (4) to determine what aid or information is needed by the schools that could be furnished by the various state departments of education, colleges, and universities; and (5) to suggest a unit in ecology to be taught in the secondary biology course.

Limitations of the Study

Some limitations of the study will be obvious to the reader. The fact that only 56 per cent of the returns could be tabulated may lead the reader to question the conclusiveness of the study. The writer must point out the fact that the returns from out of state were sufficient considering that but 10 questionnaires were sent each of those states, whereas the returns from Oregon were not as high for the number of questionnaires sent out. For further clarification, the reader is asked to refer to Table II.

Another limitation is evident since all schools did not answer the questionnaire in the same manner; for example, some schools answered certain questions and left others blank. The reasons for this are open to conjecture.

Possibly it may have been an oversight on the part of the teacher, a misunderstanding of the meaning of the question, or the question may not have pertained to the situation in a particular school.

The reader will note that since it is impossible to determine the exact per cent of ecology in the biology course, only an approximation of such has been attempted by the writer. In all fairness, the writer must state that he feels the study is adequate as far as it has gone, but that in no sense can it be considered as all-conclusive or final. Much work remains for the investigator who would write the final chapter.

CHAPTER II

BACKGROUND AND DEVELOPMENT OF THE PROBLEM

The Origin of Ecology

Although modern scientists know more about plant ecology than they do about animal ecology, it was, nevertheless, a zoologist who originated the term "ecology." According to Daubenmire: (3, p.1)

> The term ecology was proposed in 1885 by the zoologist Reiter. His combination of the Greek roots oikos (meaning home) and logos (meaning study, or discourse) etymologically implied a study of organisms at home, although he made little further attempt at definition. A year later Haeckel, another zoologist, formulated a simple definition which was in keeping with the original usage and etymology, and which remains today the most widely accepted interpretation of the scope of the word. Haeckel defined ecology as the study of the reciprocal relations between organisms and their environment.

That zoologists contrived a new word and scientific study which was ardently fostered by botanists, rather than themselves, seems altogether odd. This may have happened due to the difference in approach which zoologists and botanists make to the subject. This hypothesis is advanced by Clements and Shelford (2, p.3-4).

> More than a quarter of a century ago, the statement was made that ecology was to be considered the central and vital part of botany, and this is equally true for biology.
>
> .... In connection with the preceding, it should be realized that progress in zoo-ecology

> has been much slower. The natural unity has been obscured by the separate treatment of taxonomic groups and by such faunistic concepts as that of life zone, which, in view of the widespread destruction of many species, has rendered synthetic interpretation very difficult. Moreover, although animals are obviously physiological in their response to climate, food, etc., much progress can be made in the field of interactions (coactions and reactions) without the use of physiological experiments. Furthermore, the correlations involved are usually to be suggested by studies in the biotic community and then lead properly to physiological experiments that permit more definite control and exact analysis. In sharp contrast to plant physiology, animal physiology as taught and applied has little concern with physical factors, while general physiology deals with particular internal processes and physiological ecology with one or more species withdrawn from the community for some particular study. The consequence is the ignoring or splitting of the physiology of interactions, since this field finds its inspiration in the study of the biotic community itself.

Since botanists have so freely adopted ecology to their own uses, one is not surprised to learn that more books have been written about plant ecology than any of the other phases of ecology.

Ecology in the College Curricula

On the college and university level, offerings in ecology courses have been rather scanty in the past few years. The type of educational training offered by the particular institutions apparently had no correlation with

the scantiness of ecological subjects offered. Writing about forest schools, Taylor says: (11, p.345)

> A few years back I had occasion to go over the catalogs of more than twenty forest schools in some detail. There were plenty of courses in plant ecology, and a sprinkling of animal ecology, but almost none could be found which frankly embraced both plants and animals. In at least one university there were courses in plant ecology, animal ecology, and forest ecology!
>
> Nor could I gain information from the catalogs that indicated any attempt to coordinate or correlate the courses in ecology that were offered in the different departments.
>
> Seemingly, the ecological point of view has not, to any extent, affected the curricula.

In engineering schools the situation was found to be comparable to that in the forest schools by the investigator Sears (10, p.2).

> Turning now to the curricula in engineering schools, those of 10 leading institutions with enrollments from 2,100 to 4,900, are of interest.
>
> ... Biological engineering, as exemplified in one of the 10 institutions, is slanted toward industrial production of biological materials and includes adequate training for certain types of biological research, fundamental in character but wholly remote from environmental studies - that is, ecology.
>
> .... In only one of the institutions under discussion is a course in ecology available, and then outside the pale of engineering education.

Checking the various college bulletins on file in the Oregon State College Library, the writer discovered

that while upper division and graduate courses in plant and animal ecology are offered at Oregon State College, this seems to be the exception rather than the rule. Few of the colleges in the 11 western states offer any lower division courses in ecology and only about 50 per cent offer work on the graduate level. Table I gives a complete breakdown of the number of courses offered at the various institutions.

TABLE I

NUMBER OF COURSES IN ECOLOGY OFFERED IN COLLEGES OF THE II WESTERN STATES

Colleges	Lower Div	Upper Div	Graduate
Arizona State	0	1	0
Univ of Arizona	0	2	0
Univ of S California	0	1	2
Univ of Calif at Los Angeles	0	0	1
Colorado A & M	0	3	0
Univ of Colorado	0	2	0
Idaho State	0	1	0
Univ of Idaho	0	3	1
Montana State	0	2	1
Univ of Montana	1	2	1
Univ of Nevada	0	1	0
New Mexico A & M	2	1	0
Univ of New Mexico	0	1	0
Oregon State	0	3	6
Univ of Oregon	0	0	1
Univ of Utah	0	6	1
Utah State Agricultural	0	2	0
Washington State	0	3	1
Univ of Washington	0	0	0
Univ of Wyoming	0	6	1

At present there are four college textbooks on plant ecology, one textbook on bio-ecology, and two books on animal ecology, the latter being of older vintage, meaning that in reality there are no books on animal ecology which are up-to-date enough for use in college classrooms.

Not only is there a dearth of material on ecological subjects, but the colleges themselves do not seem inclined to emphasize ecology very much at the present time. It is probable that one reason for this is the lack of instructors with suitable professional preparation to teach ecology. This, in turn, is due to the lack of ecological courses available to the student wishing to become an ecologist. As one can see, the proverbial "vicious circle" exists. Noland (9, p.177) advances another reason for the lack of demand.

> But in the colleges most of our students are not headed for ecological work. Some will go into medicine, others into various phases of science and others into fields outside of science. For them the ecological material brought into the courses they take serves mainly to vitalize the material they are taking up in the course work.

The apathy of the colleges toward ecology will be overcome only when popular demand for it is made by the students. That this demand is slow in coming lies in the fact that ecology is still, comparatively speaking, a new subject for study.

Ecology in the High School Curricula

As has been stated previously, ecology is the practical application of the principles of biology. This being the case, it would be rather difficult for the high school biology teacher, knowingly or unintentionally, not to teach a few ecological principles in biology. How much ecology would be taught is determined by the professional training and attitude of the teacher in regards to ecology. Michaud says: (7, p.166)

> It is natural for the teacher to pass on to the students what he knows best ..... Perhaps the college ecology course needs to lay more stress on adequate interpretation for teachers rather than search for greater verbosity.

In high school biology textbooks, ecology is not incorporated as a separate topic or unit. Scatterings of ecological principles can be found throughout the various texts according to Michaud (7, p.165-6).

> Interdependence, necessities of life, influence of environment, adjustment, habitat, distribution and conservation are unit areas in high school biology that lean most heavily upon ecological thinking. Yet, ecology is seldom mentioned.
>
> ... To my knowledge, however, no high school text has been tried that uses the theme of ecology throughout. Unfortunately, many texts include essential portions of ecology, without mention of the word nor any explanation of the simpler ecological termination.

A probable reason for not teaching ecology as a separate unit has been advanced by Michaud: (7, p.166)

> As a separate unit there might be a tendency to revert to the ramifications of the college courses.

The writer disagrees with Michaud in the matter of reverting to ramifications of college courses, and believes that if biology is to be vitalized, the fundamentals of ecology must be taught as a separate unit in order to make the student more aware of the real-life relationships involved rather than merely memorizing "dry facts."

After thoroughly perusing the Readers' Guide and the Education Index, the writer was forced to conclude that ecology, as such, in the high school curricula is practically non-existent at the present time. There are many reasons for this, a few of which are called to the reader's attention.

One reason is that the professional background of the teacher would be a determining factor in how much ecology would be taught. Secondly, there seems to be a dearth of ecological material written on the high school level for teachers to utilize. The investigator may also ask the question: "How many biology teachers can define 'ecology' and are aware of its importance to science teaching?"

One way in which the above difficulties could be remedied is explained by Weaver (13, p.163).

> ... We must find and use the best methods possible for training teachers. Conservation workshops or laboratories where students can learn the principles of wildlife management, soil conservation, forestry, stream improvement, mining, sound planning of parks, highways, and playgrounds, and at the same time develop working plans and units of study for school use with the assistance of trained specialists and consultants from all the subject matter fields, seems to offer one of the better means of producing inspired, well-trained teachers who understand the role and significance of ecology as the basis for much of the conservation and nature programs of today.

It is the writer's opinion that Weaver offers the most logical remedy for the situation. It is to be hoped that Oregon State College will be one of the institutions to lead in training teachers who recognize the scope and significance of ecology in science education.

Too many high school courses today have no significance or meaning for a great majority of the pupils. This is often due to the fact that the impractical rather than the practical aspects of a course are emphasized by the teacher, or that the teacher fails to relate the subject matter to the everyday life of the community. The writer believes that biology can be given significance and meaning if the teacher will emphasize the ecological aspects of the course. The best reasons for doing so have been summed up in the following statement: (4, p.104)

> To make secondary education more meaningful, especially to the youth now commonly neglected

> by the schools, will require closer interrelationships between the school and the life and the social problems of the community. This means that the school must not go out of its way to serve as a center for more of the community's cultural and recreational activities but must plan to help study and solve its social and economic problems, cooperate with its institutions, and utilize its physical and human resources in the educational program.

Recent trends in the teaching of biology seem to indicate that some teachers are aware of the necessity for relating biology to the everyday life of the pupils and are attempting to do something about it. According to Laton and Powers: (6, p.90-1)

> Conservation has always been one of the major fields of interest for alert biology teachers and their classes. Recent work in the field of ecology has given study of conservation an underpinning of general principles which was necessarily lacking or inadequate earlier. At one of the first workshops of the Bureau considerable time was spent in discussion of Life and Environment. In this volume Paul B. Sears presents a picture of the everchanging interrelationships in plant and animal communities, which tend toward equilibrium but never become static. He goes on then to use these ecological generalizations in the interpretation of human communities.
>
> The concepts thus presented were reflected in all the community surveys made by cooperating teachers.
>
> In addition, all the schools developed units, or expanded already existing units, specifically concerned with conservation of our biological resources. These were usually included in courses in biology. Many classes approached the study of conservation from the standpoint of ecology and included human communities, especially the students' city or

> region, in their discussions. Usually a unit dealing with one topic was included in one or more classes; often it was a unit on conservation of one kind of plant or animal. In one school, however, the idea of the interrelatedness of plant, animal, and human communities proved the organizing center for one semester's work. In at least one school, students felt the significance of conservation sufficiently to make it the center of an extracurricular project.
>
> Members of the Bureau staff prepared pamphlets entitled Plant and Animal Communities, Forests and Man, and Plants and Animals for Daily Use for students.

These new developments in subject matter emphases are hopeful signs that in the future, ecology will be granted the place it deserves in the biology course along with unit status in high school biology textbooks yet to be written.

CHAPTER III

THE STUDY

Two hundred questionnaires were sent to secondary schools of various sizes in the 11 western states. One hundred questionnaires were sent to high schools in Oregon while 10 questionnaires were sent to each of the other western states. Of the 200 questionnaires sent out, 120 were returned. Of these, 112 were usable making 56 per cent of the returns available as a basis for the study. A complete breakdown of the numbers of questionnaires returned by the various states appears in Table II, shown below.

TABLE II

NUMBER OF QUESTIONNAIRES SENT AND RETURNED

State	Sent	Returned	Per cent
Oregon	100	63	63%
Arizona	10	10	100%
California	10	7	70%
Colorado	10	4	40%
Idaho	10	6	60%
Montana	10	8	80%
Nevada	10	4	40%
New Mexico	10	3	30%
Utah	10	4	40%
Washington	10	5	50%
Wyoming	10	7	70%
Totals	200	121	

The questionnaire consisted of six questions, with question No. 4 being divided into three parts. Question No. 1 was an attempt to determine what biological science courses are being offered in the schools of the various states. Schools replying from Oregon indicated that they offer more courses in general biology than other courses of a biological nature. A little more than 10 per cent of the Oregon schools offer courses in physiology and hygiene, 10 per cent offer courses in general science, while 5 per cent or less of the Oregon schools replying offer courses in botany.

General biology is offered by nearly all of the schools replying to the questionnaire from the other 10 western states. In these states 22½ per cent of those schools replying indicated that they offer courses in physiology, 12 per cent offer courses in botany, 10 per cent offer courses in zoology, 8 per cent have courses in general science, 6 per cent offer courses in health, and 2 per cent or less offer a variety of other courses. For the number of schools offering the various courses, the reader is asked to refer to Table III on page 21.

The writer was interested to note that general science was listed as a biological science course by most of the teachers answering the questionnaire. Technically, however, biology is only a part of the general science course which

also includes physics, chemistry, geology, astronomy, and meteorology.

TABLE III

1. WHAT BIOLOGICAL SCIENCE COURSES ARE OFFERED IN YOUR SCHOOL?

State	Courses offered	No. of schools offering course
Oregon	General Biology	54
	Physiology	7
	Hygiene	6
	General Science	5
	Botany	3
Other 10 western states	General Biology	55
	Physiology	13
	Botany	7
	Zoology	6
	General Science	5
	Health	4
	Advanced Biology	2
	Genetics	2
	Vocational Homemaking	2
	Vocational Agriculture	1
	Psychology	1
	Chemistry	1

The second question was an endeavor to determine approximately what per cent of the biology courses being offered was comprised of ecology in relation to other topics taught in the courses. On the questionnaire the teachers were requested to give the approximate per cents of all topics comprising the biology course.

Table IV shows that the topic health comprises 12 per cent of the biology course in the 11 western states. After health, the topics structure and ecology each make up 10 per cent of the total biology course, heredity comprises 9½ per cent, nutrition 9 per cent, behavior and reproduction each 8½ per cent, classification 8 per cent, photosynthesis 7 per cent, evolution 5 per cent, and all other topics 12 per cent.

TABLE IV

2. APPROXIMATELY WHAT PER CENT OF YOUR BIOLOGY COURSE IS COMPOSED OF THE FOLLOWING TOPICS?

Topic	Oregon	Other 10 states	All 11 states
Health	12%	12%	12%
Structure	10%	10%	10%
Heredity	8%	11%	9.5%
Nutrition	10%	8%	9%
Behavior	9%	8%	8.5%
Reproduction & sex education	9%	8%	8.5%
Classification	7%	9%	8%
Photosynthesis	6%	8%	7%
Evolution	5%	5%	5%
Others	14%	10%	12%

The figures in Table IV indicate that ecology comprises approximately 10 per cent of the high school biology course in the 11 western states. This figure pertains to the per cent which is actually taught in the classroom under the topic called "ecology." The total amount of ecological principles underlying the present biology course are, in all probability, far in excess of the per cent taught as a topic in the classroom.

The third question brought out the ecological subjects emphasized the most and the least by the teachers. It is interesting to note that adaptations to the environment, water, soil, forest, and wildlife conservation are subjects emphasized most in the biology course in the 11 western states. Probable reasons for this are that the teachers are better informed or trained in these subjects. By the same token, the fact that plant and animal communities and plant successions are emphasized least is indicative of the need for training and information on the part of the teachers. The writer is, however, cognizant of the fact that in some cases the teacher's training or background may not be the determining factor inasmuch as the teacher may have emphasized only those subjects which in his opinion were important. Also the teacher may place more emphasis on those ecological subjects which are important to the welfare of the people in the local

community. For example, a teacher in an area with a scarcity of water may emphasize water conservation in his biology course. A teacher in a logging community would most likely emphasize forest conservation in his biology course.

A glance at Table V will show that water conservation ranks fairly low among the ecological subjects emphasized most. Apparently teachers are doing a good job of promoting all phases of conservation except water conservation. Yet, of all conservation phases, that concerning water is perhaps the most important to the greatest number of living things, human beings not excepted.

TABLE V

3. WHICH ECOLOGICAL SUBJECTS DO YOU EMPHASIZE MOST?

Ecological subjects	No. of schools emphasizing most	No. of schools emphasizing least
Adaptations to environment	74	14
Forest conservation	68	17
Soil conservation	65	25
Wildlife conservation	59	31
Water conservation	51	36
Symbiotic relationships	48	31
Plant & animal dists.	48	36
Animal communities	37	48
Plant communities	32	54
Plant successions	17	69

The various uses to which water is put, such as hydro-electric power and irrigation, are important enough

reasons in themselves for teachers to advocate water conservation. But a more important reason for water conservation is the startling fact that in a great many states the water table is being lowered too rapidly by artificial methods for replacement by precipitation and other natural means. Educators have done their part to inform the public of the necessity for forest conservation. The time has come for similar emphasis to be placed upon the need for conservation of our water resources. The educators who should lead in this movement are the biology teachers.

Part "A" of question No. 4 asked the teachers to check the instructional aids used in developing ecological principles. Table VI shows the various aids and the number of schools using the aids.

TABLE VI

4. (A) WHAT INSTRUCTIONAL AIDS ARE USED IN DEVELOPING ECOLOGICAL PRINCIPLES?

Instructional aid	No. schools using aid	Per cent
Habitat studies	58	48%
Field trips	62	51%
Student projects	68	56%
Community surveys	28	22%

The writer was not surprised to discover that the student project was the aid most often used. There are several reasons why this should be so, but probably the

most important reason is that it is the easiest aid of the four listed to employ. Coupled with the fact that it also meets the needs and demands of the individual student more effectively, the student project is an aid well worth fostering.

The reader will note that the next instructional aid most widely used is the field trip. In spite of the difficulties sometimes encountered with transportation problems, it is encouraging to learn that biology teachers are making field visitations an integral part of their program. This is particularly desirable in the western states where there is an abundance of flora and fauna with which to confront the student.

Since field trips are part of the ecology program, it logically follows that the habitat study is also an aid often employed. Once in the field, it is a simple matter for the teacher to have the students make observations of the various plants and animals in their native habitat.

The instructional aid used the least, according to Table VI, is the community survey. The reasons for this are not always clear. The teacher is not always to blame for failing to undertake a community survey. Whether or not a survey can be made often depends upon the friendship and cooperation extended to the teacher by the officials and citizens of the community. If the officials and

citizens are not inclined to be friendly, the teacher will have to be a good salesman in order to get the cooperation he needs. Here is where the personality of the teacher will, at times, be sorely tested.

Another factor to be considered is the size of the community. Because of its complexity, a large city will present more problems than a small city. The type of community, logging, fishing, industrial, will also have to be taken into consideration. But whatever the problem may be confronting the teacher, his primary job is to educate. This being true, he may find it necessary to educate the citizens in order to make them more cooperative in the matter of community surveys.

In the "B" part of question No. 4, the writer has attempted to determine what biology books are being used as textbooks in the various schools. Table VII on page 28 shows the books currently used as texts in Oregon.

The books most popular in the other 10 western states are, with the exception of Baker and Mills, not the same as the ones used in Oregon. Table VIII on page 29 shows the books currently in use in the other states.

The writer was curious as to the ecological content of some of the books reported in use, so he selected four books with the intention of determining their approximate ecological content. Those selected were the former state

adopted text for Oregon, Bayles and Burnett; the book used most in the other western states, Baker and Mills; the city adopted text of Portland, Oregon, Moon, Mann and Otto; and the new state adopted textbook, selected for purposes of comparison, by Smith.

TABLE VII

4. (B) WHAT TEXTBOOK OR GROUPS OF TEXTBOOKS ARE USED IN YOUR BIOLOGY COURSE?

Books used in Oregon		No. of schools using book
Bayles & Burnett	Biology for Better Living	33
Ritchie	Biology and Human Affairs	33
Baker & Mills	Dynamic Biology Today	19
Curtis et al	Everyday Biology	9
Smith	Exploring the World of Life	8
Smallwood et al	New Biology	7
Hunter	Life Science	5
Hegner	Parade of the Animal Kingdom	5
Mank	The Living World	2
Vance	Biology for You	2
Fenton & Kambly	Basic Biology	1
Crisp	Health and You	1

With the exception of the book by Moon, Mann and Otto, the word "ecology" is seldom or never used, nor is ecology included as a separate topic in any of the textbooks selected for comparison by the writer. The ecological content of the book by Baker and Mills is, perhaps,

TABLE VIII

4. (B) WHAT TEXTBOOKS OR GROUPS OF TEXTBOOKS ARE USED IN YOUR BIOLOGY COURSE?

Books used in other 10 western states		No. of schools using book
Baker & Mills	Dynamic Biology Today	21
Curtis et al	Everyday Biology	19
Moon & Mann	Modern Biology	13
Smallwood et al	New Biology	11
Ritchie	Biology and Human Affairs	8
Bayles & Burnett	Biology for Better Living	5
Smith	Exploring Biology	5
Vance & Miller	Biology for You	2
Piper et al	Everyday Problems in Biology	2
Hunter	Life Science	2
Hegner	Parade of the Animal Kingdom	1
Kroeber & Wolf	Adventures with Living Things	1

a little greater than the others. This is limited to symbiosis, plant and animal distributions, animal

communities, adaptations to environment, and conservation of forest, wildlife, soil, and water. The same is true, in varying degrees, of the books by Bayles and Burnett, and E. T. Smith. The topic on ecology in the book by Moon, Mann and Otto is good as far as it goes, but the authors seem content to mention ecology only in this one topic. Some ecological principles are scattered throughout the rest of the book, however, thus compensating somewhat for the omission of the word "ecology" from the rest of the text. Table IX is an evaluation of some of the more commonly used textbooks in the 11 western states. As will be seen, the general ecological content of the books evaluated is almost the same.

TABLE IX

APPROXIMATE ECOLOGY CONTENT OF FOUR BOOKS CURRENTLY USED IN THE 11 WESTERN STATES

	Book	Ecology as a topic	Ecology content of entire book
Baker & Mills	Dynamic Biology Today	0%	30%
Bayles & Burnett	Biology for Better Living	0%	25%
Smith	Exploring Biology	0%	25%
Moon, Mann & Otto	Modern Biology	5%	15%

The evaluation is only an approximation of the ecology content of the textbooks and was determined by the number of ecological topics and total number of pages devoted to ecology in the books.

No high school textbook used at present in the 11 western states has a unit on ecology. Apparently no high school biology textbook has been written yet which has ecology organized on the unit basis. Until such a book is forthcoming, the writer believes that little ecology will be emphasized in the high school biology courses of the nation.

The "C" part of question No. 4 asked the teachers to list the magazines and other books they found helpful in developing ecological principles. Table X on page 32 shows the magazines used in the various schools. As will be seen, after glancing at Table X, the magazines most frequently used are Nature, National Geographic, Natural History, Science Illustrated, Science News Letter, and Life.

The writer questions the usefulness of some of these publications in developing ecological principles. When ecological material is available in magazine articles, it is generally written on a higher reading level than is desirable for use in secondary schools. This means that if the teacher plans to use such material he must first reword it into language more usable on the secondary level. For

the teacher with a hazy background of ecology, the task may be difficult.

TABLE X

4. (C) WHAT MAGAZINES AND OTHER BOOKS HAVE YOU FOUND ESPECIALLY HELPFUL IN DEVELOPING ECOLOGICAL PRINCIPLES?

Magazines used in the 11 western states	No. of schools using magazine
Nature	42
National Geographic	18
Natural History	16
Science Illustrated	16
Science News Letter	13
Life	11
Readers' Digest	7
Hygiea	6
Science Digest	6
Wild Life	4
Nature Study	4
Scientific American	3
US Gov't Bulletins	3
Popular Science	3
Field and Stream	3
Turtox News	3
American Forests	2
Science Monthly	2
Wyoming Wild Life	2
Outdoor American	2
Sports Afield	2
Time	2
The Science Teacher	2
Natural Science	1
Ecology	1
The Biology Teacher	1
Audobon Magazine	1
Bird Life	1
Science Survey	1
Science Weekly	1

The writer interprets Table X to mean that at times the magazines listed by the teachers are helpful in

developing ecological principles, but that this should not be construed to mean that such is always the case.

Out of the list of other books found helpful in developing ecological principles, only two of the books listed were actually written about ecology. A glance at Table XI will show the reader that Plant Ecology by Weaver and Clements, and Buchsbaum's Book of Ecology are, apparently, the only two books on ecology being used to any extent in the 11 western states.

The book by Weaver and Clements is written for the college level as is the book by Buchsbaum. The other books listed in Table XI are either about botany and biology, or some phase of zoology. This means that from the available books the teacher must be able to glean enough ecological material to make his own unit of work on ecology. All of which indicates to the writer that there is a definite dearth of material on ecology written for the secondary level.

TABLE XI

4. (C) WHAT MAGAZINES AND OTHER BOOKS HAVE YOU FOUND ESPECIALLY HELPFUL IN DEVELOPING ECOLOGICAL PRINCIPLES?

Other books used in the 11 western states	
Bailey	Mammals and Life Zones of Oregon
Brown	Botany
Bogert	Nutrition
Buchsbaum	Book of Ecology
Burdick	Vizualized General Biology
Compton	Conquests of Science
Coulter	A Textbook of Botany
Day & Ritchie	Studies and Activities in Biology
Ditmars	Snakes of the World
Dupuy	Romance of Science
Elliot	Conservation of America's Resources
Finlay	American Birds
Frye & Rigg	Elementary Flora
Gilkey	Northwest Flowering Plants
Gray	New Manual of Botany
Grinnel & Stores	Animal Life in Yosemite
Gruenberg & Bingham	Biology and Man
Hall	Partner of Nature
Jaffe	Outposts of Science
Jordan & Everman	American Food and Game Fishes
Loyd & Needham	Life of Inland Waters
Mier & Shoemaker	Essentials of Biology
Pack & Gill	Forest Facts for Schools
Peck	Manual of Higher Plants
Powers	Exploring our World
Renner & Hartley	Conservation and Citizenship
Ricketts	Between Pacific Tides
Transeau	General Botany
Weaver & Clements	Plant Ecology

Question No. 5 was an attempt to determine what importance is attached to ecology by the teachers in the field. Table XII shows that over half of the teachers queried would include more ecological material in the future if they revised their biology courses. The majority of the teachers apparently feel that ecology should be an important part of the biology course. In this the writer most heartily concurs.

TABLE XII

5. IF YOU WERE CHANGING YOUR BIOLOGY COURSE, WOULD YOU INCLUDE MORE ECOLOGICAL PRINCIPLES IN THE REVISED COURSE?

State	No. of schools reporting	Yes	No	Undecided
Oregon	54	32	20	2
Arizona	10	4	6	
California	7	5	1	1
Colorado	4	1	3	
Idaho	6	2	3	1
Montana	8	2	5	1
Nevada	4	2	2	
New Mexico	3	2	1	
Utah	4	4		
Washington	5	2	3	
Wyoming	7	3	3	1
Totals	112	59	47	6

In answering question No. 6 the teachers were almost unanimous in replying that they believed courses on ecology should be included in the professional preparation of biology teachers. Table XIII on the next page shows

that 103 teachers answered "yes" to the question while 9 were opposed with answers of "no." In addition to

TABLE XIII

6. IN THE LIGHT OF YOUR EXPERIENCE, SHOULD COURSES ON ECOLOGY BE INCLUDED IN THE PROFESSIONAL PREPARATION OF BIOLOGY TEACHERS?

State	No. of schools reporting	Yes	No
Oregon	54	48	6
Arizona	10	9	1
California	7	7	
Colorado	4	3	1
Idaho	6	6	
Montana	8	8	
Nevada	4	3	1
New Mexico	3	3	
Utah	4	4	
Washington	5	5	
Wyoming	7	7	
Totals	112	103	9

answering "yes" or "no" to the question in Table XIII, many of the teachers added comments of their own to emphasize their answers. A few of the comments are reproduced herewith:

> "Probably - for wide knowledge of subject."
>
> "I believe a minimum of six semester hours (in ecology) should be required."
>
> "Yes, especially if field trips can be taken some distance from school."
>
> "I feel teachers should be very conscious of this phase of biology. It is

one of the best means of making the course practical. For that reason I feel more training would increase their 'awareness'."

"Certainly"!

"Yes, but not to the exclusion of or substitution for other phases of biology such as anatomy, physiology, classification, genetics, etc."

"Concerning the training of the teacher, it is my opinion that the teacher should have more biological background than he has. I think that this should not entirely be straight lecture-lab type of course that is given at the college, but rather of the field zoology nature. The educational trip that your department made to the Institute of Marine biology last summer is what I have in mind ..... I believe that those people who attended could give a more interesting presentation of biology, particularly ecology. If similar trips could be made to the mountains and to the desert, not just for a day but for a period of time, the teacher could give a more interesting presentation and it wouldn't be entirely necessary for him to take a course in ecology ..... I just believe that biology begins in the field and not in the classroom."

"Yes, very definitely."

"Field courses - yes."

"Decidedly, yes."

"Yes, unless emphasis is given in general (college) courses."

"I have always felt that biology should be a course in which ecological biology had a dominant place in the program. Having worked directly with forest and wildlife service, I feel a keen interest in this phase of biology."

"Very much - with lots of field work."

"It all dovetails in work stress."

"Yes, but I had one such course at the University of Montana last summer - conservation of natural and human resources - which was completely worthless."

As can be seen from the foregoing comments, the teachers believe that ecology should be included in the professional preparation of new teachers. Most of the teachers seem to feel that the ecology course should be composed of studies in the field. The writer, having had such field courses in ecology, is quite in agreement with the teachers on this point.

Comments on the study, while not solicited by the writer, were nevertheless forthcoming from some of the teachers.

"I'm very happy to do what I can to help your research in this field ..... Perhaps after you receive many returns, you might tell me about it."

"We shall be interested in the results of your study."

"I would like to see a summary of your findings when available. It strikes me as being a valuable study. I advocate teaching a course in conservation in which ecology could be stressed more than in present general biology courses."

The writer is proud of the fact that the comments on the study itself were of the positive rather than of the negative type.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Of 200 questionnaires sent out to high schools of various sizes, 121 were returned of which 112 were usable. The study shows that fewer courses in biological science are offered in Oregon than in the other 10 western states. Ten per cent of the Oregon schools offer courses in physiology and hygiene, ten per cent offer general science, while five per cent offer courses in botany. Of the schools in the other 10 states, 22.5 per cent offer courses in physiology, 12 per cent offer botany, and 10 per cent offer courses in zoology.

Of the various topics in the biology courses of the 11 western states, only one topic, health, is emphasized more than ecology; health comprising approximately 12 per cent and ecology 10 per cent of the total content of the course.

In the matter of emphasis on ecological subjects, the teachers seem to be doing a good job of promoting all phases of conservation except water conservation. Ecological subjects emphasized most are adaptations to environment, forest, soil, and wildlife conservation. Subjects emphasized least are plant and animal distributions, plant and animal communities, and plant successions.

Instructional aids used most in developing ecological principles are student projects and field trips. Textbooks used most in Oregon (aside from former state-adopted text) are texts by Ritchie, Biology and Human Affairs; Baker and Mills, Dynamic Biology Today. Textbooks used most in the other 10 western states are texts by Baker and Mills, Dynamic Biology Today; Curtis, Caldwell, and Sherman, Everyday Biology. Apparently none of the textbooks in use allot unit status to ecology, however, approximately one-fourth of the contents of the biology books in use is devoted to ecological principles.

Magazines most often used in developing ecological principles, in order of importance, are Nature, National Geographic, Natural History, Science Illustrated, Science News Letter, and Life. Quite a large variety of books were reported as being found helpful in developing ecological principles.

A majority of the teachers indicated that they would include more ecology in their courses the next time they were revised. An overwhelming majority of teachers indicated that courses on ecology should be included in the professional preparation of future biology teachers.

Conclusions

The study seems to indicate the following conclusions: (1) Ecology is not being taught as a separate unit but is being integrated with the other topics of the course. (2) Ecology comprises about 10 per cent of the total content of the biology courses offered in the 11 western states. (3) There seems to be a dearth of material on ecology written for the secondary level. (4) The majority of teachers are convinced of the importance of ecology and stress it wherever possible. (5) The teachers are almost unanimous in declaring ecology to be an essential course for prospective biology teachers.

Recommendations

As a result of the foregoing, the writer would like to make the following recommendations:

(1) That courses in plant and animal ecology or bio-ecology be required of all prospective biology teachers.

(2) That special workshops and field studies in ecology be provided for biology teachers by the institutions of higher learning throughout the 11 western states.

(3) That teachers, professors, and other qualified persons be encouraged to write more articles, books, and pamphlets on ecology for the secondary level.

(4) That authors of high school biology books devote more space to ecological subjects (symbiosis, adaptations, conservation, plant and animal communities, etc).

(5) That ecology be taught as a separate unit in the biology classroom as well as integrated with the other topics of the course.

Appendix "A" contains a suggested unit on ecology for the secondary level.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Aikman, J. M. What in ecology is most significant to the biology teacher? The ecologist's viewpoint. Amer. Biol. Teacher. 9:168-72, 1947.

2. Clements, F. E. and V. E. Shelford. Bio-ecology. New York, John Wiley and Sons, 1947.

3. Daubenmire, R. F. Plants and environment. New York, John Wiley and Sons, 1947.

4. Federal Security Agency. US Office of Education. Life adjustment education for every youth. Washington, D.C., 1947.

5. Grant, C. L. Ecology in science teaching. Am. Biology Teacher. 9:231-2, 1947.

6. Laton, A. D. and S. R. Powers. New directions in science teaching. New York, McGraw-Hill Book Co, Inc, 1949.

7. Michaud, H. The teaching of ecology from the biology teacher's viewpoint. Am. Biol. Teach. 9:164-7, 1947.

8. Mullen, J. A. Observations of the teaching of biology. Sch. and Soc. 65:142-4, 1947.

9. Noland, L. E. What in ecology is most significant to the biology teacher? A zoologist's viewpoint. Amer. Biol. Teach. 9:176-7, 1947.

10. Sears, P. B. Importance of ecology in the training of engineers. Science. 106:1-3, 1947.

11. Taylor, W. P. What is ecology and what good is it? Ecology. 17:333-346, 1936.

12. Thone, F. E. A. Ecology in catholic education. Cath. Ed. Reader. 36:610-13, 1938.

13. Weaver, R. L. The teaching of ecology from the nature study viewpoint. Am. Biol. Teach. 9:162-3, 1947.

APPENDIX A

SUGGESTED UNIT ON ECOLOGY

BIO-ECOLOGY; THE ORGANISM AND ITS RELATIONSHIPS

Overview

During our study of living things we learned about their composition and structure as well as their activities and functions which distinguished them from non-living things. We discovered that living things are made up from the chemical substances of the area in which they live. The place in which an organism lives is called a habitat. The relation of this habitat or environment to the organism is the basis for a field of biology called ecology. Ecology is the study of the organism in relation to its habitat and other organisms. Another and newer definition of ecology is that it is "the general economy and sociology of the household of nature."

Ecology is divided into two phases, autecology and synecology. Autecology is the study of the individual plant or animal, while synecology is the study of community relationships or plant and animal communities. By studying living organisms and their relationships, man has learned much about what is essential for his own welfare. For example, scientists have used ecological information to assist in establishing balanced communities at a high level of welfare for man.

In this unit on ecology we shall learn how the organism responds to the environment and, in turn, affects the environment.

Objectives

1. To learn what the environmental factors are and how they affect the organism.
2. To show how the organism may affect the environment.
3. To learn why all life is dependent upon green plants.
4. To show how all living things are dependent upon one another.
5. To develop interest in the coactions and reactions of living things and show how they are a means of restoring the balance of nature.
6. To develop skills in applying ecological principles.

Content Outline

I. The Environment

A. What are the things or influences around an organism that affect its life?

B. What is the word that describes these influences?

C. Do all living things have an environment?

II. The Physical Factors of Environment

A. Climate

1. What are the elements that make up a climate?
2. Why are temperature and light important?
3. Why does the earth's rotation around the sun affect climate?
4. How does the revolving and tilting of the earth in its axis affect climate?
5. In what way does the moon affect climate?
6. How may glacial and sun-spot cycles affect climate?
7. How does climate affect organisms in the environment?
8. How may living things affect the climate?
9. Do seasonal changes affect organisms?
10. What special structures or protection do organisms have for seasonal changes?

B. Soil

1. What is soil? Of what is it composed?
2. On the basis of structure and texture, what types of soil are there?
3. What kinds of vegetation do these types of soil support?
4. Is soil a result of vegetation or vice versa?
5. What does climate have to do with soil formation?
6. How does soil differ chemically?
7. Why is soil important to man?
8. How does changing soil affect plants and animals?
9. In what ways have special structures varied plant requirements for soil?

C. Physiography

1. What effects do slope and exposure have upon climate? Upon living things?
2. What effects do altitude and latitude have upon climate and living things?
3. How does topography affect plant and animal distributions?
4. Why do changes in the earth's surface make it necessary for plants and animals to migrate?

D. Living Things

1. Why is photosynthesis the most important biological process?
2. How do plants and animals affect the environment?
3. What is meant by the expression "a balance of life"?
4. Why do periodic changes take place in an environment?

III. Basic Activities of Organisms

A. Food Getting

1. What are "food chains"?
2. Why are green plants essential to food chains?
3. Why are the carbon and nitrogen cycles important?
4. What are the factors limiting the supply of food?
5. What is meant by the "biological potential" of an area?
6. Why is energy-getting the basis for relationships of organisms with the environment?

B. Self-preservation

1. What are the factors in self-preservation?
2. From what things must all organisms be protected?
3. Why, in the ultimate sense, is self-preservation important?

C. Race preservation

1. What are the factors in race preservation?
2. What causes periods of change in numbers and populations of plant and animal communities?

IV. Physical Environments

A. Terrestrial

1. What is a terrestrial environment?
2. What kinds of plants and animals live in it?
3. What special structures do terrestrial organisms need?
4. Is gaseous and thermal stability retained or lost by terrestrial environments?

B. Water

1. How does a marine environment differ from a fresh water one?
2. What kinds of organisms live in salt water?
3. Do water organisms need any special structures?
4. Which do water environments have: thermal stability or gaseous stability?

C. Aerial

1. What organisms live in air or spend part of their time in the air?
2. What special structures do such organisms need?

D. Arboreal

1. What kinds of organisms live on or in trees?
2. What adaptations are essential to such organisms?
3. Are they of economic importance to man? Why?

E. Subterranean

1. What organisms live underground?
2. What special structures do they have for such existence?
3. Are such organisms of economic importance to man? How?

F. Organismal

1. What are parasites?
2. What are saprophytes?
3. Which are more important to man economically, parasites or saprophytes?
4. Strictly speaking, how does the organismal environment of the parasite differ from that of the saprophyte?

V. Biotic Succession

A. What is biotic succession?

B. What causes biotic succession?

C. Steps in succession

1. What is denudation?
2. What is migration?
3. How do plants and animals migrate?
4. What is aggregation?
5. What is meant by invasion?
6. What must the organism be able to do before invasion is successful?
7. Why is ecesis important?
8. How does competition affect organisms in the environment?
9. What is reaction? How long does it continue?
10. What is an example of a man-made reaction?
11. What are coactions?
12. What regulates the speed of succession?

D. What are the two main types of succession?

VI. Symbiosis

A. What is symbiosis?

B. What are some examples of symbiotic relationships in nature?

VII. Biological Communities

A. Permanent Community

1. What is a permanent community?
2. What are dominants and subdominants?
3. What would be an example of a permanent plant or animal community in your locality?

B. Successional (temporary)

1. What is a successional community?
2. What would be an example of a successional community in your area?
3. How do plant communities act as "indicators"?

VIII. Life Zones

A. What is the basis for establishing life zones?

1. How does physiography aid in creating life zones?
2. Do altitude and latitude have any significance on setting up a life zone? How?
3. What role does climate have in establishing life zones?

B. Austral (North temperate)

1. What kind of life zones are in this area?
2. What plants and animals live in them?
3. What special structures or protection are needed for survival by organisms in these zones?
4. What is an example of an austral zone near your community?

C. Boreal (Arctic region)

1. What life zones are found in this region?
2. What organisms live here?
3. What special structures or protection is useful to organisms in these life zones?
4. Is there a boreal zone near your locality? Where?

D. Tropical (Humid-Arid)

1. What life zones are found in this area?
2. What organisms live in tropical regions?
3. Do such organisms need special structures?
4. Is there an example of a tropical life zone in the United States? Where?

IX. Value of Ecology to Human Welfare

A. How does developing an understanding and appreciation of ecological principles aid in conservation of natural resources?

1. Is ecology concerned with maintaining a "balance of nature"? In what way?
2. Does man play an important part in maintaining the balance of nature? How?
3. Should man develop skills in applying ecological principles? Why?
4. Is maintaining balanced communities important in human ecology? Why?

B. Soil, Water, Forest, and Wildlife Conservation

1. Why should we conserve our natural resources?
2. How are they lost or wasted?
3. What can we do to save our resources?
4. What is the economic value of our resources?
5. What resources are left in this country?

Approach Activities

I. Through observation and field trips to the various natural environments to make habitat and community studies.

A. A visit to a pond or lake to make a habitat study of aquatic flora and fauna.

B. A visit to the seashore where charts can be drawn to indicate the life zones at the various tide levels.

C. A visit to a forest-plant community where a study can be made of the various "layer-societies" of plants. Specimens can be brought back to the lab.

D. A visit to a swamp or marsh where the typical plants and animals of such an area can be listed.

E. Observing a peat-bog and making a chart of the various plant communities present.

F. A visit to a boreal or mountain region where the plant and animal life of the various life zones can be noted.

G. Visiting a sand dune or desert and listing the plant and animal life present. Specimens can be returned to the laboratory for comparison with specimens from other environments.

II. Through Guest Speakers

A. Secure speakers from the community who have jobs related to plant and animal relationships to discuss with the class the importance of ecological principles in their work. Such speakers could include:

1. Manager of a fish hatchery
2. A local florist or botanist
3. A representative of the Nat'l. Forest Service
4. Owner of a fox farm or chinchilla ranch
5. A member of the State Game Commission

B. Have interested citizens of the community discuss with the class the problems of the community pertaining to plant and animal relationships, interdependencies, and communities.

C. Secure speakers from the community who can show the class how the environmental factors affect the life of the local community (Human Ecology).

D. Local club leaders such as scoutmasters, Grange Masters, presidents of nature and 4-H Clubs, etc, can show the class the roles their organizations play in bettering the life of the community through developing skills in applying ecological principles.

E. Secure individuals who have hobbies based on the natural environment. For example:

1. Individuals growing species of undomesticated flowers, shrubs, and trees.
2. Amateur meteorologists
3. Individuals raising wild animals, birds, fish, reptiles, amphibians, or insects
4. Individuals photographing plants and animals in their natural habitats.

III. Through Motion Pictures

The following pictures are suggested as approach activities for this unit. (The main list of movies for the unit will be found listed under "Materials.")

A. Human ecology

1. Dwellers in Cold Countries
2. Dwellers in Hot Dry Countries
3. Urban Dwellers in Temperate Countries

B. Animal ecology

1. Elk for the Future
2. Private Life of the Gannets
3. How Nature Protects Animals
4. Bird Homes

C. Plant ecology

1. Phantom Sea
2. The Valleys
3. Gift of Green
4. Desert in Bloom

IV. Through Laboratory Projects

A. Building and maintaining a balanced aquarium in the classroom. Different types of aquaria should be set up to contrast similarities and differences as follows:

1. Fresh water aquaria
2. Salt water aquaria
3. Pond water aquaria
4. Tropical water aquaria (heated)

B. Building and maintaining a balanced terrarium in the classroom.

1. Desert terrarium with characteristic plant and animal life
2. Swamp terrarium with characteristic plant and animal life
3. Combination desert-swamp terrarium

C. Growing plants from varying types of environments:

1. Xerophytes - plants living in extremely dry environment
2. Hydrophytes - plants living in excess water
3. Mesophytes - plants requiring ordinary moisture
4. Psammophytes - sandy, dry soil plants
5. Oxylophytes - acid soil, bog plants

D. Obtaining and caring for animals in the laboratory:

1. Golden hamsters
2. Ant colony
3. White mice
4. Drosophila cultures
5. Infusoria cultures
6. Birds
7. Rabbits
8. Guinea pigs

V. Through Pictures, Charts, Exhibits, Drawings, etc

A. Collect (for posting on bulletin board) articles, pictures, drawings, etc; in magazines and newspapers pertaining to phases of ecology such as habitats, interdependencies, food-chains, etc.

B. Have posters made of the various cycles in nature such as carbon, nitrogen, water, and sun spot cycles.

C. Put charts on the walls and bulletin board showing the different life zones (such as arctic alpine, upper sonorran, etc) and the typical vegetation and animal life.

D. Make charts showing the various stages of succession in the two main types of succession, hydrarch and xerarch.

E. Have an exhibit of animals, birds, and insects to show protective coloration and mimicry or resemblance.

F. Construct posters depicting a variety of natural "food-chains" and their importance to us.

G. Make a drawing of the life zones in a fresh water pond. Post on bulletin board.

VI. Through Interest in Reading

A. Read books on various phases of ecology such as plant ecology, animal and bio-ecology. (See Bibliography)

B. Obtain and read pamphlets and bulletins issued by the state and federal governments on game laws, conservation of natural resources, etc.

C. Read general biology books which have ecology included in topical or unit form.

D. Obtain and read pamphlets produced by biologists and ecologists. Save for class discussions.

E. Watch for magazine articles on various phases of ecology. Save them for class use.

F. Compile a bibliography of books, articles, and pamphlets on ecology and post on bulletin board. These can be used later as a basis for library research and reports.

Suggested Activities

A. Research and Experimental Activities

1. Reading and Library Research

a. Select books from the bibliography of the unit to read and make reports from. Books such as the following will be found useful:

(1) Carr, W. H. Desert Parade
(2) Clements, Edith Flowers of Prairie and Woodland
(3) Mason, Geo F. Animal Homes
(4) Needham, J. G. Introducing Insects
(5) Webb, Addison Birds in Their Homes

b. Certain pamphlets contain interesting material, such as the following:

(1) Parker, B. M. & Bucksbaum, Ralph Balance in Nature
(2) Row Pub. Co. Plant and Animal Partnerships

c. Magazine articles are one of the better sources of ecological information inasmuch as more writers produce short articles on ecology than write books on the subject. Some of these articles are:

(1) Baker, J. H. "Surplus Populations" Audobon Magazine, 45:120. March 1943
(2) Bonner, J. "Chemical Warfare Among the Plants" Scientific American, 180:48-51. March 1949
(3) Bragg, A. N. "Protozoan Ecology" Science News, 86:307-8. Oct 1, 1937
(4) Coker, R. E. "Functions of an Ecological Society" Science News 87:309-15. April 8, 1938
(5) Devoe, A. "Trickery of Nature" American Mercury, 60:746-50. June 1945

(6) Friedmann, H. "Ecological Counterparts in Birds" Science Monthly, 63:395-8. Nov 1946
(7) Park, T. "All Life Depends on Food" Hygeia, 19:376-84. May 1941
(8) Pearse, A. S. "Ecological Segregation" Science News, 79: 167-72. February 23, 1934
(9) Peterson, R. T. "Life Zones, Biomes, or Life Forms?" Audobon Magazine, 44:21-30. January 1942
(10) Pough, R. H. "Wildlife Community" Audobon Magazine, 46:160-6, 224-33. May-July 1944

2. Laboratory Research and Experimental Activities

a. To determine the effects of organisms upon other organisms (Co-actions):

(1) Place salamander larvae and frog tadpoles (of the same size) in a half-gallon size fish bowl. Do not feed. In a similar fish bowl, place salamander larvae and tadpoles. Feed daily. Record your observations of what occurs in the two bowls. What are your conclusions?
(2) In a five-gallon aquarium (heated to approx 78 F), place two dozen week-old guppies (rainbow fish), and four baby angel fish (scalares) about six weeks old. Feed daily with small amounts of prepared food. Watch and record results. If angel fish are not available, four-lined "Barbs" or "Convict Barbs" (Barbus tetrazona) will do.
(3) In a five-gallon heated aquarium, place one dozen adult guppies and four Black or Midnight "Mollies" (Mollienesia sphenops). In another five-gallon aquarium (heated) place six "Mollies". Watch the two tanks and record your observations and conclusions in your notebook. During the observation period (10 days) pay particular attention to the "Mollies".

(4) In a two-gallon aquarium containing plants place a dozen adult guppies and numerous aquatic snails such as Red Ramshorns, and Pond (Physa) snails. In another two-gallon aquarium place six white cloud mountain fish (tanichthys albonubes), and numerous Pond and Red Ramshorn snails. Watch the two tanks and record your observations. What happens to the snails in the guppy tank? What happens to the snails in the white cloud tank? Conclusions?

b. To demonstrate biological control:

Set up an aquarium of three-gallon size and with a five-watt heater, bring water to a temperature of 78 F. The tank should be sparsely planted with vallisneria (a fresh water eel grass). Place a "ripe" female guppy and a dozen other guppies of varying sizes in the tank. Watch for the birth of the baby guppies and count them daily for two weeks. As a control, set up another aquarium in the same manner including the same number of adult guppies and the "ripe" female. This second tank should be heavily planted with vallisneria, water-sprite, Salvinia, and Duckweed. If cabomba is available, this can be used too. Watch the two tanks and record your observations. In which tank does the "population" increase most rapidly? In which tank is the population increase lowest? Conclusions? (Before making your conclusions, be sure you have made an accurate count of the fish in each tank daily for two weeks.)

c. To show the effect of environmental factors:

(1) Put clay, gravel, sand, and loam into four small flower pots so that each pot will contain a different type of soil. Plant two grains of corn in each of the pots. Place the pots in a place where sunlight strikes daily. Water the pots daily or when

necessary. Which of the pots contains the healthiest-looking corn? After 3 weeks, which pot has the best corn shoots? Write your observations and conclusions in your notebook. Be sure to indicate which type of soil proves to be best in growing corn.

(2) Water a normal, healthy cactus plant daily until soil around plant is thoroughly moist. As a control, use another cactus plant which you water only when necessary. Observe four or five days and record your conclusions. Is water very important to a cactus plant? Why?

(3) Repeat the above experiment but use nasturtiums. Observe five days and write your conclusions. Is water very important to nasturtiums?

(4) Examine the leaf and stem tissues of a hydrophyte (Cabomba or Anacharis), a xerophyte (sand Verbena or Cactus), and a mesophyte (nasturtium or sweet pea). Make drawings of each. Why do they differ in structure?

(5) Obtain one or more of the following reptiles: Rubber boa (Charina bottae) Plated or Alligator Lizard (Gerrhonotus Multi-Carinatus), Douglass' Horned Lizard (Phrynosoma douglassii) or the American chamaeleon (Anolis carolinensis). Place one of the above creatures in a warm or sunny spot and observe for 30 minutes. Then place the reptile in a container and gradually lower the temperature in the container by placing near an electric fan or running cold water around the sides of it. If a refrigerator is available, the container can be placed in it to further lower the temperature. This must be done gradually, and in no event should the temperature be lower than 30 F, nor remain for any length of time at that

point. After the temperature is lowered, observe the reptile for 30 minutes. Try various stimuli on the creature. How fast does the reptile react? Does it show much signs of life or great activity? How important is temperature to reptiles? Write your conclusions in the form of a special report.

(6) Place salamander larvae or frog tadpoles in a half-gallon fish bowl containing "old" water. Gradually raise the temperature of the water (by placing near stove or heater) until the larvae show signs of distress. Record the temperature at that point. To determine the thermal death point (high or low temperature mark beyond which results in death of the organism) raise or lower the temperature accordingly until the larvae give definite evidence of succumbing. How important is temperature to amphibians? Are they "tolerant" of sudden or wide temperature changes? Write your conclusions in report form.

(7) Place four six-week old goldfish in a half-gallon bowl containing "old" water. Floating plants such as "duckweed" and rooted plants such as vallisneria should be placed in the bowl. In a five-gallon aquarium, which is moderately planted with vallisneria, cabomba, and watersprite place four six-week old goldfish. Feed the fishes in the bowl and tank daily with commercial powdered foods, and every other day with white worms or chopped earthworms. Observe for two months. In which container are the largest fish? Why are the fish in one container larger than those in the other? Does the environment (bowl or aquarium) have anything to do with the size of the fish? How?

(8) Obtain two potted geraniums. Water both as needed. Place one where it will receive plenty of sunlight. Place the other where there is an absence of light. Observe the two plants in a week. Which plant is the greenest? Why? Is light an important environmental factor? Write your conclusions.

d. To demonstrate community relationships, obtain an ant colony and observe for two weeks. Make a list of the things done by the various ant "citizens". In what ways are human communities similar? Write your conclusions.

e. To show the effect of the organism upon the environment (reaction), plant small shoots of vallisneria and water-sprite in a one-gallon fish bowl or aquarium. Place the bowl where it will receive a normal amount of sunlight. Observe for two weeks and record results. Then place six adult guppies or four white cloud mountain fish in the bowl. Observe for two weeks and record results. Did the plants grow better with, or without, the fish? Why? Write your conclusions in report form.

f. To demonstrate special adaptations (structures) the organism has developed due to the environment, obtain specimens of birds, insects, amphibians, fishes, reptiles, and mammals as well as plants. Make a study of one organism from each group and record the results in table form.

3. Interviews

a. Consult the county farm agent on such problems as soil and water conservation.

b. Talk with a state or federal forester about forest ecology and conservation.

c. Interview long-time residents of the community to find out the changes wrought in the environment by Man.

d. Interview residents and see if they can be persuaded to predict what future changes may be wrought in the local environment.

e. State Game Commission officials can be interviewed about animal ecology and game conservation.

f. Write to any of the above-mentioned persons who are not available for personal interviews or discussions.

4. Motion Pictures (See list of materials at the end of this unit)

5. Community Projects

a. A survey can be made to determine what the immediate problems of the community are that may be related to ecology.

b. Upon the basis of the findings of the survey, special projects attacking the various problems can be started. For example: a project to devise ways and means of conserving the natural resources of the community; a project to study ways and means of eliminating birds, animals, insects, or plants that have become pests to the community.

B. Field Trips and Excursions

These may be made by individuals, groups, or entire classes.

1. Visit a woodland community of trees, shrubs, and flowering plants. Make sketches of the different "layer" societies.

2. Select a small hill with north and south exposures. Make a sketch of the vegetation growths on each exposure. Select specimens from each slope and bring back to the lab for further analysis.

3. Visit a local museum or one in a nearby town or city and observe the collections of plant and animal life, both extinct and present forms.

4. Make a trip to observe plant partnerships, (such as algae and fungus making up a lichen) and plant parasites and saprophytes.

5. Explore the woods and woodlands in the immediate locality to discover epiphytes or epiphytic relationships.

6. Visit a cultivated field which adjoins a plot of uncultivated land to illustrate how plants act as "indicators".

7. Make a trip to a peat bog that is drying up or an eroding hillside to observe how the environment is in a constant state of change.

8. Visit a local aquarium or aquarist supply shop and observe the differences in structure of the various aquatic flora and fauna.

9. Make a trip to a lake and observe the different communities of plants and animals that live around, on, and in the lake.

10. Visit a small pond and estimate the animal population of the pond by seining methods.

11. Make trips to secure animal and plant specimens that illustrate phases of ecology such as protective resemblance and coloration, special structures (adaptations) for defense, locomotion, seed dispersal, etc.

12. Make a series of trips to discover the plant and animal communities near the local community.

C. Construction Activities

1. Build an aquarium for home or school use.
2. Prepare a chart showing various "food-chains".
3. Build a terrarium for use at home or school.
4. Prepare an exhibit of animals and insects to illustrate types of special structures the organisms have evolved to live in the various types of environments.
5. Make a series of kodachrome pictures on life zones and plant communities.
6. Make a model of a woodland community, showing the various "layer" societies of trees, shrubs, herbs, etc.

7. Make a collection of seeds to show the various sizes, forms, and specialized structures for seed dispersal.
8. Construct a chart showing the various life zones such as boreal, austral, etc, and indicate, by means of drawings, the animal life forms found in each zone.
9. Construct a model of a small hill showing the types of vegetation on north and south exposure slopes, and the different plant forms found at the various altitude levels.
10. Make a chart of a woodland or forest community and a chart of a small hill showing the vegetation types and "layer" societies.

D. Appreciative and Creative Activities

1. Appreciation Activities

a. Prepare a large chart showing man's place in relation to food "chains".
b. Observe a balanced aquarium, making a list of the "services" performed by snails, fishes, and plants. Note that each organism has a special job to do or a special contribution for the welfare of all.

2. Creative Activities

a. Write an original play, dialogue, or radio script about some phase of ecology that appeals to you, such as plant communities.
b. Write an interesting story or article on food "chains" or some other phase of ecology.
c. If you like to draw, prepare a picture or series of pictures on the life zones of a pond, plant and animal communities, life zones, etc.
d. If you like to draw cartoons, make a series of cartoons on conservation of natural and community resources, plant and animal relationships, etc.
e. If photography is your hobby, make a series of kodachrome pictures on life zones, plant communities, etc.

E. Reporting and Discussion Activities

1. Individual and Committee Reports

a. The importance of water and soil conservation.
b. Food "chains".
c. Effects of improper methods in cutting timber.
d. Economic importance of ecology.
e. Man and the balance of nature.
f. Strange bedfellows, symbiosis and parasitism.
g. "Layer" societies of a forest community.
h. What good is wildlife conservation?
i. Plants have defenses.
j. Citizens of a wildlife community.
k. Plants are "indicators" of soil.
l. Biological control among animals.
m. Organisms that aid seed dispersal.
n. Nature punishes mistakes of man.
o. Human ecology and its importance.

2. Problems for Discussion

a. Why do all living things depend upon one another for existence?
b. Why is ecesis important to plants?
c. Which group could live without the other, plants or animals?
d. How does competition affect organisms?
e. In what ways does a changing environment affect plants and animals?
f. Why does an ever-increasing insect population threaten mankind?
g. How do plants and animals maintain the balance of nature?
h. What are man-made reactions?
i. Why is biotic succession inevitable?
j. Why is photosynthesis the most important biological process?
k. What are the types of physical environments?
l. What problems must man solve before he can live in harmony with his environment?

3. Outside Speakers

Outside speakers can often be obtained to present materials and ideas pertinent to

various phases of the unit. Although the local situation may often determine the availability of speakers, the following is a list of possibilities:

a. Professional Ecologist
b. State Game Warden
c. College professors of biology, botany, and zoology
d. National and State Foresters
e. Manager of a tropical fish shop
f. Officers of local wildlife clubs
g. Curator of a zoological garden
h. Explorers and big game hunters
i. Supt of a fish hatchery
j. County Farm Agent
k. A local florist

Culminating Activities

A. Special committees can perform demonstrations before the class or in the school assembly.

B. Students may write and present a play to the school assembly on some phase of the unit.

C. "Ecology Day" can be held with exhibits of the work done being displayed to other students, teachers, and parents in an assembly.

D. Special groups may conduct the class on their particular phase of the unit, ie, habitat studies, parasitism and symbiosis, etc.

E. Individual students studying different plant and animal communities may conduct the class on field trips.

F. Students may write script and present radio program on human ecology or other topics connected with the unit.

G. The class can see a movie pertinent to the unit, following it up with a discussion.

H. A movie on general ecology or some particular phase of the subject can be made by the class for subsequent showing in assembly.

I. Students may write a humorous skit entitled "Inhuman Ecology" to demonstrate some of the

things man shouldn't do in relation to his environment. "Skit" can be presented in class or assembly.

Materials to be used in Study of the Unit

A. Reference Books for Students

1. Breland, Osmond P. Animal Facts and Fallacies. New York: Harper & Brothers, 1948. 269p.
2. Brown, Vinson Amateur Naturalist's Handbook. Little, Brown & Co, 1948. 475p.
3. Cahalane, Victor H. Mammals of North America. New York: Macmillan, 1947. 682p.
4. Carr, William H. Desert Parade. Viking Press 1947. 96p.
5. Carrighar, Sally One Day at Teton Marsh. Knopf Pub. Co, 1947. 239p.
6. Clements, Edith G. Flowers of Prairie and Woodland. Wilson, 1947. 83p. 24 color plates
7. Evans, Eva All About Us. Capitol Publishers 1947. 95p.
8. Harpster, Hilda T. Insect World. Viking Press, 1947. 211 p.
9. Linton, Ralph Man's Way From Cave to Skyscraper. Harper & Brothers, 1947. 185p.
10. Mansfield, James C. Dawn of Creation. Lothrop Press, 1947. 238p.
11. Mason, George F. Animal Homes. Morrow, 1947 96p.
12. Mason, George F. Animal Sounds. Morrow, 1948. 96p.
13. McKenney, Margaret Birds in the Garden and How to Attract Them. Minneapolis: Univ of Minnesota Press, 1946. 349p.
14. Merrill, Elmer D. Plant Life of the Pacific World. New York: Macmillan, 1945. 295p.
15. Meyer, Jerome S. Picture Book of the Weather Lothrop, 1948. 48p.
16. Morris, Percy A. Boy's Book of Snakes. Ronald, 1948. 185p.
17. Needham, James G. Introducing Insects. Ronald, 1943. 129p.
18. Osborn, Fairfield Our Plundered Planet. New York: Little, 1948. 217p.
19. Peattie, Donald This Is Living. New York: Dodd, Mead & Co, 1938.
20. Pettit, Ted Book of Nature Hobbies. Didier Publs, 1947. 280p.

21. Pickwell, Gayle B. Deserts. New York: McGraw-Hill Book Co, 1939. 174p.
22. Sanderson, Ivan T. Animal Tales; An Anthology. Knopf, 1946. 510p.
23. Shippen, Katherine B. Great Heritage. Viking Press, 1947. 230p.
24. Stewart, George R. Man, An Autobiography. New York: Random House, 1946. 310p.
25. Von Hagen, Victor W. South American Zoo. Messner, 1946. 182p.
26. Webb, Addison Birds in Their Homes. New York: Garden City, 1947. 66p.
27. Zim, Herbert S. Plants, New York: Harcourt Brace & Co, 1947. 398p.

B. General Biology Texts

1. Baker, Arthur and Mills, Lewis Dynamic Biology Today. New York: Rand McNally, 1948. 799p.
2. Grant, Charlotte, Cady, Keith and Neal, Nathan American High School Biology. New York: Harper & Bros, 1948. 888p.
3. Fenton, Carroll and Kambly, Paul Basic Biology. New York: Macmillan, 1948. 711p.
4. Hunter, George Life Science. New York: American Book Co, 1941. 793p.
5. Kinsey, Alfred C. New Introduction to Biology. Chicago: J. B. Lippincott Co, 1938. 821p.
6. Moon, Truman; Mann, Paul and Otto, James Modern Biology. New York: Henry Holt & Co 1947. 663p.
7. Ritchie, John W. Biology and Human Affairs, New York: World Book Co, 1948. 805p.
8. Smallwood, William, Reveley, Ida and Bailey, Guy Elements of Biology. New York: Allyn & Bacon, 1948. 655p.
9. Smith, E. T. Exploring Biology. New York: Harcourt Brace & Co, 1943. 595p.
10. Vance, B. B. and Miller, D. F. Biology For You. New York: Lippincott, 1946. 713p.

C. Reference Books for the Teacher

1. Bodenheimer, F. S. Problems of Animal Ecology. London: Oxford Press, 1938.
2. Borradaile, L. A. The Animal and its Environment. London: Hodder and Stoughton, 1923.

3. Chapman, R. N. Animal Ecology. Minneapolis Burgess-Brooks, 1925.
4. Clements, F. E. and Shelford, V. E. Bio-ecology. New York: Wiley & Sons, 1947.
5. Daubenmire, R. F. Plants and Environment. New York: J. Wiley & Sons, 1947.
6. Drabble, H. Plant Ecology. London: E. Arnold & Company, 1937.
7. Elton, C. S. Animal Ecology. New York: Macmillan Company, 1935.
8. Haupt, Arthur W. Laboratory Directions for General Biology. New York: McGraw-Hill Book Co, Inc, 1932. 65p.
9. Hesse, R. Ecological Animal Geography. New York: J. Wiley & Sons, 1937.
10. McDougall, W. B. Plant Ecology. Philadelphia: Lea and Febiger, 1941.
11. Oosting, H. J. The Study of Plant Communities. San Francisco: W. H. Freeman & Co, 1948.
12. Pearse, A. S. Animal Ecology. New York: McGraw-Hill, 1926.
13. Weaver, J. E. and Clements, F. E. Plant Ecology. New York: McGraw-Hill Book Co, 1938.

D. Motion Pictures (16mm)

The following visual aids are listed according to the company from which they may be secured. The symbol si. is used to indicate silent film, and sd. sound films. All should prove useful in teaching the unit on ecology.

1. Allen and Allen Productions 3947 W. 59th Pl, Los Angeles, 43, California.
   a. Phantom Sea, 27 min. sd. $90.
2. Akin and Bagshaw, Inc. 2023 E. Colfax Av, Denver, Colorado.
   a. How Animals and Birds House Themselves, 15 min. si. rent 75¢.
      "Animal and Bird habitats"
3. Arthur Barr Productions 6211 Arroyo Glen, Los Angeles, 42, Cal
   a. Wild Animals - Their Homes and Habits, 10 min. sd. $40.
      "Habitat studies"
   b. The Desert, 10 min. sd. $40.
      "Desert Flora"

c. The Mountains, 10 min. sd. $40. "Plant and Animal Communities"
d. The Seashore, 10 min. sd. $40. "Plant and Animal Communities"
e. The Valleys, 10 min. sd. $40. "Plant and Animal Communities"

4. Atlantic Refining Company — Film Lending Library, Sales Promotion Dept, 260 S. Broad St, Philadelphia 2, Pa.
a. The Sea, 11 min. sd. Must be purchased. "Community Life in Marine Water"
b. Demons of the Deep, 11 min. sd. Must be purchased. "Turtle, Ray, Shark in Natural Habitats"
c. King of the Arctic, 11 min. sd. Must be purchased. "Sea Lions in Natural Habitat"

5. American Museum of Natural History — 79th St & Central Park W, NYC.
a. Animals of the African Plains, 1 reel si. rent 50¢. "Habitat Studies"

6. Edited Pictures System, Inc. — 165 W 46th St, New York 19, NY
a. Dwellers in Cold Countries, 9 min. sd. rent $1.50. "Human Ecology"
b. Dwellers in High Mountain Countries, 9 min. sd. rent $1.50. "Human Ecology"
c. Dwellers in Hot Dry Countries, 9 min. sd. rent $1.50. "Human Ecology"
d. Dwellers in Hot Wet Countries, 9 min. sd. rent $1.50. "Human Ecology"
e. Urban Dwellers in Temperate Countries, 9 min. sd. $1.50. "Human Ecology in Cities"

7. Encyclopedia Britannica Films, Inc. — 1150 Wilmette Ave, Wilmette, ILL
a. The Zoo, 11 min. sd. color, rent $5. "Simulated Natural Habitats of the Various Animals"
b. How Nature Protects Animals, 10 min. sd. $50. "Habitats and Protective Coloration"
c. Bird Homes, 15 min. si. $24. "Eggs and Nests"

d. Birds of the Sea Coast, 15 min. si. $24. "Nests and Young"
e. Carbon-Oxygen Cycle, 15 min. si. $24. "Plants"
f. Nitrogen Cycle, 15 min. si. $24.

8. Film Highlights, Inc. 1697 Broadway, NY 19.
a. Smaller Rodents, 15 min. si. $15. "Rats, Mice, Squirrels - Adaptations"

9. Harvard Film Service Graduate School of Education, Lawrence Hall #4, Cambridge, Mass.
a. Animals of the Seashore, 15 min. si. rent $1. "Habitat Studies"

10. Film Center, Inc. 25 W 45th St, NY 19.
a. Desert Land, 10 min. sd. rent $1.50. "Reptile Competition"
b. Swampland, 10 min. sd. rent $1.50. "Competition among Reptiles"

11. Knowledge Builders 625 Madison Avenue, NY 22.
a. Jungles of the World, 11 min. sd. rent $2. "Jungle Plant Communities"

12. Midland Cooperative Wholesale 739 Johnson St NE, Minneapolis 13, Minnesota.
a. Undersea Fight for Life, 12 min. si. Must be purchased. "Competition Underwater"

13. Modern Talking Picture Service, Inc. 9 Rockefeller Plaza, New York 22, N. Y.
a. Gift of Green, 20 min. sd.-color Loan. "Photosynthesis"

14. National Film Board of Canada Travel Film Library, Canadian Embassy, 1746 Mass. Ave, NW Washington 6, DC
a. Home of the Birds, 10 min. si. Free. "Habitats--Shore and Sea Birds"
b. A Bird City, 10 min. si. Free. "Habitats--Pelican, Cormorant, etc"
c. Canoe Trails through Mooseland, 10 min. si. Free. "Habitat of Moose"
d. The North Shore, 10 min. si. Free. "Habitat of Shore Birds"
e. Return of the Buffalo, 10 min. si. Free. "Conservation"

15. Skibo Productions, Inc. 165 W 46th St, NY 19.
    a. Private Life of the Gannets, 11 min. sd. $30. "Life of Water Bird"
16. Teaching Film Custodians, Inc. 25 W 43rd St, New York 18, NY.
    a. Desert Demons, sd. Loan. "Competition Among Desert Reptiles"
17. Texas Forest Service, Texas A & M College, College Station, Texas.
    a. Harvesting Pine Timber, 9 min. si. color, loan. "Proper Cutting Methods, Conservation"
18. United World Films, Inc. RCA Bldg, 30 Rockefeller Center, NY 20
    a. Desert in Bloom, 10 min. sd. rent $1.50, color $3. "Desert Flora"
19. Wildlife Films 6063 Sunset Blvd, Hollywood 28, California.
    a. Elk for the Future, 18 min. sd.-color, rent $6. "Life Cycle and Conservation of Elk"
    b. Return of the Pronghorn, 18 min. sd.-color, rent $6. "Conservation"
20. Young America Films, Inc. 18 East 41st St, New York 17, NY.
    a. Let's Look at Animals, 11 min. sd. $40. "Animal Adaptations"

E. Film Strips (16mm)

The following visual aids are listed according to the company from which they may be procured.

1. The Handy Organization 2821 E Grand Ave, Detroit 11, Michigan.
    a. Life in Ponds, Lakes, and Streams, 60 fr. si with text, color $6.75. "Aquatic Plants and Animals"
    b. The Soil, 66 fr. si. with text, $4.50. "Where Soil Comes from and Why It's Important"
    c. Temperature, 65 fr. si. with text, $4.50. "Heat as a Source of Energy"
2. Popular Science Publishing Co. Audio-Visual Div, 353 4th Ave, NY 10.
    a. Animals Round the World, 45 fr si. with text, color $5. "Natural Habitats & Protective Coloration"

3. Society for Visual Education, Inc. 100 E Ohio St, Chicago 11, Ill.
   a. Biology of Spiders - Spider Houses, 40 fr si. with text $2. "Spider Habitats"
   b. Biology of Spiders - Biological Control, 37 fr. si. with text $2. "Balance of Life - How it is Controlled"

F. Pamphlets

1. Parker, B. M. and Buchsbaum, Ralph Balance in Nature. Row Publishing Company, 1941. 35p
2. Row Publishing Company, Plant and Animal Partnerships. 1944. 35p.

G. Magazine Articles

The following magazine articles are listed according to the phase of ecology with which they deal such as plant ecology, adaptations, etc.

1. General Ecology

   a. "Western Habitats; effects of physiography and climate on distribution of vegetation and animal life." Audobon Magazine 48: 206-11, July 1946.
   b. "Ecological Aspects of Population Biology" T. Park, Science Monthly, 60:311-13. April 1945.
   c. "Conservation and Scientific Forecast." R. C. Murphy, Science 93:603-9. June 27, 1941.
   d. "Fantastic Forest." J. Israels, Saturday Evening Post, 215:14-15. August 22, 1942
   e. "Requirements of Parasites for more than Hosts." G. N. Wolcott, Science, 96:317-18. October 2, 1942.
   f. "Soil Erosion as an Ecological Process." E. H. Graham, Science Monthly, 55:42-51. July 1942.
   g. "Indian Relict Area." S. W. Bromley, Science Monthly, 60:153-4. February 1945
   h. "Wild Life Community." R. H. Pough, Audobon Magazine, 46:160-6, 224-33. May-July 1944.
   i. "Wildlife Zones across Central California, Habitat Groups." W. T. Shaw, Science Monthly, 60:97-107. February 1945.

j. "Arid Farming and Ecology." Scientific American, 159:233. November 1938.
k. "Biological Associates." E. L. Palmer, Nature Magazine, 31:622. December 1938.
l. "Concerning Ecological Principles." W. C. Alee and T. Park, Science News, 89: 166-9. February 24, 1939.
m. "Conference at Cold Spring Harbor on Plant and Animal Communities." Science News, 88:28. July 8, 1938.
n. "Co-operation in Nature." J. H. Bradley, Yale Review, 27 No. 4:712-32. June 1938.
o. "Functions of an Ecological Society." R. E. Coker, Science News, 87:309-15. April 8, 1938.
p. "Importance of Ecology in Relation to Disease." R. P. Strong, Science News, 82:307-17. October 4, 1935.
q. "Some Effects of Animals on Plants." W. P. Taylor, Science Monthly, 43:262-71. September 1936.
r. "Units of Environment." W. E. Allen, Science Monthly, 33:307-12. October 1931.
s. "Ecological Nomenclature." Science News, 74:648-9. October 1931.
t. "Regional Balance of Man." R. Mukerjee, American Journal of Sociology, 36:455-60. November 1930.

2. Plant Ecology

a. "Plants and Vegetation as Exhaustible Resources." S. A. Cain, Science Monthly, 68:321-8. May 1949.
b. "Plants Use Weapons." Science News Letter, 54:205. September 25, 1948.
c. "Tyrants among Plants." R. Sudell, House and Garden, 94:142-3. October 1948.
d. "Chemical Warfare among the Plants." J. Bonner, Scientific American, 180:48-51 March 1949.
e. "Locale Guides the Planter; Native Plant Communities Give the Key to Environment." R. H. Smiley, House and Garden, 89:72-3. February 1946.
f. "Corn and Weeds." F. Thone, Science News Letter, 43:126. February 20, 1943.
g. "Weed Patches and Waste Places." E. L. Palmer, Nature Magazine, 34:325-32. June 1941.

h. "North American Prairie." J. E. Weaver, American Scholar, 3:329-39. July 1944.
i. "Hunting Our Native Wildflowers; Where to Find Colonies and the Kinds you will Discover Growing Together." W. E. Thwing, House and Garden, 79:49. June 1941.
j. "Marsh Gas in the Ecology of Some Peat-Bogs." H. A. Allard, Science News, 89: 533-5. June 9, 1939.
k. "Plant Sociology." Science Monthly, 46: 574. June 1938.
l. "Ecology of the Prairie." Ramaley, F. Science News, 79:504. June 1, 1934.
m. "Plant Communities of the Dunes on the Shores of Lake Michigan." G. D. Fuller, Science Monthly, 38:444-51. May 1934.
n. "Plants that Feed Each Other; Strange Partnership of Fungi and Algae." M. C. Walling, Popular Science, 126:38-9. February 1935.
o. "Ecological Aspects of the Transition from Old Forests to New." T. T. Munger, Science News, 72:327-32. October 3, 1930.

3. Animal Ecology

a. "Pet Birds are Fun." M. Stevenson, Recreation, 43:68-70. May 1949.
b. "Method for Self-Control of Population Growth among Mammals Living in the Wild." J. B. Calhoun, Science, 109:333-5. April 1, 1949.
c. "Birds as Seed Carriers." W. L. McAtee, Nature Magazine, 41:440. October 1948.
d. "Birds Against Beetles." H. Brackbill, Nature Magazine, 41:240-1. May 1948.
e. "Ecological Counterparts in Birds." H. Friedmann, Science Monthly, 63:395-8. November 1946.
f. "Bird Geography in the Southwest Pacific." E. Mayr, Audobon Magazine, 47:159-65. May 1945.
g. "Deer Trouble; White-Tail in the North East." D. Cook, Audobon Magazine, 47:74-9. March 1945.
h. "Life Zones, Biomes, or Life Forms"? R. T. Peterson, Audobon Magazine, 44:21-30. January 1942.

i. "Birds of Britain: How and Why They Differ from American Birds." R. M. Lockley, Audobon Magazine, 45:8-13. January 1943.
j. "Consider the Fox." A. Devoe, Audobon Magazine, 46:204-10. July 1944.
k. "Animal Population Cycles; Review of Voles, Mice, and Lemmings; Problems in Population Dynamics." C. Elton, and W. C. Allee, Science Monthly, 56:561-4. June 1943.
l. "Biological Control of Rodents and Predators." V. E. Shelford, Science Monthly, 55:331-41. October 1942.
m. "Poison and Ecology." L. R. Dice, Bird Lore, 40:12-17. January 1938.
n. "Protozoan Ecology." A. N. Bragg, Science News, 86:307-8. October 1, 1937.
o. "Ecological Segregation." A. S. Pearse, Science News, 79:167-72. February 23, 1934.
p. "Wild Life of the Forest Carpet." Jacqat, Science Monthly, 40:425-30. May 1935.

4. Human Ecology

a. "Geography of Recreation." T. Kelley, Education, 69:30-4. September 1948.
b. "Ground from under Your Feet." W. Vogt and R. Lord, Saturday Review of Literature, 31:13. August 7, 1948.
c. "Nature Can Write on the Wall." D. C. Coyle, Survey Graphic, 37:402. September 1948.
d. "Arid Acres Point to Arid Living." W. Vogt, Business World, 80+82-3. October 2, 1948.
e. "Earth and Man; New Attitude Toward Wild Nature." A. F. Skutch, Audobon Magazine, 50:356-9. November 1948.
f. "Human Ecology." L. Wirth, American Journal of Sociology, 50:483-8. May 1945.

5. Ecological Adaptations

a. "Egg Came Before Chicken," Science News Letter, 51:21. January 11, 1947.

b. "Evolution: Insects' Secret Weapon." R. P. Brundage, Science Digest, 20:52-4. November 1946.
c. "Passing of the Passenger Pigeon, Lesson in Biological Survival." L. Griscom, American Scholar, 2:212-16. April 1946.
d. "Trickery of Nature." A. Devoe, American Mercury, 60:746-50. June 1945.
e. "Warning, Bacteria are Fighting Back." C. D. Darlington, Science Digest, 19: 37-40. March 1946.

6. Balance of Nature

a. "Man and Nature." W. P. Taylor, Science Monthly, 41:350-62. October 1935.
b. "Whose Wildlife"? D. Hough, Nature Magazine, 27:43-5. January 1936.
c. "Mosaic of Nature." G. J. Pierce, Science Monthly, 41:269-71. September 1935.
d. "Why Do Insects Become Pests"? E. P. Felt, Science Monthly, 46:437-40. May 1938.
e. "Balance of Nature." A. Devoe, American Mercury, 50:491-4. August 1940.
f. "Biologic Balance on the Farm." W. L. McAtee, Smithsonian Report, 1939:319-23.
g. "Chair for Insects"? R. C. Murphy, Science Monthly, 50:357-64. April 1940.
h. "Closed Farm; Emphasis on Biological Balance." H. Tetlow, Commonwealth, 31: 484-6. March 29, 1940.
i. "Predators, Human and Wild." P. A. Taverner, Bird Lore, 42:4-9. January 1940.
j. "Smaller Animals of the Great Plains." V. E. Shelford, Science News, 91:167-8. February 16, 1940.
k. "Excess Deer Problem." A. Leopold, Audobon Magazine, 45:156-7. May 1943.
l. "Man, Maker of Wilderness." P. B. Sears, Science Digest, 15:35-8. January 1944.
m. "Nature, the overseer." A. Devoe, Audobon Magazine, 45:270-6. September 1943.
n. "Why Pick on the Predators"? S. Baker, Natural History, 48:212-15. November 1941.
o. "Surplus Populations." J. H. Baker, Audobon Magazine, 45:120. March 1943.

p. "Nature Punished Mistakes of Man; Transportation of the Mongoose into Jamaica." Science Digest, 11:45. March 1942.
q. "Keeping Nature in Balance; Activities of the Government's Experimental Ranges." Popular Mechanics, 78:14-15. July 1942.
r. "Conservation Spiral; Facts Behind the Present Elk Reduction Program in Yellowstone National Park." V. H. Cahalane, Audobon Magazine, 45:14-18. January 1943.
s. "Wholeness of Nature." A. Devoe, American Mercury, 63:618-22. November 1946.
t. "Don't Monkey with the Platypus." B. Evans, Harper's 193:492-7. December 1946.
u. "DDT and the Balance of Nature." Wigglesworth, Atlantic, 176:107-13. December 1945.
v. "Concerning Predators." D. Cook, Audobon Magazine, 48:130-6. May 1946.

APPENDIX B

LETTER
QUESTIONNAIRE

OREGON STATE COLLEGE
SCHOOL OF SCIENCE
Corvallis, Oregon

Department of Science Education

Dear Biology Teacher:

A survey is being made of the place and importance of ecology in the high school biological science program in representative schools of the eleven western states. Your school has been selected as one of the ten representing your state.

Oregon State College is very much interested in the professional training of biology teachers. For this reason it is hoped that the survey will reveal answers to the following questions: (1) How much ecology is taught in the present biology course? (2) How much ecology should be included in the professional preparation of teachers?

Since the returns from every school are important, your cooperation in marking and promptly returning the questionnaire (in the enclosed stamped envelope) will be greatly appreciated.

Very sincerely yours,

STANLEY E. WILLIAMSON
Prof. of Science Education

JACK W. CARMICHAEL
Graduate Student

QUESTIONNAIRE ON ECOLOGICAL PRINCIPLES

I. What biological science courses are offered in your school? (Please check:)
   A. Biology (General) _____
   B. Zoology _____
   C. Botany _____
   D. Physiology _____
   E. Others (Please list) _____

II. Approximately what per cent of your biology course is composed of the following topics?

Behavior _____	Nutrition _____
Classification _____	Photosynthesis _____
Ecology _____	Reproduction & Sex Education _
Heredity _____	Structure _____
Health _____	Others _____
Evolution _____	

III. Which ecological subjects do you emphasize most? (Please check) (Please mark with an "x" those emphasized least.)

Conservation of:

a. water ____	c. wildlife ____
b. soil _____	d. forest _____

Symbiotic relationships _____	Plant communities ___
Plant & Animal distributions _____	Animal communities ___
	Plant successions ___
Adaptations to environment _____	

IV. What instructional aids are used in developing ecological principles?

A. Field trips ____	Student projects ____
Habitat studies ____	Community surveys ____

B. What textbooks or groups of textbooks are used in your biology course? (Please list ones used the most.)

_____

_____

C. What magazines and other books have you found especially helpful in developing ecological principles? (Pleast list)

_____

_____

_____

V. If you were changing your biology course, would you include more ecological principles in the revised course? Yes _____ No _____

VI. In the light of your experience, should courses in ecology be included in the professional preparation of biology teachers? Yes _____ No _____