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Creating an environmental awareness in 4-H conservation projects : a 4-H ecology project.

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CREATING AN ENVIRONMENTAL AWARENESS IN 4-H CONSERVATION PROJECTS -A 4-H ECOLOGY PROJECT-

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- A 4-H ECOLOGY PROJECT -

by

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CHAPTER I

The Problem in Its Setting

> Let us permit nature to have her own way:
> She understands her business better than we do-
>
> Michel de Montaigne

Introduction

Man has always been interested in ecology since early in his history. From the day when he started to domesticate wild animals and to cultivate plants, man has had to learn the forces of nature in order to survive. Today perhaps he needs to know more than ever about his environment and how far he can go in changing it if civilization is to survive.

Ecology has many definitions. The most general meaning is the study of the relationship of organisms and their environment. Another way to look at this subject would be to consider it as a study of groups of organisms and their function in the world of nature.

As early as 1900, under the inspiration of Dr. Liberty Hyde Bailey, Junior Naturalist clubs and boys and girls clubs similar to the 4-H clubs of today were being organized to study nature.[1] "4-H Club Work received its official start in 1914 when the Federal Congress passed the cooperative demonstration act, known as the Smith-Lever Act.

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1. Lincoln D. Kelsey and Cannon C. Hearne, Cooperative Extension Work, p. 24.

Up to that time the rural youth movement had no official name or definite plan of organization".[2]

> 4-H work is an educational movement rather than an organization. Members do not pay dues, do not have an elaborate organizational structure above the county level, and can be compared more closely with the public school system than with a typical youth organization. However, for most of our two and one-fourth million participants, the teaching opportunity and the learning experience centers around autonomous little clubs averaging twenty members in size and meeting in homes, schools or other public buildings. There are many variations of this pattern. Clubs are led by more than a third of a million volunteer leaders, mostly parents. These, in turn, are recruited, trained, and serviced by county extension workers. The 11,000 county extension agents are professionally trained in agriculture or home economics and are under the direct supervision of the Extension Service of the State Land-grant colleges.[3]

It was in 1913-1919 that nature study clubs were numerous. In the 1920's 4-H club forestry projects were initiated. Soil and water conservation was introduced in the 1930's. In the 1940's wildlife conservation and entomology were added. In the 1950's geology was introduced. All of these projects together with soil management, rangeland, trapping, land judging, rifle clubs and a variety of outdoor recreation projects have been used in the 4-H program in the United States.

After some years of experience with junior sportsmen clubs, bird clubs, nature clubs, conservation and forestry camps, this writer was interested in ways in which conservation education (both economic and ecological) could be promoted in the 4-H program.

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2. H. A. Willman, The 4-H Handbook, p. 1.

3. E. W. Aiton, Report of Science in 4-H Club Work, Kellogg Center Conference, p. 7.

It is the purpose of this study to prepare a twelve lesson program for use by leaders and members as a basic study course before 4-H members get into the practical application of the principles of biology in conservation projects. This writer feels that 4-H members should know that we must have new attitudes about our resources and that man must not destroy nature in order to conquer it.

This program was developed as a 4-H ecology project based on twelve project lessons drawing from other sciences - geology, physics, chemistry, and the life sciences. Grouped together collectively the lessons could be called the cycles of nature. Included in the program were the following:

1. From geology, three lessons which explain the crust of the earth, its age and the making of our New England soils.
2. From physics, two lessons giving information about the radiation of our sun and its effect on our planet and its seasons.
3. From chemistry, three lessons about the chemical behavior and cycling of certain elements.
4. From the life sciences, four lessons concerning biological facts about plants and animals.

Many subjects could be chosen for study in ecology. Some other subjects are probably just as important but they will not receive emphasis in this study. This program attempts to develop in 4-H members an ecological awareness.

Today very few 4-H Conservation projects mention ecology although some project books in Conservation with wildlife are using a few ecological terms such as environment, community, producers, consumers, food chains, succession and limiting factors.

Background of Study

Time was when our ancestors were satisfied to take life about them as they found it. Their food and clothing came from hunting and fishing, their shelter a cave, or protected area. They did little to disturb the grass, trees and water which were abundant.

Their soil and water conservation problems were few and their lives were short with few expectations of a better life. They were hungry, sick and uncomfortable most of this time.

From the beginning days of soil tilling and making a better life by using the natural resources, there has been a price to pay for the materials that come from the soil. Plowing the soil, denuding the forest, mining the minerals, and building dams to get the earth's riches has often run against nature.

Man's presence on earth has been but an instant in geological time, but he has made a sizeable dent in resources that took millions of years to create.

Man has been drilling and pumping oil for about a hundred years and at an alarming rate for the past fifty years. The very same oil was in the making for millions of years.

Our top soil which took hundreds of years to build up is now gone and lost forever in many areas. From these two examples we should learn this simple lesson; we cannot continue to abuse our resources and hope for natural replacements. We must start to be fair to the future generations by using less of our limited resources so they may last as long as possible.

When we consider our renewable resources such as forest, grasslands, and wildlife, a new dimension enters the picture. We must not only preserve these living things, but keep the natural balance between them so that the web of life is not upset or destroyed. We must recognize the close relationship between all living things. We must appreciate that all living things are related in ways so intricate that even the scientist of today does not understand them fully.

Most of the people of earlier generations know little or nothing about the complicated and delicate inter-relationship that runs through all nature. Most failed to realize that if one part of the environment is in an unhealthy state, it ultimately will be harmful to all the others.

It will be almost impossible to ignore the great changes taking place around us in the field of conservation and use of natural resources today and in the near future. The task should not be felt as a hardship because of the wise use of natural resources, promotes the best condition for man himself.

The word Ecology was coined first by the German biologist, Ernst Haeckel, in 1869.[4] It took time before it was recognized as a distinct field of biology, but by 1900 it was recognized by the scientific world as one of the new sciences of biology. Wildlife reviews were devoting one tenth of their writings to ecology in 1937. Since World War II, this word has been extensively used in writings on natural resources, biology and conservation.

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4. Eugene P. Odum, Fundamentals of Ecology, p. 3.

Literally ecology means a "study of the organism at home" or "the place where it lives". Another way of describing ecology is the science of the inter-relation of living organisms and their environment. A short definition is "the science of the living environment" and another even shorter description would be "environmental biology".[5]

Ecology is chiefly concerned with populations, communities, ecosystems and the biosphere. When we talk of the balance of nature we are talking about a very important mechanism of nature. Ecology deals with the checks and balances and forces which effect populations, communities, ecosystems and the whole life zone of the earth. Populations are concerned with groups of individuals of any kind of organism; communities include all the populations in a given area. The community and the non-living environment, functioning together, make up an ecosystem and that portion of the earth where ecosystems function is called the biosphere.

Ecosystems are chiefly concerned with four divisions: 1-the basic organic and inorganic materials in an environment; 2-the producers, largely the green plants; 3-the consumers, which use other organisms; and 4-the decomposers, which break down the complex compounds and release substances useable by the producers.

Ecology deals with biogeochemical cycles, food chains, successions, and limiting factors.

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5. Ibid, p. 4.

Chemical elements including all the essential elements of protoplasm tend to circulate in the biosphere from environment to organism and back to environment. These processes are known as biogeochemical cycles.

Two well known examples of such cycles are the nitrogen and phosphorous cycles.

Food chain is referred to as the series through which food energy is transferred from the source in plants to a series of organisms by repeating eating and being eaten. Food chains are of three types; predators, parasites, and saprophytes. Food chains are not isolated series but are interconnected with each other.

Ecological succession is the orderly process of community change. In another way, it is the sequence by which communities replace one another in a given area. This idea replaces the old idea that the balance of nature was static. Now we are beginning to realize that communities change in an orderly way, resulting in a new concept, i.e., a dynamic balance of nature.

Limiting factors are those conditions which exceed the limits of tolerances within which organisms occur and thrive. Organisms must have essential materials for growth and reproduction. When one of these materials approaches the critical minimum amount needed, it will tend to be the limiting factor. Physical factors which are important as limiting factors are temperature, light, water, moisture and temperature together, atmospheric gases, biogenic salts, pressure and currents, soil, fire and microenvironment.

This writer feels that ecology has a place as a 4-H project - not only because of its scientific values of understanding and appreciation of conservation projects but also in the principles of nature which effects the member's everyday living.

As already reported 4-H members have been involved in various conservation projects since the 1900's. In these projects they have learned how to raise more wildlife, conserve more soil and plant more trees. They have exhibited in their projects, judged articles and exhibits, and demonstrated in various fields of conservation.

The Journal of Education for November 2, 1916, concluded about the 4-H project exhibits and judging and demonstrations:

> These three steps begin with the practice of an art and end with a knowledge of the science which underlies the act - a real educational triumph.[6]

State 4-H Leader Horace M. Jones states that:

> There is an ever increasing proportion of 4-H members from non-farm homes. Projects adapted to village and urban areas are in great demand. As we enter the space age with its great need for scientists 4-H projects in the field of science are called for. In harmony with its tradition of 50 years the 4-H program seeks to do the things that need to be done, always progressing, exploring, adapting and devising ways of meeting new situations.[7]

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6. Horace M. Jones, <u>50 Years of 4-H in Massachusetts</u>, p. 8.

7. <u>Ibid</u>, p. 15.

Conservation Identification Contest

Identification contests have been used by 4-H members and leaders for years. These have been used effectively in dairy, sheep, poultry, garden and wildbird projects.

In 1963, 1964 and 1965 this writer has used the conservation identification sheets as shown on page 101 and 102. The summary is on page 18.

As this ecology project developed, the animals and plants found in New England were used to find out what young people knew about their environment.

Three groups which were tested provided some interesting results. Two groups were tested in Essex County and one in Worcester County. All groups elected to participate in the contests.

In one group, fifty boys and girls whose ages averaged 10 years were given the test in May 1964. The quiz was given in a camp atmosphere and most of these members had a wildbird project background.

A second group of one hundred fourteen 4-H boys and girls who came from Eastern Worcester County were tested in June 1964. Their average age was about twelve. This quiz was given 4-H members during a 4-H Achievement Day.

Another group of thirty-six in Essex County were tested at a 4-H camp field day. The average age was twelve. Again the choice of participating was made by the 4-H members and most of these members had a wildbird project background.

Evidently young people are able to recognize mammals to a great extent. Birds are nearly as high in their recognition. Insects and flowers rank third and fourth.

The test shows that members possess a low degree of competence when it comes to identifying fish and local trees. Weeds and rocks also rank very low in these identification centests.

Three other groups of less than twenty 4-H Club members were also tested. These tests also showed that members recognized mammals, birds, and insects to a high degree. The least known were fish, weeds and rocks.

It would seem that young people today are not aware of the stones under their feet, the trees and flowers of their neighborhood, completely ignorant of most weeds and fish of their area, but have some knowledge of birds and insects and can identify mammals in a way which makes this writer question, "why do they do such a good job in recognizing the mammals?" Could it be that television programs and stories about wild animals are more numerous? Are they seeing these animals at animal farms and zoos?

These identification contests seem to be well received. Members were enthusiastic about seeing something they knew. Some asked to do it again. The specimens were left on the plates and identified by the writer for the group. Some volunteered to try to give the correct identification for the group. The results of this test made the writer aware of the pressing need to teach young people some understanding of at least the common plants and animals and rocks of their state. Here is a wonderful opportunity to teach conservation, nature study, and ecology. If our young people know so little of nature around them this writer questions how very little they must know about water, heat, sunlight, plant and animal life, the earth and its elements. It is the hope of this writer that the proposed project will create an environmental awareness in our 4-H members so they may better understand their 4-H conservation project.

TABLE I

RESULTS OF CONSERVATION IDENTIFICATION CONTEST

SUBJECT	114 boys & girls Group I per cent correct	50 boys & girls Group II per cent correct	36 boys & girls Group III per cent correct
MAMMALS	60	56	68
BIRDS	57	40	47
INSECTS	37	30	43
FLOWERS	34	47	--
FISH	25	23	32
ROCK	23	16	24
TREES	20	27	26
WEEDS	10	10	--

Statement of the Problem

An exploratory conference was held at the Kellogg Center, Michigan State University in September 20-22, 1959. It was sponsored by the Cooperative Extension Service and the National Science Foundation. The report listed five objectives of which three are considered by this writer.[8]

1. Exploration of ways in which to expand the understanding and appreciation of science in the present 4-H Club program.

2. Consideration of additional scientific areas that could be added to the 4-H club program.

3. Acquainting 4-H club members with principles of science that affect their everyday living.

Since 1914 4-H has traditionally had a much greater emphasis on skills and handicraft than on true science. There seems to be a growing appreciation that for the future we need to develop the potential of the scientific why for the Head H in our program. An important implication may be that skills will always be an important part of the program for younger age members of whom we have a large proportion in our current enrollment. For older adolescent age youth, skills alone do not provide an adequate challenge. For them we need to develop further scientific aspect of our projects.[9]

In the biological science group it was pointed out that we should try to show the relationship of the principles of life. We should teach through projects some of the basic fundamentals of life.

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8. Report, National Conference on Science in 4-H Club Work, p.1.

9. Ibid, p.10.

We should try to arouse an interest in members to go into the why connected with projects.

One of the program areas suggested at the conference was in the general biology field and it was ecology.

As stated in the introduction this 4-H ecology project will draw on four sciences - chemistry, physics, geology and biology.

The project was designed to show the relationship of the principles of life as well as arouse an interest in understanding why in order that 4-H members may appreciate nature, understand conservation and use resources wisely - one of the ten major objectives of 4-H club work.

CHAPTER II

CHAPTER II

Review of Related Literature

4-H members have been carrying on projects for years in the various conservation fields of soil and water, forestry, nature and entomology. This writer has surveyed nearly all of the states from the standpoint of ecology and finds that several hint about certain aspects of ecology but that almost all do not mention ecology in their club literature.

The nearest to ecology is the 4-H club bulletins from Arkansas on Conservation; the importance of water, the importance of plants to animal life and wildlife controls of nature and man are explained.

Ohio's 4-H Conservation Guide gives some good points for exploring the out-of-doors but except for a slight discussion of plant communities, does not go into ecology to any extent.

North Carolina's conservation booklet mentions biological balance but immediately goes back to projects which used improved habitat.

The older New York publication "Conserve Our Soil, Forest and Wildlife" has excellent ideas for conservation projects but little on the principle of ecology. Minerals in soil, predators and habitat are mentioned but are not emphasized.

Nebraska's 4-H Wildlife Habitat lists habitat requirements for wildlife. The importance of good soil and water are explained in their relationship to cover our food supply.

The Minnesota 4-H bulletin on Conservation for the Beginners, in its chapter on trees makes note of growing conditions of trees and shrubs and their ability to adjust to light, soil and water. Tolerant and intolerant definition and forest types are mentioned. Habitat needs are mentioned in the chapter on wildlife. Life in the soil and water cycle chart gives the beginner some thoughts on the inter-relationship of soil and water.

One Idaho bulletin has a fine explanation of limiting factors. It explains the law of the minimum in pointing out that the resource or factor available in the smallest amount limits the production on supply of whatever the item is.

Many of the states have bulletins which were written mainly for soil and water conservation, forestry and wildlife projects. Most all of them mention at least one of the limiting factors which this writer has mentioned in the background of the study.

Water as a limiting factor is discussed by the Utah, Wyoming, Minnesota, Wisconsin, Oklahoma, Nevada and Michigan bulletins. Water pollution is accounted for in a Nebraska publication.

Soil, plant nutrients and organic matter are discussed in Wisconsin, Nevada, Nebraska and Kentucky 4-H bulletins.

Carbon dioxide used by plants is explained in a Nevada bulletin.

The Nitrogen supply in the air and nitrogen stored in the soil are explained in a Minnesota and Virginia bulletin.

Oxygen in water and its role to support fishlife are explained in a Michigan bulletin.

Habitat and cover are featured in Ohio, Nebraska, Michigan and Illinois bulletins while wind is mentioned in an Oklahoma bulletin, and Michigan speaks of the effect of weather on wildlife.

In a survey of the literature this writer has had many interesting moments with books on various subjects in the area of natural resources and biology, but the main influence has come from the following sources. A correspondence course from Cornell University - Conservation of Natural Resources prepared by Assistant Professor Carl A. Carlozzi stated the ecological as well as economic approach to conservation. This writer became interested in the ecological approach to conservation and this has been the avenue of approach in this paper. The title speaks for itself when we call it "Creating an Environmental Awareness in 4-H Conservation Projects".

One of the books which has always interested this writer has been Out of Doors, by Paul Mann and George Hastings. This book emphasizes that all nature is important to man.

The main idea on ecology came from Odum's Fundamentals of Ecology. Just about the whole outline of this paper has been based on the principles which Odum stresses in his college textbook.

The Crust of the Earth by Rapport and Wright has given this writer much to think about as far as the geologic subjects are concerned. The idea of life and living organisms concentrating minerals is a fascinating subject and one that could be pursued further in a future ecology program. Crust formation and geological process were interesting reading.

As the writer studied Odum's "Fundamentals" he was introduced to the Web of Life by John Storer. This paper back produced several hours of exciting reading on the relationship of living things and their environment. This book also approaches conservation with an ethical as well as an economic perspective. Web of Life explains "The basic principles of ecology are known, and on the functioning of these known principles depends the future of all human life".

A Sand County Almanac by Aldo Leopold, started this writer to think about cycling of elements in his story of Odyssey.

The 1938 USDA Yearbook, Soil and Men brings out facts as to the extent of wind and soil erosion and an understanding of the need for soil conservation.

In Marston Bates book the Forest and the Sea, the author takes a look at the economy of nature and the ecology of man. He stresses facts of food chains and the roles of producers, consumers and decomposers.

Scarseth's Man and His Earth points out the time factors which need to be understood if we are to use the land with love and respect. He explains that a scientist's major goal is to make mankind's future safer and surer and his lot easier.

The Wise Use of Natural Resources in New Hampshire published by the New Hampshire State Department of Education was helpful in explaining the concept of the inter-relationship and inter-dependence of natural resources. The balance of nature or the equilibrium condition is advanced in this guide for elementary schools in the field of conservation.

CHAPTER III

NATURE'S MERRY-GO-ROUND

NATURE GOES ROUND AND ROUND IN A PROCESS OF CREATING, DESTROYING AND REBUILDING BY CYCLING NATURE'S ELEMENTS.

FOREWORD

> Familiarity with nature never breeds contempt.
> The more he learns, the more he expects surprises,
> and the more he becomes aware of the inscrutable.
> Archibald Rutledge

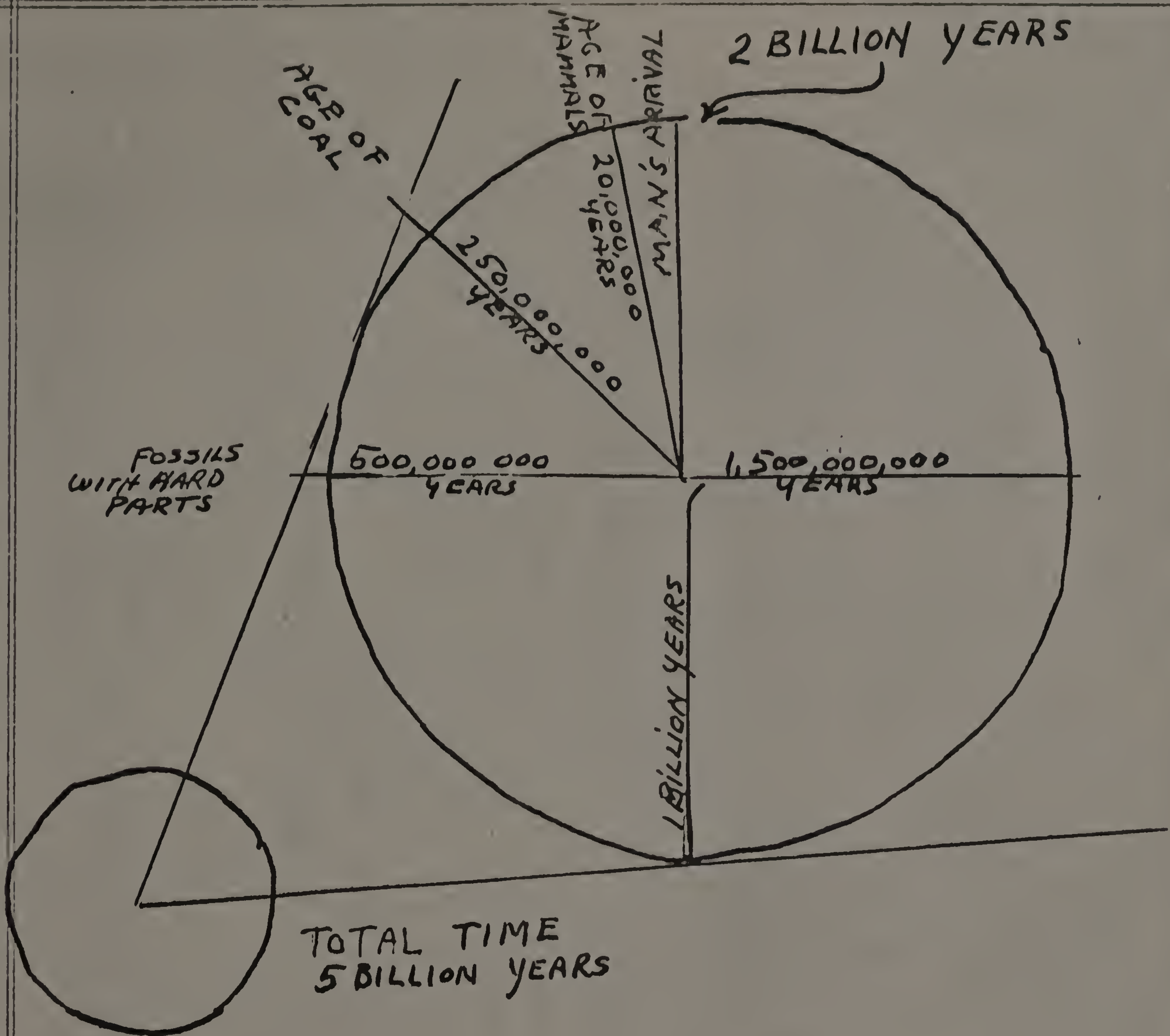
With each new generation our scientific knowledge increases fivefold. At the current rate of increase it has been anticipated that by the year 2000 there will be a hundred times as much acquired knowledge to master as there was in 1900. With all the information available we must be selective in our facts, concepts and principles.

Primitive man generally lives in balance with nature. Civilized man, especially in recent times, has looked at nature as if he could do without it. He has failed to realize that the world of life could do without him. Animals, plants, and microorganisms live as interdependent parts of communities with habitats in the sea, the forest, the grasslands, even the desert. In each habitat the green plants are the primary producers, and other forms of life, the consumers. The stockpile of material in dead organisms is decomposed and returned to the living by bacteria, fungi or other decomposers. All organisms are part of a great cycle that ultimately depends on the light of the sun. We cannot all be biologists but anyone can be a naturalist and no branch of natural history is more rewarding than the study of ecology - the science of the inter-relation of living organisms and their environment.

Civilized man by poor agricultural practices has destroyed vast acres of productive soil. He has cut and uprooted forests only to find his water supply diminished and his soil eroding, he has polluted the rivers and lakes, making the drinking water unsafe and he is fouling the air with his industry. But today he is beginning to behave as he must, as a rational living creature who depends on other life for his own existance.

It has been said we live in the present, we dream in the future and we learn eternal truth from the past. We hope young people learning about the balance of nature today will have a wonderful future in step with nature; and not a nightmare.

Someone has also said, the most important purpose of education should be to put one in touch with his environment. Surely no one can be truly educated unless he has some knowledge of the great world around him and of the constant fight for survival between man and his natural enemies.



3 BILLION YEARS OF CONDITIONING

2 BILLION YEARS OF LIFE

OUR EARTH: THE TIME, THE PLACE

OUR EARTH - The TIME - The PLACE

The earth no longer looks the way it did "in the beginning". Great changes have taken place on its surface. An aging process, taking hundreds of thousands of years, conditioned the outer sheet to sustain plant and animal life. Countless types both lived and grew on vast areas, flourished or became extinct as their ability to survive permitted.

For us, this lifeless world would have been a grim and barren place. No tree or flower to soften and vary the scenery, no insect or bird to provide movement and color. The only sound provided by wind, wave, falling rock, escaping gas and volcano.

It is the many varieties of life that give the earth its chain, and these varieties are the end results of a long and very complex series of events.

It appears that for long ages after the first appearance of living matter, nearly all organisms both plant and animals, must have been soft bodied.

Geologists agree today that only during the last five-hundred million years have plants and animals produced hard parts capable of being fossilized.

Our brief life time period is too small a part of the millions of years of the earth's span. Time is a dimension which is difficult to comprehand because our days on earth are too brief. Yet the earth has passed through five billion years.

Scarseth in Man and His Earth states that:

> Time as an ingredient of eternity cannot easily be grasped by the human mind. But if we take only the time of one billion years (the earth is probably over five billion years old) and telescope it down to a scale of one year, we can generalize that man first shows up about sixteen minutes before the end of the last day of the year. Christ is born about fifty-nine seconds before the end. Columbus discovered America in the last fourteen seconds, and our own life span is less than one second.[1]

This writer knew that we had some old areas in New England but he did not know how old! Betty Thomson writes in her foreword on the Changing Face on New England of its age not only in history of the country but in the age of the planet.

> New England has had a long history, not only in relation to the nation of which she is a part but also in relation to the history of the planet. The folded and faulted rocks that form her bony structure are so ancient that their exact history has not yet been fully deciphered, but most of us know them at least vaguely as examples of "old worn-down mountains" in contrast to the "young rugged mountains" of the West. The marks of the last wave of glacial ice, on the other hand, are clear and fresh, and lie about us everywhere. Once one learns to see them, the glacier seems a very real and tangible thing and the twelve thousand years since the ice disappeared become as the twinkling of an eye.[2]

Since the beginning of time, part of New England, 500,000,000 years ago, the following Table Number[2] will show what has happened to the first rocks of the Berkshires and the many to follow.

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1. George D. Scarseth, Man and His Earth, p. 64.

2. Betty F. Thomson, The Changing Face of New England, Foreword VIII.

TABLE 2

NEW ENGLAND GEOLOGIC TIME TABLE

PALEOZOIC	CAMBRIAN 500,000,000	Ancestors of Berkshires and Green Mountain rose as a chain of islands in an island sea.
	ORDOVOCIAN 450,000,000	Islands rose further, land increased in the east. Limestone deposited in west.
	SILURIAN 320,000,000	Folding and cracking, ancestoral White Mountains.
	CARBONIFEROUS 250,000,000	Coastal margin sank. Vegetation deposited in swamp around Boston and Providence.
MESOZOIC	TRIASSIC 180,000,000	Sediment from mountains poured into 100-mile rift in rocks in the Central valley. Central valley became imbedded with lava sheets from volcanoes.
	JURASSIC	Erosion of entire area to form peneplain with Monadnocks. Original surface of New England upland formed.
	and	
	CRETACEOUS 150,000,000	Coast subsided - sediment deposited on edge. Rivers flowed toward southeast.
CENOZOIC	TERTIARY 60,000,000	Broad gentle uplift, soft triassic rock eroded to form the central lowland.
	12,000,000	Renewed uplift brought an erosion of new steep valley in old broad valley floors.
	PLEISTOCENE 1,000,000	Glaciation began.
	15,000	Last retreat of ice began.

Glaciation is thought to be a tremendous factor in erosion. However, Professor Bain in his Principles of Geology states that ice sheets were not effective agents of erosion. The last ice age wore the earth on the average less than seventy feet. "River erosion on the same area for the same time would denude it by 100 to 150 feet."[3]

The geological chart above has shown the building up and tearing down of the profile of New England for over 500,000,000 years. This is a normal process for a world that is torn between two forces. There are forces derived from without the earth and the ones within the earth. The greatest of these within the earth forces is that of gravity; another is the centrifugal force of rotation and another is the nature of the condition within the earth. These forces give our earth a greatly diversified outline but in general an oblate form.

The chief outside force is sunlight or radiant energy. It, in many various modified forms, becomes an agent of huge changes in the lithosphere. It acts through the atmosphere to give us weather. Heat is the means that mixes the atmosphere to make weather. It sets the atmosphere in motion, creating the fall of water on the earth where it runs away under the pull of gravity. This causes great changes of the surface of the earth when operating through long periods of time. "It is one of the vital factors upon which life on the earth depends, and life is one of the

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3. George W. Bain, Principles of Geology, p. 64.

agencies of change in the surface of the lithosphere."[4]

Gravity operates to hold the members of the solar system together. It is another important force, upon which depends many of the activities of the earth resulting from the influence of radiant energy. Tidal waves which sweep over the surface of the oceans have modified the prehistoric coastlines and are modifying present day coastlines, especially along the continental margins.

> Forces within the earth are making irregular surface forms, those outside the earth together with gravity, and utilizing air and water as agencies, are tending toward reduction of these irregularities, "tearing down the higher portions and building up the depressions."[5]

The geological history of the New England area is a varied and interesting one, contributing to the many inorganic parent soil material of the region. Buckman and Brady suggest that two groups of inorganic parent materials usually recognized are sedentary and transported.[6] These are subdivided as follows:

1. Sedentary:	Still at original site -	Residual
	Gravity -	Colluvial
2. Transported:	Water -	(Alluvial (Marine (Lacustrine
	Ice -	Glacial
	Wind -	Aeolian

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4. Ralph S. Tarr and Laurence Martin, College Physiography, p. 16.

5. Ibid., p. 17.

6. Buckman and Brady, The Nature and Properties of Soils, p. 274.

Field trips around the Connecticut Valley area will certainly show fine specimen areas of these groups. In upland areas, bedrock of micaeous schist are still seen in place in the original site. Near the basalt cliffs in the Holyoke Range, Colluvial or Talus slopes show the force of gravity in building parent material. The glacier produced many examples of alluvial. The largest areas are probably in the Massachusetts Valleys today, along the river banks.

Marine deposits can be found in the lower Connecticut Valley or along the Massachusetts Coast. The whole Connecticut Valley at one time was a lake, thus the central part of the valley is characterized by underlying lake bed deposits of varved clay covered by later silt deposits.

A large delta deposit of sand and gravel are characteristic of the eastern side of the Connecticut Valley, dumped as glacial streams entered the lake. Sand dunes in parts of the Connecticut Valley and extensive silt deposits on the high lands to the east and west are evidence of wind activity after the lake drained or glacier receded. Some of these Aeolian deposits could be from the fall drying of glacial outwash. One might expect to find such deposits in glaciated areas.[7]

Thus, within the boundaries of Massachusetts, some of the oldest land areas of the world may be found on some of the oldest parent rock material. The most effective agent of erosion, running water, is continuously changing

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7. William Colby, Mitchell Light and T. A. Bertinieson, The Influence of Wind-Blown Material on the Soils of Massachusetts, reprint from Soil Society of America, October, 1953.

the appearance of the surface of the earth. It is still changing the hills and valleys of Central New England.

TEACHING PLAN

OUR EARTH - THE TIME - THE PLACE

Objectives: To develop an appreciation of the age and geological history of the areas in which we live. To develop in boys and girls an understanding of the natural surroundings in which they live, so as to create an "at home" feeling in connection with the world about them.

Discussion questions: How does water change the surface of the earth? How old is a piece of coal? Is there coal in Massachusetts? Where? What are fossil fuels? How old are fossil fuels?

References: George W. Bain, Principles of Geology, Eduard Bros., Inc., Ann Arbor, Michigan, 1959.

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Biological Sciences Curriculum Study, Biological Science, an Inquiry into Life, Harcourt, Brace and World, Inc., New York, 1963.

Activities: Discover evidence of glacial activity in your area. Collect specimens of sand, gravel, clay, and wind blown material. Look for and observe fossils in your area. Visit a geological museum in your area.

VOLCANIC AREA

M-MAGMA
S-SILL
D-DIKE PRODUCING LAVA FLOW ON SURFACE
N-NECK OF VOLCANO

ROCK CYCLE

The solid part of our earth, known as the lithosphere, is constructed of natural formations called rocks. Minerals are the individual materials that make-up rock. Usually rocks consist of two or more minerals, but if a single mineral exists on a large scale it is considered a rock.

Rocks also include natural glass, organic products formed from plants and animals, as well as coal derived from partly decomposed vegetation.

Some rocks such as sand or gravel are not solid. All of these formations are the result of geologic processes through the centuries. Rocks can be identified by their origin, texture, and the minerals they contain. The normal rock cycle begins from molten rock and changes to igneous, to sedimentary and finally to the metamorphic stage.

Igneous

The word igneous means made by heat. Igneous rocks were made with high temperature. Such rocks often come from deep underground where the rocks were melted into semi-liquid magma. When pushed to the surface the molten rock flowed out of volcano as red hot lava.

The crust of the earth is composed mainly of igneous rocks. Granite predominates under the continents and basalt under the ocean. Frequent outcroppings appear on the surface in large areas of the earth. Most of the continents, however, are covered over by thick layers of sedimentary rocks interspersed with igneous forms due to volcanic eruptions.

If magmas cool beneath the surface they form intrusive rock. If they cool above the surface they form extrusive rock. Granite is the best known of the deeper igneous rock.

Extrusive rock makeup a large group of rocks, the most common member of which is lava. This molten material pours out through fissures and volcanoes. It spreads in great lava flows or builds up cones. Volcanic explosions throw fragments into the air as volcanic ash or volcanic bombs.

Sedimentary Rocks

Sedimentary rocks are extremely varied, differing widely in texture, color and composition. Nearly all are made of material that have been moved from its origin to a new place of deposition. The distance moved may be a few feet or thousands of miles. They are formed by the action of wind, water and organic agents on buried igneous rock that became exposed by erosion. Fragments of rocks may have been carried by gravity, water or wind to other areas where they gathered and hardened with other materials. Some may have formed by the evaporation of mineral bearing water and others by having been carried in glaciers. Rivers or streams are the most important agents that transfer the materials that will form sedimentary rock. Several characteristics are: (1) stratification (layering), (2) the presence of fossils and (3) the presence of foreign lumps called concretions. Sedimentary rock contains a greater number of fossils in a better state of preservation than any other kind of rock.

Gravel usually becomes a conglomerate rock. Sand formed sandstone. Silt and mud formed siltstone or shale. Shells of sea animals become limestone. Loose rock fragments falling from cliffs formed breccia. Major sedimentary strata form slowly over millions of years. In total, sedimentary rocks cover about three-quarters of the earth's surface.

Metamorphic

The word metamorphic refers to a change in form. A metamorphic rock was once sedimentary or igneous but was changed by heat, pressure or chemical action. Sandstone for example is changed by pressure or heat to quartzite, a much harder rock - in which the grains of sand are actually fused together.

Shale is changed by great pressure into slate. Granite, an igneous rock is changed by great pressure into schist, a rock formed of very thin crystals, layers or flakes.

With still greater pressure, the granite is changed into gneiss in which the crystals are flattened in parallel streaks.

Marbles are re-crystalized limestones. When limestone is altered by heat, pressure and water, the new rock is marble.

Rocks Have Their Ups and Downs

Throughout time all types have been moved by the earth's crust, some of these deposits have been lifted high above the ocean. Many of our Western Mountains are capped by rocks holding fossils or shells that were made of lime taken from the water of an ancient sea.

These rocks are now attacked in their turn by sun first and rain finally to be deposited over the earth by wind and water. In the past million years large quantities of rocks have been ground to dust by the ice of moving glaciers and carried miles before being added to the material of the soil.

Soil Gets Around

It is estimated that there is hardly a square mile of the earth's surface that does not contain some rock particle from some other square mile because of the action of wind and water.

Like Parents - Like Soil

With all this stirring and mixing the soil usually draws most of its mineral content from the parent material which is underlying the soil. Rich parent rock material produces a soil which can provide a rich environment for life. A poor parent rock material will give very little nourishment to the environment.

TEACHING PLAN

ROCK CYCLE

Objective: To develop a knowledge of the characteristics of rocks which form the solid part of our earth and to appreciate how they change.

Discussion Questions: Has there been any volcanic activity in your area? Where are the three types of rocks used in our culture? Why are some soil types better than others for supporting life?

References: Golden Nature Guide, Rocks and Minerals, Golden Press, New York, 1957.

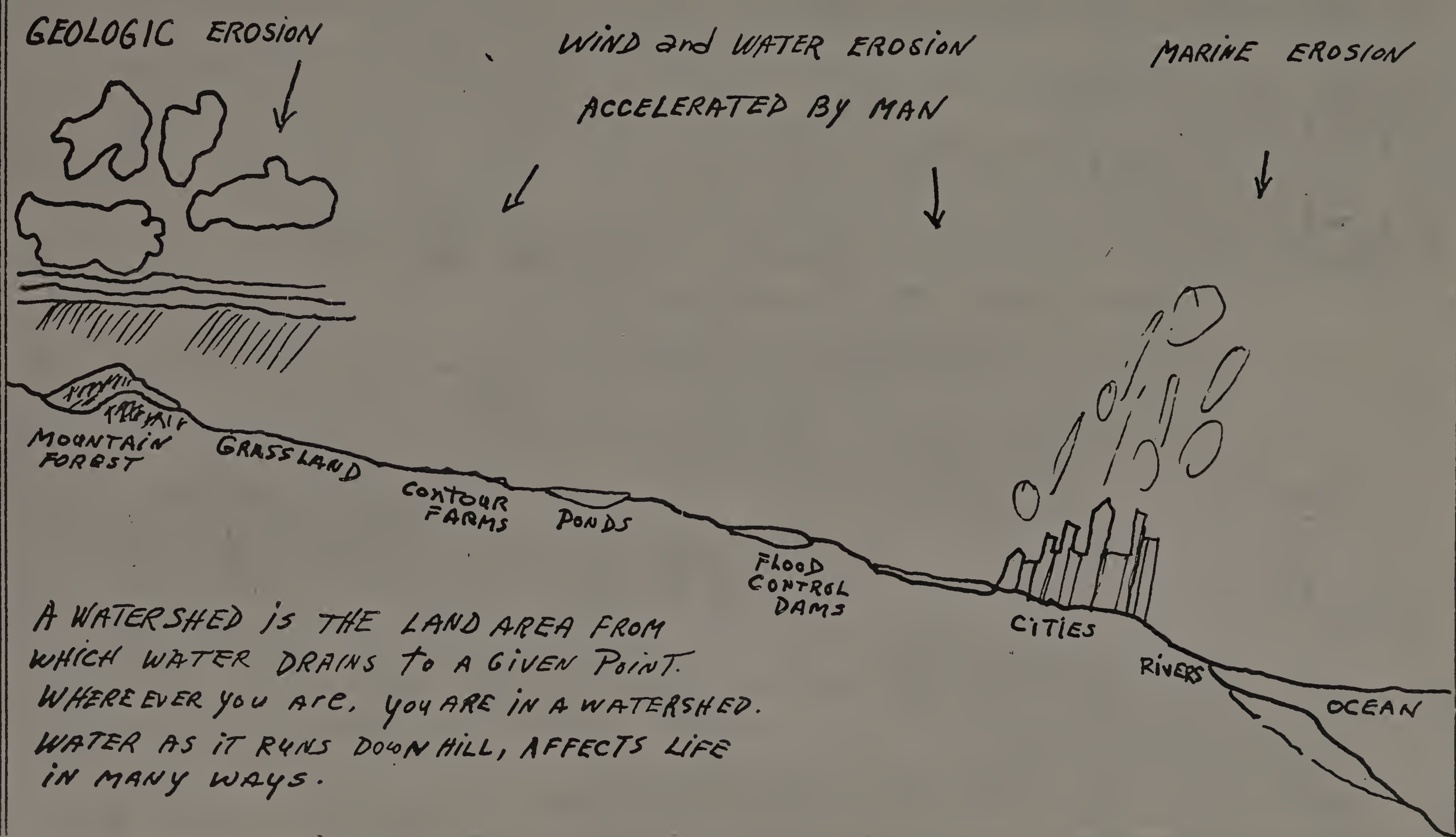
Vinson Brown, Experiment Book-Lab Fossils, Science Material Center, Inc., New York, 1964.

Carroll Lane Fenton, Rocks, Minerals, Gems, Nelson Doubleday, Inc., New York, 1958.

Rappert and Wright, The Crust of the Earth, Signet Science Library, New York, 1955.

Activities: Collect at least one specimen of the following rocks; igneous, sedimentary and metamorphic. Pour vinegar on limestone. What happens? Explain the reaction in terms of the rock cycle.

WATERSHED and the SOIL Cycle



A WATERSHED is THE LAND AREA FROM WHICH WATER DRAINS to A GIVEN POINT. WHERE EVER you are, you ARE IN A WATERSHED. WATER AS IT RUNS DOWN HILL, AFFECTS LIFE IN MANY WAYS.

THE SOIL CYCLE ON A WATER SHED

No one knows exactly how long it took Mother Nature to form an inch of soil. Some estimate it was at least 500 years. Others estimate it takes a 1000 years. If man lived 100 years he could have seen only a one tenth of an inch of soil form. No wonder we must take care not to waste it.

The story of the soil is interesting, fascinating and important to everyone in the country.

The food we eat, the clothing we wear, the homes we live in, the paper this is written upon all come from the soil. Our streets, cities, factories, schools, occupy much of the land but most of our soil in our country is used for growing food and fiber, raising livestock and wildlife, or is used for plants and trees which are utilized in manufacturing homes, furniture and furnishings.

Soil is formed in the following ways:

The Sun - heats rocks, makes them split.

The Frost - changes water to ice, expands and cracks rocks.

The Glacial Ice - acts like a steam roller, crushes rocks and moves them around.

The Rain - hits like little hammers and gradually wears the rocks; combines with acids in the air that help dissolve the rock particles.

The Wind - throws small pieces against larger ones thus wears both down.

The Water - grinds rocks into pieces, carries pieces to new locations.

The Plants - grow in soil, roots wedge rocks apart, plants remain and enrich the soil.

The Animal Life - spreads plant seeds, tunnels, brings soil to the surface and mixes soil layers. Decayed animal products enrich the soil.

Time - over a period of ages and by a combination of processes the topsoil as we know it was formed.

There are two kinds of erosion about which we must know before we study erosion. One is called geologic erosion and the other is accelerated erosion.

Geologic Erosion

Scientists tell us that it would take 375,000 years for seven inches of our top soil to erode from a ten percent slope if the land was covered with a good forest. If the same land, having a ten percent slope were in a good sod, it would take 5,000 years for the top seven inches of soil to be washed off. But if a farmer planted row crops such as corn on this land and did not use cover crops and plant on the contour, the top seven inches of soil could wash away in only ten years. Nature tries to save our soil, while many farmers have destroyed their soil.

Accelerated Erosion

Man accelerates the movement of soil with his activity. In the 1938 United States Department of Agriculture Yearbook, Soils and Men, Hugh Bennett and W. C. Lowdermilk, make the statement that three billion tons of soil material are washed or blown out of American fields every year. This equals 3,000,000 tons of nitrogen, nearly 2,000,000 tons of phosphorus, 38,000,000 tons of potassium.[1]

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1. Hugh Bennett and W. C. Lowdermilk, Soil and Men, p. 595.

Some interesting studies have been made of the soil which is carried down our Mississippi River, our largest watershed, 1,243,700 square miles, which drains so much of the productive area of our continent. It has been estimated that about 700 million tons of solid earth is dumped annually by this river into the Gulf of Mexico. During the flood stage of the Mississippi, at Vicksburg, it has been estimated that the soil equivalent of a forty acre farm goes down the river every minute. The city of New Orleans was first established very near the mouth of the Mississippi River back in the late 1600's. It is now over 130 miles from the mouth of the river. The city has not moved, but the immense body of land now showing beyond New Orleans is the extension of the delta as a result of the vast quantity of silt that has been carried down the river.

Erosion which means removing the top layer of soil is one of the ways in which our soils are injured. Water erosion is the washing away of surface soil by running water. Wind erosion is the blowing away of surface soil by winds.

During the dry years of the middle 1930's great dust storms caused the loss of thousands of tons of soil. In May 1934, a great dust storm started in the Southwest, spread eastward until the sun was actually darkened in New York city. Even the decks of ships well out at sea in the Atlantic were covered with dust. It has been estimated that this great dust storm blew 300 million tons of the best topsoil out of the Plain States and spread it over the Eastern half of the United States. This storm made the people of the United States aware of the threat of wind erosion - and the effects on local acres such as sand drifts and burying of fences and buildings. Blocked roads and drifted fields were common sights, but the worst of the dust storm was the loss of the richest part of the soil, its light fine soil particles which were carried great distances. Soils, centuries in the making, were lost by wind erosion in a month's time.

Soil is not replaceable

When the production of soil is reduced through the removal of plant foods by growing crops the land is not ruined. The materials of plant nutrition can be restored in the form of fertilizers and manures, and by the growing of soil improving legumes. Lost fertility can be restored and the land continued in production use. But when the soil is washed off bodily and carried into streams and rivers and finally into the oceans the entire body of the soil is lost, plant food and all. It cannot be restored even though it has washed from only the upper side of a field to the lower side. Farmers cannot afford to haul it back where it belongs, and the top soil layer built by nature during centuries is the most valuable.

New England has all types of erosion, geologic and accelerated. It has physical erosion like sheet and gully caused by water and/or wind, but due primarily to moving water. Chemical erosion is wastage of organic water and plant nutrients through chemical and biological action hastened by excessive tillage and leaching caused by heavy rainfall.

Soil is more than dirt on our land, mud on our shoes and dust in our eyes. Soil is one of the most important things in our lives. Understanding the soil cycle and soil erosion of our land is important to each of us for from our soil must come the material things we want in life.

TEACHING PLAN

SOIL CYCLE

Objectives: To develop within members a working knowledge of how soil is formed and lost in an area and help members to appreciate the value of retaining top soil

Discussion Questions: How much top soil has been lost in your state? Have you seen evidence of soil erosion in your area? How can soil productivity be increased? How does Man's health depend on the quality of soils?

References:

Buckman and Brady, Nature and Properties of Soils, The Macmillan Company, New York, 1960.

United States Department of Agriculture Yearbook, Soils and Men, Washington, D. C., 1938.

Our Land and It's Care, National Plant Food Institute, Washington, 1964.

What is a Conservation Farm Plan, United States Soil Conservation Service, Washington, D. C., 1959.

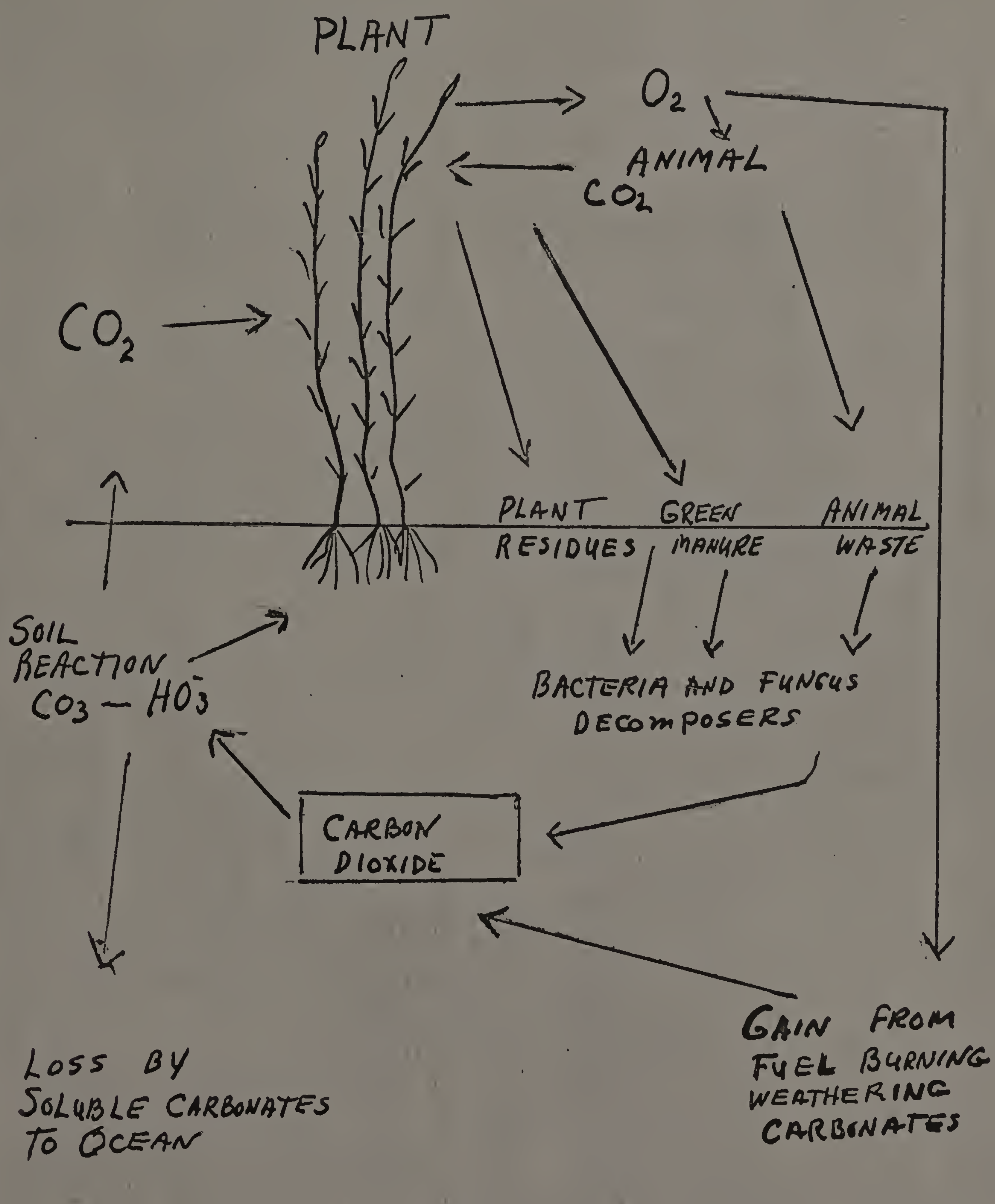
Down the River, Soil Conservation Society of America, Des Moines, Iowa, 1958.

John H. Storer, Web of Life, New York, New American Library, 1956.

Edward H. Graham, Natural Principles of Land Use, Oxford University Press, New York, 1944.

Activities: Measure soil on low side of a field. How many inches of top soil? Determine the depth of the top soil in your area.

CARBON CYCLE



CARBON CYCLE

Let's look at a piece of coal. A product which could be 250,000,000 years old. A substance in which 3000 different plant species have been identified. More than ninety percent of them were similar to plants we know today.

If we burn coal, we are releasing the carbon which was locked up in the plant and buried under sediment. If the coal is left unmined and this carbon is kept away from the atmosphere or the furnace, it will not be available to future plant growth.

Through the ages plants have locked up enormous quantities of carbon in this manner and stored it in the ground.

If we could picture the thousands of tons of coal that are used every day in the world, and all that has been used in the past it is estimated that there is enough left to last us for another thousand years or more. Totalling these estimates we begin to realize the vast amount of carbon that has been withdrawn from the air.

But this is only a drop compared with the amount that is used by plants and then returned to the air again by the animals and bacteria that eat the plants, decompose them and release their elements.

Where do we start this carbon cycle? Maybe we can understand it by observing a field of grass. The leaves in the field are working all day in the sun's rays, but when night comes the grass does not radiate it's newly gained energy back as does bare rock. In its green laboratory the chlorophyll blends the sun's captured radiation and the elements taken from the air, the water and the soil and builds these non-living materials into organized living form to make new blades of grass.

Anyone who has sat on a green lawn realizes how cool it feels. It gives no idea of the amount of sunlight stored within its framework. But dry it out and burn it and you have a prairie fire, or a barn fire so hot that it will kill man and animals. The fierce heat is merely a release of the same energy - organized gas and sunlight which the cool moist plants have been storing.

If this grass is used in a drier form, hay or silage, the energy will remain. If it is eaten by an animal, its life force transferred with it into the body of the animal to sustain the spark that we call life.

The use of plants by animals renews the carbon supply of plants and eventually the supply of animals as well. This is carried out by a process known as respiration. Waste products of animals are decomposed by bacteria molds and fungi. This group of organisms are essential to maintain the balance of the carbon cycle.

Without the decomposers, the bacteria and fungi that produce decay, the carbon in waste and dead organism would quickly become "fixed". It would no longer be returned to the carbon cycle in the form of carbon dioxide, a product of biological combustion.

Human beings and all other animals require the presence of the green plants and their photosynthesis not only to supply us with food substances, but just as important to keep renewing the atmosphere with the oxygen we require for respiration.

Just as important, the green plants must have the bacteria and other decomposers to replenish the supply of useable carbon (mainly carbon dioxide).

in the atmosphere and the hydrosphere. The carbon cycle is really inseparable with the oxygen cycle, and the producers, consumers and decomposers all play important roles in keeping the cycle going.

Agronomy books state that plant tissues that enter the soil have a heat value in the neighborhood of four to five kilocalories per gram of air dry substance.[1] A soil with four percent organic matter has an equivalent in heat value of perhaps twenty-five tons of anthracite coal.

Carbon is the common constituent of all organic matter. Its movements during the decomposition process of plant tissue are extremely important. As plants in the soil decompose, carbon dioxide is given off. This is the main soil source of this gas, although small amounts are excreted by plant roots and are brought down in rain water. It's common that from twenty to thirty pounds of carbon dioxide are released per acre per day.

The various changes that carbon undergoes within and without the soil are collectively known as the carbon cycle. Its failure to function properly would mean failure to soil plants and animals; plants and animals above ground and even man himself.

The carbon cycle could be properly called the cycle of life.[2]

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1. Harry O. Buckman and Nyle C. Brady, The Nature and Properties of Soil, p. 135.

2. Ibid, p. 138.

TEACHING PLAN

CARBON CYCLE

Objective: To present the principles of the carbon cycle in order to achieve an understanding of its importance to life on earth.

Discussion Questions: Why is organic matter so important to a good soil? What is the difference between organic and inorganic carbon? What percentage of the human body is carbon?

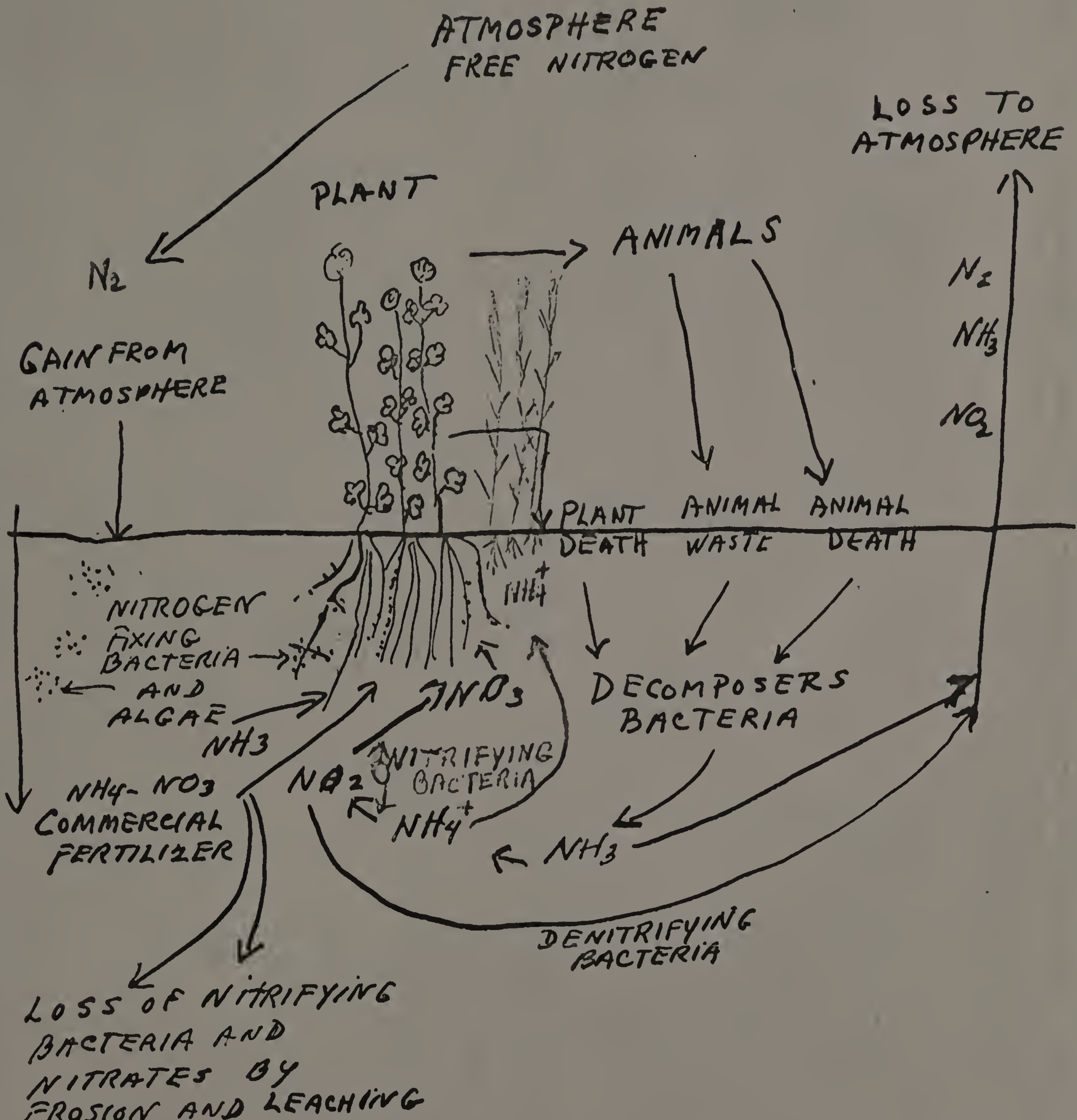
References: Biological Science Curriculum Study, Harcourt, Brace and World, Inc., New York, 1963.

Joseph Greaves, Argicultural Bacteriology, Lea and Febiger Philadelphia, and New York, 1922.

Marston Bates, The Forest and The Sea, New American Library, New York, 1961.

Activities: Record temperature of an active compost pile. Record temperature of soil near compost pile. Bury lawn clippings in garden soil. Observe and record in one week, one month and three months.

NITROGEN CYCLE



NITROGEN CYCLE

Nitrogen is one of the most plentiful elements on earth yet it is usually the element most needed by plants and animals. About eighty percent of the earths' atmosphere is nitrogen. Although there is enough of this element over a few square miles to supply the needs of plants and animals of the world, this vast supply cannot be used in its pure gaseous state. Known as free it must be fixed or combined in an available form such as ammonia.

Fixed nitrogen is supplied in many ways but the main four ways are: (1) by the atmosphere as the result of a flash of lighting passing through causing the nitrogen to combine with oxygen. These oxides combine with water to form nitrates which are carried to the earth by rain. About five pounds of nitrogen per acre are added to the soil each year this way. (2) Under favorable conditions certain free living bacteria and algae have the ability to fix nitrogen in the soil. Until recently the thought of fixing free nitrogen in soil air was limited to a few abundant organisms. Today, ability to fix nitrogen is proving to be wide spread among many soil organisms. However, no higher plant is able to fix nitrogen alone. Certain plants and legumes do so with the aid of symbiotic bacteria. (3) Symbiotic bacteria living on the roots of legumes combine the nitrogen from the atmosphere in forms which can be used directly by the legume plant. These bacteria get carbohydrates from the legume host plant and the host plant gets nitrogen. Some is excreted to the soil and is used by other plants. (4) In spite of the bacteria action in the soil and the nitrogen coming from electrical storms, man has found it necessary to use nitrogen fertilizer to supplement nature. To keep soils at high levels of productivity the average farm needs more nitrogen from fertilizer than all of nature's processes are able to fix. For example, at least 150 pounds of nitrogen are required to produce a 100 bushel crop of corn. A part of this requirement may come from the atmosphere and soil, a part from crop residue - a part from commercial fertilizer. In most soils high corn yields are produced with commercial fertilizer or manure and commercial fertilizer.

The nitrogen cycle is a complex cycle. Nitrogen is broken down from organic matter into an inorganic form by a series of decomposer bacteria which produce ammonia. Ammonia is changed to a nitrite by nitrite bacteria, which are then changed to nitrates by nitrate making bacteria.

One should not get the idea that there are no losses in the nitrogen cycle. While nature and man are working to supply nitrogen to the soil other forces of nature are removing it and returning it to the atmosphere. This is the nitrogen cycle.

Rains and flood leach and erode the soil, carrying bacteria, the nitrates, and the soil out to sea.

Other bacteria called denitrifying bacteria use nitrogen compounds such as nitrates and ammonia for energy and return free nitrogen to the atmosphere. Fires on the surface of the ground burn plant residues and in the process return gaseous nitrogen to the atmosphere. Bacterial action in the soil organic matter produces some ammonia which escapes to the atmosphere.

Crops and animals sold from the farm remove nitrogen from the soil which must be replaced. The removal of products sold off the land account for most of the loss of nitrogen from the average farm. Most of this nitrogen never finds its way back to the farm.

Other losses of nitrogen from the atmosphere to sediment in the ocean are apparently balanced by the gain from volcanic action.

TEACHING PLAN

NITROGEN

Objective: To orient members to the various forms of nitrogen and to develop an understanding of its importance to plants and animals.

Discussion Question: What plants of your area fix nitrogen? List them. How do legumes help other plants to grow better? What are the different forms of nitrogen that a farmer can buy?

References: Our Land and Its Care - National Plant Food Institute, Washington, D. C. 1962.

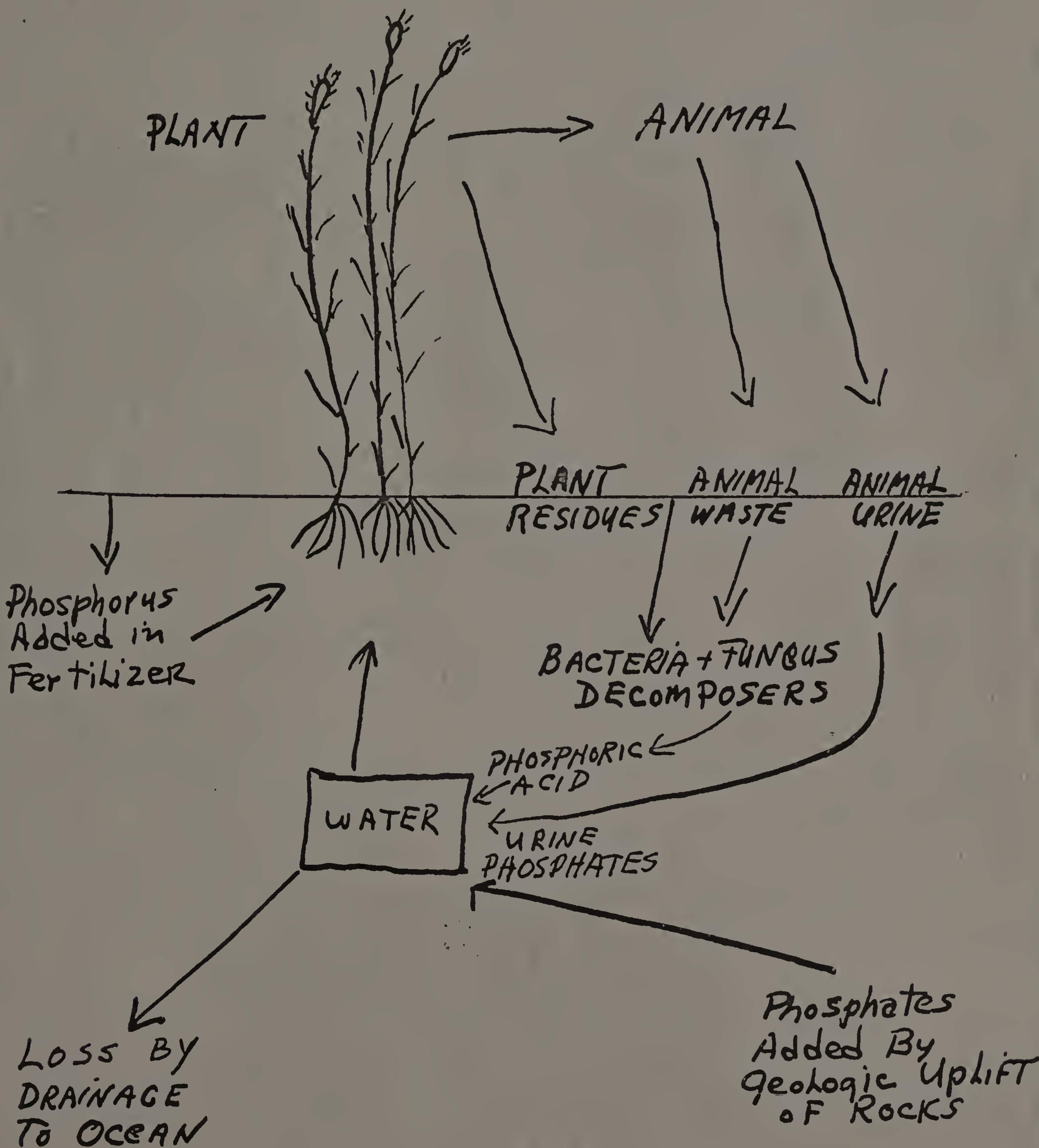
Biological Science Curriculum Study, Harcourt Brace and World, Inc., New York, 1963.

Joseph Greaves, Agricultural Bacteriology, Lea and Febiger, New York and Philadelphia, 1922.

1957 Year Book of Agriculture, Soil, U.S.D.A., Washington, D. C.

Activities: Examine a root of a clover plant. Are there any nodules? Examine other legumenous plants for nodules? What does a 10-10-10 fertilizer mean? What commercial fertilizer provides nitrates for plants?

PHOSPHORUS CYCLE
ON LAND



PHOSPHORUS CYCLE

Squanto, as our history books tell, was our first County Agent who demonstrated how to plant corn. Today we are interested in what fish did for the corn plants. Did it supply nitrogen, phosphorus, potash or some minor trace element from the sea?

We are not sure of its chief fertilizer effect but certainly nitrogen was available and so was phosphorus. Phosphorus has been used to develop soils for millions of years. Much of it has been brought inland from the sea by birds. Over countless ages a phosphorus content was developed in America so that when the white man arrived in the New World, lands were fertile and plants covered the continent.

Phosphorus has been called the master key to agriculture. Low crop production is probably due to the lack of phosphorus than any other element.

Except for nitrogen, poor plant growth more often is due to a shortage of phosphorus than any other element. Phosphorus is very closely associated with all life processes and is a vital constituent of every living cell. Without phosphorus there could be no life.

This country is fortunate in having nearly one third of the total known world supply of phosphorus - about fifteen million tons in the form of rock phosphate deposits.

About forty percent of our rock phosphate supply is in Florida and Tennessee and sixty percent in the Rocky Mountain states. It is estimated that we have in known deposits sufficient phosphates to last us for more than 2000 years.

Phosphates are one of the most deficient plant nutrients in cultivated soils. Where it has become necessary to apply commercial plant nutrients phosphates are usually the first to be added.

The phosphorus content of the soil may be low not only because of low original amounts but also because of cropping and grazing and there have been great losses from soil erosion. It has been estimated that after fifty years of land cropping the land in two states lost one third of the total phosphorus. Six carloads of cattle may contain phosphorus equivalent to that in the surface six inches of soil on an acre of land.

It is well understood that there are large areas in various countries throughout the world where the phosphorus content of plants is so low it causes considerable losses among grazing animals.

If the soil contribution to the plant is mainly minerals, then the more fertile soils must be so because they contribute more minerals. Nature has given wild animals some instincts which are demonstrated in their search and selection of feeds according to mineral supply. Phosphorus and calcium are high on the shopping list of animals when they are looking for bone building material. Research has found that rodents of the forest are principally responsible for disappearance of the deer antlers shed each year.

Phosphorus is supplied both by inorganic forms and organic forms. We have talked about the large United States supply of inorganic phosphorus rocks which are supplied by agriculture in the form of fertilizer. Some organic phosphorus is being supplied by marine fishes. Organic phosphorus in the soil is supplied through the cycle of plants - animal and decomposers being applied to organic matter such as dead plants and animals, and animal waste. Organic matter not only provides bacteria its food supply but acts as a storehouse for nitrogen, phosphorus, calcium, potash and other nutrients. It keeps these plant foods available so plants can use them. However, the availability of inorganic phosphorus is largely determined by soil acidity on one hand and available calcium on the other, the amount of organic matter and its decomposition by microorganisms and the presence of iron, aluminum and manganese as minerals and their solubles. Experiments have shown that soil reaction has a tremendous effect on the availability of phosphates.

Phosphates are most available between pH 5.5 and pH 7.5 Above the pH 7.5 phosphates are partially fixed by calcium while below the pH 5.5, the fixation is thought to be accomplished by aluminum and iron.

The small amount of control that can be exerted over phosphate availability seems to be in the fields of liming, fertilizer placement and organic matter maintenance. By holding the pH of the soil between 6. and 7. the phosphate fixation can be kept at a minimum.

With the possible exception of nitrogen no other element has been as important to plant cell growth as phosphorus. The lack of this element is serious also since it may prevent other elements from being used by the plant. In addition to its value as a primary plant food phosphoric acid acts as a catalytic agent which enables many crops to increase their use of other plant foods. Phosphorous is as necessary as nitrogen in the formation of plant proteins. It also helps in the development of a vigorous root system and is vital for the formation of seed and fruit. Phosphorus to be available to plants must be in the phosphate form. The element phosphorus' importance in animal life is unquestioned. In mammals, seventy to eighty percent of the body phosphorus is in the skeleton, ten percent in the muscle and ten percent is in the nervous system. Every cell has phosphorus. Phosphorus more than any other element is the cause of low crop production and the amount used in American farms is only a fraction of what is needed for the best results. Animals grazing on this deficient forage and not receiving supplementary food rich in minerals eventually show evidence of malnutrition. Completing the phosphorus cycle is important to man's future but it is immediately more important to the food producers, livestock farmers, conservationists and consumers.

TEACHING PLAN

PHOSPHORUS CYCLE

Objective: To familiarize members with the element phosphorous and its availability in the life cycle.

Discussion Question: How do farmers supply phosphorus to their plants and animals? What minerals are in phosphate rocks? What does lime do for making phosphorus available to plants? Why do fine boned animals come from the certain areas of the world?

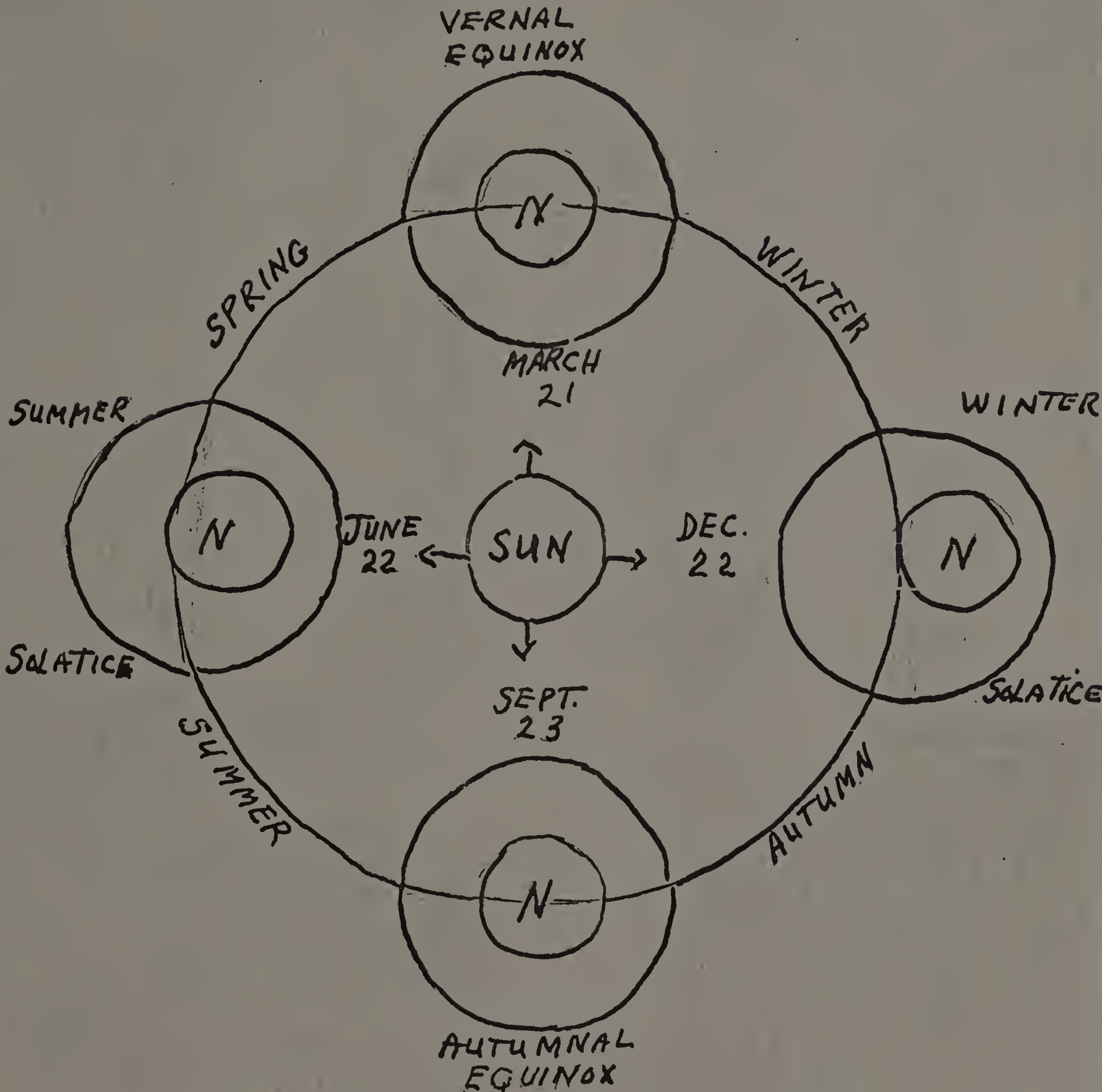
References: Biological Science Curriculum Series, Harcourt, Brace and World, Inc., New York, 1963.

Our Land and Its Care, National Plant Food Institute, Washington, D. C., 1962.

Joseph Greaves, Agricultural Bacteriology, Lea and Febiger, New York and Philadelphia, 1922.

Activities: Apply superphosphate with manure in corn production. Apply manure only - compare. Test a soil for nitrogen, phosphorous and potash. What is the recommendation for additional fertilizer?

SEASONS OF LIGHT AND HEAT in the NORTHERN HEMISPHERE



THE CYCLE OF HEAT AND LIGHT

CHANGES OF SEASONS

Two motions of our earth affect the weather. The earth's annual trip around the sun gives earth its seasons and its typical weather. Earth's daily rotation causes our days and nights and it also produces the main wind belts of our earth and each has a certain pattern of weather.

The seasons are caused because the axis on which the earth spins is slanted twenty-three and one-half degress to the plane of its orbit. When the north pole is tipped toward the sun, the northern hemisphere has summer. Then the sun's rays beat more directly down on the northern hemisphere and the days are longer.

The sun is farthest north at the summer solstice about June 22nd, when the daylight hours are longest in the northern hemisphere and the nights are the shortest of any time in the year. At this time the North pole is in the middle of its annual period of six months of sunlight.

At the winter solstice about December 22nd, the North Pole is tipped farthest away from the sun. The southern hemisphere has summer, the northern hemisphere has winter. The antarctic is now the land of the midnight sun and the arctic is sunless.

At the fall and spring equinoxes, about September 23rd and March 21st, the earth's tilt is sidewise with respect to the sun. Light falls on the earth in equal amounts in the northern and southern hemispheries. Day and night are of equal duration everywhere on the earth. The equinoxes mark the beginning of spring and fall.

Summer is warmer than winter for two reasons. The days are longer and the sun's rays, striking our part of the earth more directly, therefore, are more concentrated.

Days and nights are always twelve hours long on the equator. The farther north one goes in the summer the longer the days and the shorter the nights. The nearer one gets to the North Pole the longer the days become until finally they become twenty-four hours long. As winter comes the sun seems to move south. The farther north you go, the shorter the winter days and the longer the nights.

The summer sun follows a path more nearly overhead so the rays are more concentrated. The winter sunlight hits the earth at a greater slant. The same amount of sunlight is now spread over a larger area. In addition winter sunlight must pass through more atmosphere because it has a more slanted path. More of the sun's energy is diffused by the atmosphere and less reaches the earth to warm it.

In our state August is hotter than June even though the sun is more nearly overhead and the day is longest on June 22nd. June, July and August are our hottest months because during these months our heat gains control and continues to exceed our heat loss. The heat gain continues to exceed heat loss at a diminishing rate until August 31st. Then our area starts to lose heat faster than it receives it and begins to cool down.

The sun's apparent movement to the earth in winter and in summer is seen in the length of the shadows at these two times of year. One will be very aware of the long shadows during the short winter days. Summer time gives us a shorter shadow. On June 22nd, the sun rises farther in the north and at noon reaches a high altitude. Its path is longer and so daylight lasts about fifteen hours.

TEACHING PLAN

HEAT AND LIGHT CYCLE

Objective: To explain the amount of sunlight which produces the heat for our changing season.

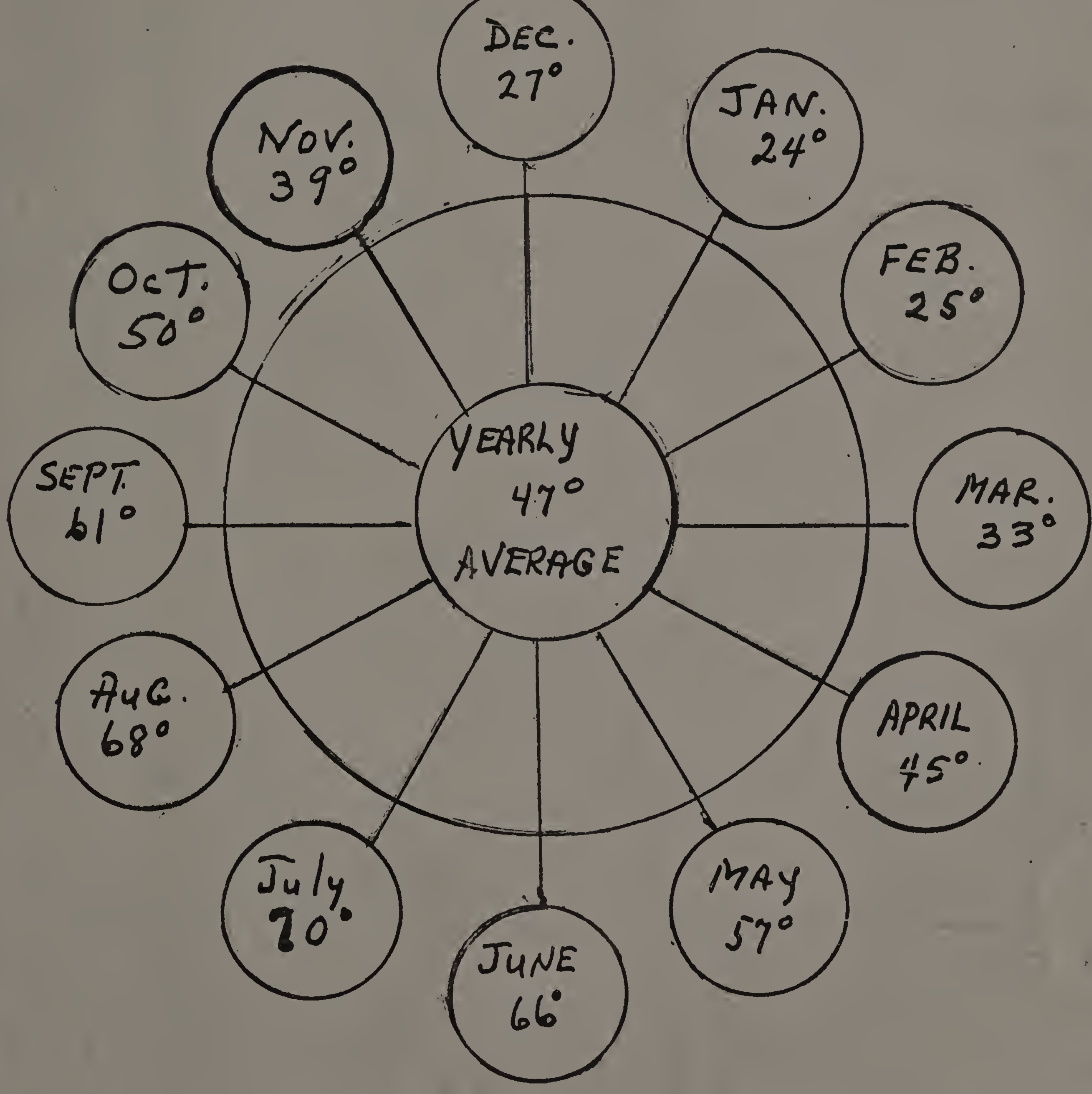
Discussion Questions: Why is our hottest weather in July when our longest day is in June? How is animal life protected from ultra violet radiation? What are the high and low records in your area? Why is there an energy gain or loss from rocks and plants at night and in day? How does sunlight create our weather?

References: Weather, A Guide to Phenomena and Forecasts, Golden Press New York, New York, 1957.

Year Book of Agriculture, Climate and Man, 1941, United States Department of Agriculture, Washington, D. C.

Activities: Record air temperature on first, fifteenth, thirtieth of each month. Record ground temperature monthly from the fifteenth of April to fifteenth of November.

MONTHLY TEMPERATURE CYCLE IN MASSACHUSETTS



SOME EFFECTS OF MONTHLY TEMPERATURE CYCLE ON WILDLIFE

No one escapes the weather. Even the wildlife have to live in it and sometimes it causes them directly or indirectly to perish. In addition to several practices in wildlife management, it is the objective of the writer to bring out the direct or indirect effect temperature plays in the environment of wildlife of our area.

Adverse weather is an important decimating factor in the production of wildlife. Limiting factors in the production of wildlife are associated with the winter season for most species of terrestrial wildlife. Temperature alone, or in combination with a lack of high energy food, may be considered a limiting factor.

Winter temperatures are often severe enough to greatly reduce the number of adults which survive and provide breeding stock for the coming year.

How do animals spend the winter? Here are some interesting facts about conditions out of doors in winter.

The frost line is the lowest point to which the ground freezes. Usually this is at a depth of two to four feet. Below this line the ground remains unfrozen so animals which burrow below the frost line will not be frozen no matter how cold it gets above. A deep snow serves as a blanket and prevents snow-covered ground from freezing as deeply as bare ground.

Ponds and streams do not freeze solid; there is only a layer of ice on the surface. Below the ice, the temperature always stays about thirty-nine degrees farenheit. This is because water is heaviest at thirty-nine degrees farenheit; if it becomes colder the water becomes lighter and rises. That is why ice floats.

There are two main types of body temperature animals. The cold blooded animals have the same temperature as the air and water around them. They cannot move about in cold weather as they would be frozen solid. Warm blooded animals have an almost constant body temperature regardless of the temperature of the air or water. Only birds and mammals are warm blooded, and only they can move about out of doors in really cold weather. Evergreens, thickets, weed patches, snow drifts, hillsides, provide them with shelter from the wind.

Hibernation is a special kind of winter sleep which is different from ordinary sleep. The temperature may drop to within a few degrees of freezing and the heart beat and rate of breathing is much slower than usual.

Animals that hibernate usually prepare for winter by eating heavily, thus storing up fat. This fat is often near the skin especially in mammals, and acts as a blanket against the cold. Little fat is needed as food during hibernation. Therefore, most of it is used after the animal awakes. This is important because food is still scarce in the early spring.

Migration is a movement from one place to another at certain seasons. Most of our summer birds migrate south for the winter. Likewise, most of the birds that spend the winter in Massachusetts, are birds that summer farther north.

There are several theories as to why birds migrate. One that seems rather probable is that in an earlier time non-migratory birds swarmed over the northern hemisphere which at that time supported a plentiful year round food supply, such as the condition which now exists in the tropics.

Another theory supposes that the ancestral home of all birds was in the tropics and that as this area became over-populated, many species were gradually forced northward to find food and breeding grounds, only to be forced southward again by the rigors of winter.

> A modern view based on studies of living behavior suggests also that there is good reason for believing that migration is an annually induced movement. One such theory is called the theory of photoperiodism and holds as its major premise that quantity of light and length of day are the stimulating causes of migration. It is pointed out by the proponents of this theory that migration is a phenomenon far too regular to be created anew each season merely under stress of circumstances, such as need for food; and that it begins before the necessity for a change of latitude becomes at all pressing.[1]

Mammals may migrate, hibernate or remain active. Some bats migrate south. In New England, we have seven mammals which hibernate either all or part of the winter. They are the bear,[2] woodchuck, raccoon, skunk, chipmunk, jumping mouse and bat.[3] Most mammals are active all winter. Some store up food for the winter as the beaver, squirrel, and many of the mice.

Insects, spiders and other land invertebrates are cold-blooded and so do not move about in cold weather. They spend the winter hidden under bark, leaf mold, or stones, in rotten logs in the ground. Often, the adult dies in the fall and only the eggs live over winter. This is true of most spiders and many insects. They prepare for hibernation by drying up, otherwise they would burst when they froze.

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1. Robert Hagey, Bird Migration, p. 1.

2. Howard Spencer, Black Bear in Maine, p. 11.

3. N.R. Barger, Wisconsin Mammals, p. 50.

Frogs and turtles burrow into the mud at the bottom of ponds and hibernate. A few frogs may winter in rotten logs or under leaf mold.

Salamanders hide in rotten logs at the bottom of streams and ponds. Snakes and toads find holes in the ground and spend the winter below the frost line. Often many snakes will hibernate together in huge balls.

Fish swim about under the ice or remain fairly quiet at the bottom of the ponds and lakes. In some areas where ice covers the pond for a month or more, fish may die from the lack of oxygen or from gases trapped under the ice. Inflow of water during the winter is the surest way to provide oxygen to the wintering fish.[4]

There are many correlations between weather conditions and duck migrations. Extensive migrations of a particular species or many species were nearly always associated with passage of a cold front.

Primary considerations must be given to the conditions under which living things are forced to live. Man can move or change his surroundings to suit his needs, but in the case of animals (such as deer) they must stay rather close to where they are born and accept things as they are. Climate in Massachusetts, varies from the mild Cape Cod area to the severe conditions of the Berkshires. In general, the climate is humid with annual temperatures about forty-seven degrees Farenheit. Winter temperatures average twenty-six degrees Farenheit, with several days going below Zero. The

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4. Adrey E. Borell and Paul M. Scheffer, Trout in Farm and Ranch Ponds, p. 16.

summer temperatures average sixty-eight degrees Farenheit, with a few days reaching 100 degrees Farenheit.[5] The growing season, as a rule, extends from May into early October, a period of about five months. It is during this warm weather that some animals store up considerable quantities of excess fat to tide them over the leaner winter months.

Summer is usually the critical period in Massachusetts for trout. "Being a cold water fish, they often are unable to withstand the rise in temperature which occurs in many streams during the hot, dry summer months."[6] In streams where warm water temperatures occur, one of the most important management techniques is to encourage growth of plants along the stream bank, for shade to help prevent water from warming. Trout in lakes and ponds are also in a critical period in summer.

Extreme heat and cold have a marked effect on pond and lakes. Extreme heat warms more of the water area thus more decomposition of organic matter takes place. This can cause summer stagnation. In winter, excess vegetation in the water with prolonged ice cover and shallow water causes winter stagnation and fish die from winter kill or suffocation from lack of oxygen.

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5. Mark T. Nesmith, 1941 Year Book of Agriculture, p. 991.

6. Carl A. Carlozzi, Conservation of Natural Resources, p. 15.

TEACHING PLAN

EFFECTS OF TEMPERATURE ON WILDLIFE

Objective: To develop an understanding of how temperature effects the life of many of our native animals.

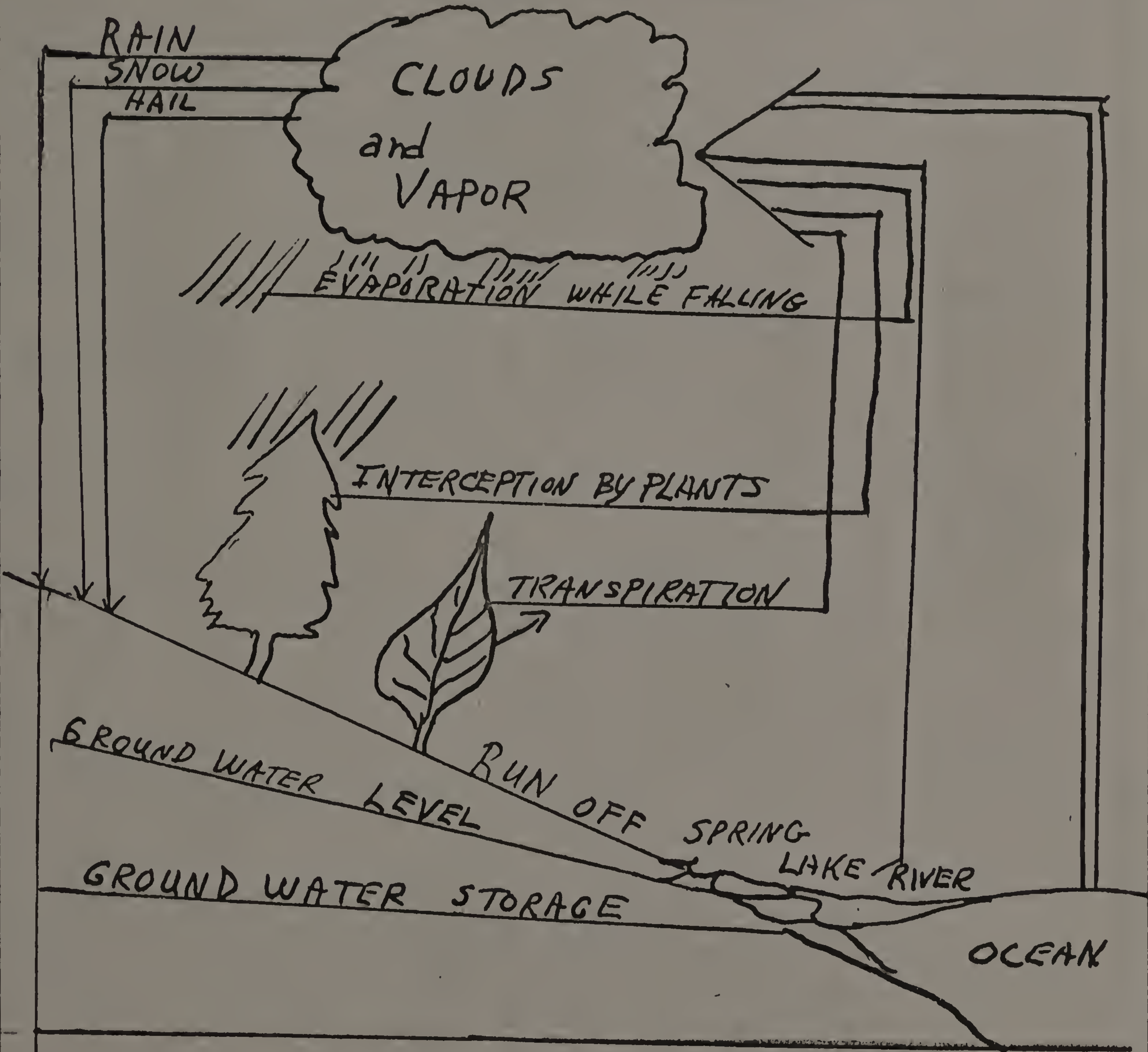
Discussion Questions: How does temperature affect migration? Why does ice form on the surface of a pond? In what ways do animals spend the winter?

References: Massachusetts Bulletin 511, 1959, Climatological Data, 1959 Yearbook of Agriculture, Climate and Man, United States Department of Agriculture, 1941, Washington, D. C. Mann and Hastings, Out of Doors, Henry Holt and Company, New York, 1922.

Activities: Record pond temperature monthly from April-October. Look under a brush pile in April and November; record findings. Look under a decaying log in April and November. Record findings.

THE HYDROLOGIC CYCLE

THE MOISTURE MERRY-GO-ROUND



THE HYDROLOGIC CYCLE

The unending circulation of the earth's moisture and water is called the water cycle or hydrologic cycle. It is a gigantic system operating in and on the land and oceans of the earth and in the atmosphere that surrounds the earth.

"About 80,000 cubic miles of water are evaporated each year from the oceans. About 15,000 cubic miles are evaporated from the lakes and land surfaces of the continents. Total evaporated is equal to the total precipitation of which about 24,000 cubic miles falls on the land surfaces; equivalent to a depth of 475 feet — over all of Texas."[1]

Actually the cycle has no beginning or ending but since two-thirds of the earth's surface is ocean, we can begin with the waters of the ocean. Water from the ocean is evaporated into the atmosphere. Moisture is lifted and is eventually condensed and falls back to the earth's surface as precipitation. The part that falls as rain, hail, dew, snow, sleet on the land is of particular concern to man, agriculture and wildlife. Some of this precipitation is in the form of rain which causes erosion and is the main factor in floods. Of the precipitation that soaks into the ground, some is available for growing plants and some for evaporation. Some reach the deep areas of the earth to become our underground streams and springs. Much finds its way into streams and rivers which eventually lead back to

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1. W.M.C. Ackerman, A. Coleman and Harold Ogrosky, Water, United States Department of Agriculture Yearbook, 1955, p. 41.

the ocean where the water originated. Water does not usually return directly to the lakes or sea; but often is evaporated from the surface of the ground or is transpired through the leaves of plants and falls again as rain, snow or hail. This happens many times before the cycle is completed.

Water, next to air, is man's most plentiful and precious resource. Where there is no water there is no life. Humans can go over a month without food, but can live only three or four days without water. Even knowing this, man takes water for granted using and misusing it with little regard for the future.

Some people think we are running out of fresh water and that when we drink it, it is lost forever. Most scientists, however, agree that the amount of water on hand in the earth has diminished very little in the history of man. No matter what you do to it, water eventually comes back.

Water is always present, either in the soil, rivers and lakes, oceans or in the air. More than half of all living things is made of water. We are fortunate in New England in having plenty of rainfall almost every year. However, much of it is lost because of poor conservation practices.

The water we use today could have been last year's snow storm, last summer's thunder storm, last year's hurricane or last week's snow storm. It is a fascinating substance. It freezes at thirty-two degrees Farenheit, vaporizes at 212 degrees Farenheit and flows as a liquid anywhere between.

It covers seventy percent of the globe and makes the earth friendly to life. It will dissolve more substance than any known liquid. Its specific gravity permits it to float and melt. Otherwise, it would probably pile-up on the ocean floor, raise sea levels to flood the land and gradually turn the earth into another frozen planet.

Our forefathers denuded the land with the axe and plow and contributed to years of floods. Much of the damage done then still haunts us today. Every spring and fall millions of gallons of much needed water rushes over everything in its path in a headlong dash to the sea, not stopping to soak into the earth, not being used by man. First it's too much water then too little. It's either a flood or a famine.

Water must move slowly through its cycle - earth to atmosphere - atmosphere to earth.

"Water in all forms, as a gaseous, liquid or even solid, plays an important part in mammalian ecology."[2]

For land mammals, water is first of all an essential factor in the life processes. Yet the various groups do not have the same requirements, and these requirements can be satisfied in various ways. Since mammals drink a great deal and are restricted, habitats must provide free water in sufficient quantity. Other animals in the absence of a temporary or permanent water supply, drink dew or water running down tree trunks or foliage after a rain. Some animals find enough water in the animal or vegetable food they eat.

Atmospheric humidity is another important ecological factor particularly for certain species. The small bats for example, can live only in

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2. Francois Bourliere, <u>The Natural History of Mammals</u>, p. 257.

rather humid air. Some insectivores such as moles also require dampness. Outside their very humid burrows, moles do not live long in a dry atmosphere. "Snow and ice constitute an important ecological factor for mammals living in cold regions. When winter snow reaches a certain depth, it seriously interferes with the feeding of herbivores and impedes the locomotion of even the largest species".[3]

On the other hand, snow is a poor conductor of heat and this property helps many species to survive in low atmospheric temperatures.

All the direct or indirect effects of water which have just been briefly mentioned are dependent under natural conditions upon the annual rainfall and moisture in the atmosphere.

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3. Ibid, p. 260.

TEACHING PLAN

WATER CYCLE

Objective: To give members a working knowledge of the water cycle and its limitation for plant and animal life.

Discussion Questions: What do you consider to be our two chief water problems? Explain. Do you see any connection between water shortages and soil erosion? How much average rainfall can you expect in your community? How much water does your family need a day?

References: Washington, SCS-TP-147, Water and the Land, July 1965.

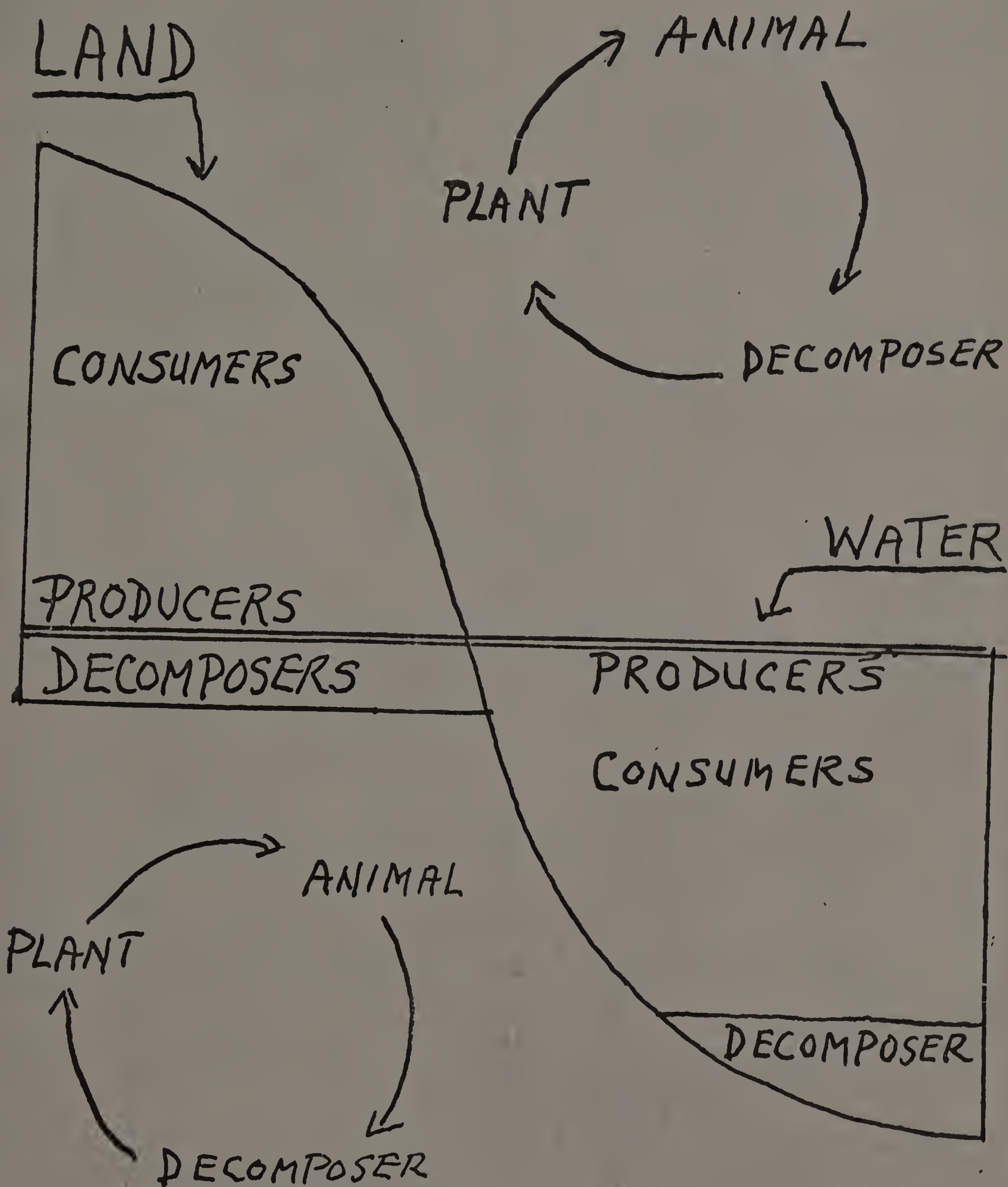
United States Department of Agriculture Yearbook on Agriculture, Water, Washington, 1955.

Leopold and Langbein, A Primer on Water, Geological Survey, Washington, 1963.

Soil Conservation Society of America, Down the River, Des Moines, Iowa.

Activities: Collect sample of water from stream in Spring-Summer-Fall. Make a rain gauge. Record rainfall from May-October.

FOOD CHAIN


LAND
ANIMAL
PLANT
DECOMPOSER
CONSUMERS
WATER
PRODUCERS
DECOMPOSERS
PRODUCERS
CONSUMERS
ANIMAL
PLANT
DECOMPOSER
DECOMPOSER

THE FOOD CHAIN

> "A food chain is a steady series of processes within the realm of nature where one form of organism provides food for another beginning with the microbe and ending for the microbe."[1]

We can group organisms into three broad categories: The producers, the consumers and the decomposers.

The producers are the green plants, the organisms with chlorophyl. The importance of green plants lie in the fact that they are responsible for the primary production of all food needed by other living things, including all animal life.

It was only after primitive life had acquired this new kind of metabolism that anything like our present plant life kingdom could become established on earth.

The animal kingdom is of course, still younger, although perhaps only slightly so, because it scavengers the carbon transformed to organic substances by plants by organic photosynthesis, a process of which animals are incapable.

Animals then are basically consumers living off the green plants, They give back many chemicals to the plants in excretion or from decomposition of their dead bodies, but they live by burning the carbon compounds they get directly or indirectly from the plants. The end product of this burning is carbon dioxide which only can be recovered by the plants by photosynthesis.

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1. New Hampshire State Department of Education 1961, The Wise Use of Natural Resources in New Hampshire, p. 52.

The animals that live directly off the plants are generally very small and very numerous. They have been called "Key Industry Animals" by British Ecologist, Charles Elton, because all of the rest of the complicated animal world depends on them. In water the producers are generally microscopic organism floating in the surface plankton and the Key industry animals are either microscopic or very tiny, also part of the drifting plankton. On land the producers are mostly ferns, grasses and seed plants and the key industry animals are the thousands of species of insects that live directly on the leaves of these plants.[2]

The food chain, the way of passing around the carbon supply would not be complete without the decomposers. The decomposers, mostly bacteria and fungi, are always with us playing a very essential role of reducing the bodies of plants and animals to their component material so that the chemical cycles can start all over again. Bacteria act upon plant and animal residues liberating carbon dioxide, ammonia, sulfides and phosphates in this mineralization process, transform mineral substances in nature. The bacteria act merely as the link between the living and the dead.

Were this not true, all the carbon and combined nitrogen of the world would soon become locked up in the dead bodies of animals, plants would starve and die and animals would likewise become extinct.

The absence of bacteria is incompatible with life on this earth and

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2. Marston Bates, The Forest and The Sea, p. 118.

as Pasteur said, "they protect the living against the dead".

A young friend of mine was telling his story of catching a twenty-one inch pickerel. Inside the pickerel was an eight inch pickerel, inside the eight inch pickerel was a crayfish. Here is a very vivid food chain which can be seen with the naked eye.

Tracing the food chain further back we would probably see the crayfish as a link in the chain of food cycle. Crayfish live on the bottom of streams where they walk slowly, sifting through sediment. They are true scavengers, although fresh plant matter is eaten. Water insects and other animal life products are consumed. Eventually we can trace the food supply back to the aquatic plants which captured sunlight to make food for aquatic animals.

Another food chain easily seen is the wild rabbit eating clover and soon he is eaten by a fox. Another food chain would show man eating an ear of corn which he had raised. Sometimes the chain is very short, other times its a complicated chain of events. The shorter the food chain the more energy is available to be concentrated into living weight.

While a food chain can be complete on land in perhaps as few as three or four steps, in aquatic environments this seldom happens in fewer than seven steps.

TEACHING PLAN

FOOD CHAIN

Objective: To explain and describe various food chains to members.

Discussion Questions: Why are there more steps in a food chain in a water environment than a land environment? Why are insects so important in the animal food chain ? Why are bacteria so important in the food chain?

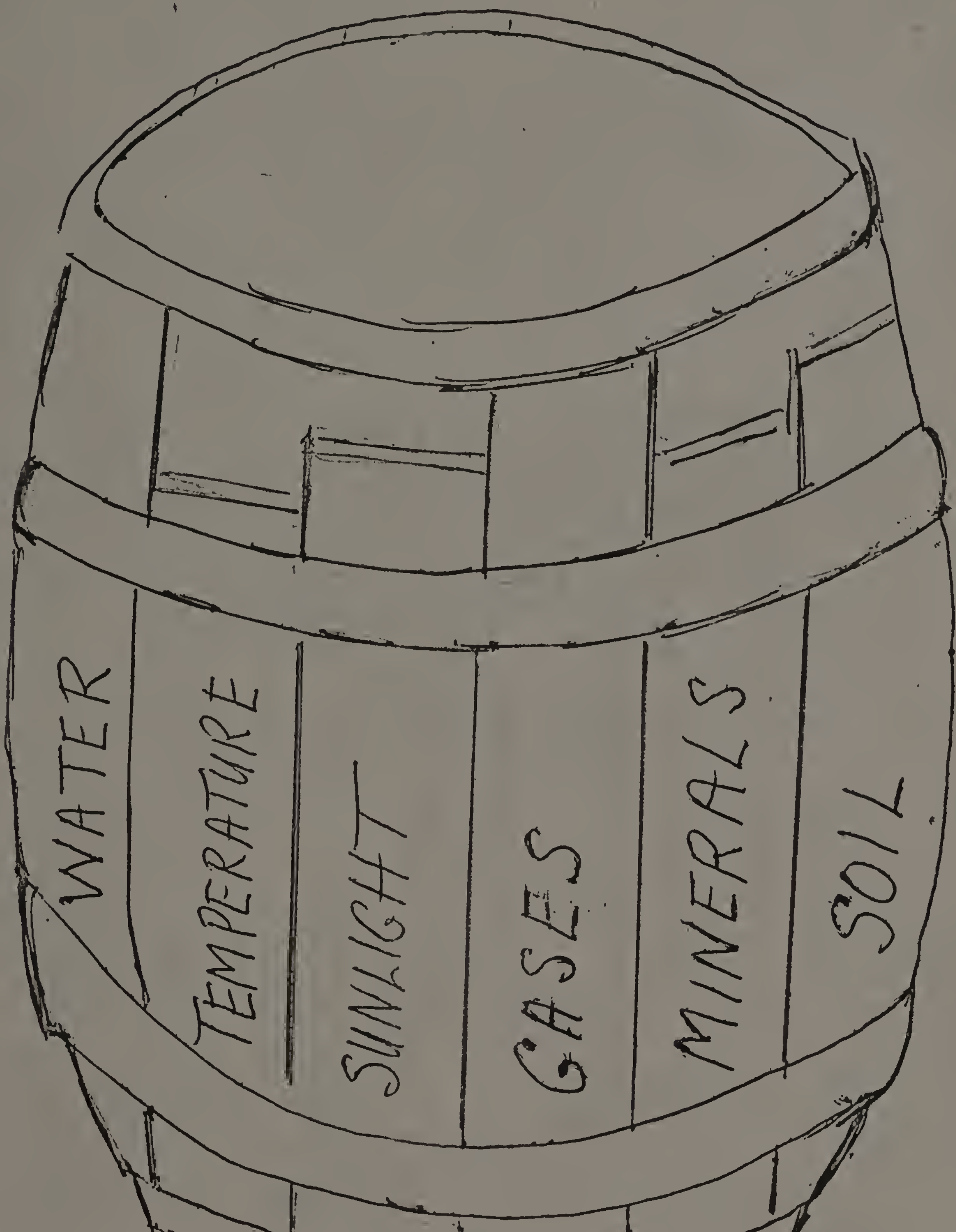
References: Eugene Odum, Fundamentals of Ecology, W. B. Saunders Company, Philadelphia, 1959.

John H. Storer, Web of Life, New American Library, New York, 1953.

Edward H. Graham, Natural Principles of Land Use, Oxford University Press, New York, 1944.

Activities: Observe and record the food chain or rabbit, deer, bass Canada Geese, Mexican Bean Beetle in your area. Observe and record animals found in swamp or pond water.

LIMITING FACTORS



THE AMOUNT THE BARREL HOLDS IS ITS SHORTEST STAVE OR ITS LIMITING FACTOR

LIMITING FACTORS

The food or water supply, the climate or weather conditions, the cover available or the space available, the pressure from human activities all determine how many wild animals and game will be available and how long it will last.

The law of the minimum was established by Justin Liebig between 1840-1859 and was first applied to field crops. The law points out that the resource or factor available in the smallest amount limits the production of the supply of whatever the item is. Another way of putting it is that a species cannot increase beyond the limit set by the least abundant necessary factor in its environment.

If feed is the limiting factor in a game area, no amount of additional space, no more water, or no more freedom from disease or no less hunting pressure will provide a greater quantity of the game.

The same can be applied to fish production in polluted streams. Polluted streams may carry enough food and permit sufficient penetration of light to maintain a high fish population but where the oxygen content is made unusually low by sewage the stream will not support vertebrate organisms although lower forms of animal life may be present.

The principle of the law of the minimum is an important one for the land management ecologist. Much time and effort can be saved in solving an ecological problem involving the plants and animals if attention is given to "learning the habitat factor or factors which tend most to limit its abundance, and then to improve conditions on the basis of that knowledge".[1]

The simplified diagram illustrated at the beginning of this lesson shows the principle of limiting factors. The stave of the barrel represents temperature. The level of water in the barrel represents the level of production. Temperature represents the most limiting factor. Even though the other factors are present in more adequate amounts, production can be no higher than that allowed by the temperature. When the temperature is raised, the level of production is raised until it is controlled by the next most limiting factor, in this case minerals.

Not only may too little of something be a limiting factor as stated by Liebig, but also too much as in the case of such factors as heat, light, and water. Therefore, organisms have an ecological minimum and maximum, with a range in between which represents the limits of tolerance. This concept of a maximum as well as a minimum was incorporated into a law of tolerance by V.E. Shelford in 1913.

Some other principles which can be linked with the law of tolerance are:[2]

1. Organism with wide ranges of tolerance for all factors are likely to be most widely distributed.
2. Organism may have a wide range of tolerance for one factor and a narrow range for another.
3. When conditions are not the best for a species in respect to one ecological factor, the limits of tolerance may be reduced in respect to their ecological factors.

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1. Edward H. Graham, Natural Principles of Land Use, p. 63.

2. Eugene P. Odum, Fundamentals of Ecology, p. 89.

4. The limits of tolerance and the optimum range for a physical factor often vary geographically.

5. Sometimes it is discovered that organisms in nature are not actually living at the optimum range with regard to a particular physical factor.

6. The limits of tolerance for reproductive individuals seeds, eggs, embryos, seedlings, larvae, are usually narrower than for non-reproducing adult plants and animals.

In its modern form though, the law of the minimum is usually restated to take into account the interaction existing between the various single factors. "We may say with authority that whenever a factor approaches minimum, its relative effect becomes very great".[3]

Briefly some of the physical factors which we must review and consider are temperature, radiation, water, temperature and moisture together, atmospheric gases, mineral nutrients, currents and pressures, soil, fire, and microenvironment. Most have been covered lightly in various lessons in this project. The others will have to be considered a future project.

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3. Stephen H. Spurr, Forest Ecology, p. 13.

TEACHING PLAN

LIMITING FACTORS

Objective: To define and describe limiting factors and give the member a working knowledge of some important limiting factors. To develop an acceptance of changing limiting factors in habitat improvement.

Discussion Questions: Where can oxygen easily be a limiting factor? Why do plants grow so slowly in Spring? What are the limiting factors? How can fire be a limiting factor? Why is polluting a limiting factor? Why don't trout do well in a bass pond?

References: Eugene Odum, Fundamentals of Ecology, W. B. Saunders and Company, Philadelphia, 1959.

Werner O. Nagel, Habitat Improvement, National Wildlife Federation, Washington, D. C., 1956.

Edward H. Graham, Natural Principles of Land Use, Oxford University Press, New York, 1944.

Aldo Leopold, Game Management, Charles Scribner's and Sons, New York, 1933.

Activities: Build a bluebird and wood duck house. Observe a ledge along a road. Record plants which are found. What are the limiting factors of each? Observe a local stream or river. Is it polluted? List the principal forms of life in the stream.

PLANT AND GAME CYCLE AFFECTED BY LAND USE

PLANT SUCCESSION
A. BARE SOIL
B. ANNUAL WEEDS
C. PERENNIAL WEEDS
D SHRUBS
E FOREST

GAME SPECIES
A. FARM
B. FOREST-RANGE
C. WILDERNESS
D. MIGRATORY

PLANT AND GAME CYCLES AFFECTED BY LAND USE

Vegetation constantly changing in a predictable and orderly process is called ecological succession. An awareness of ecological succession is necessary in understanding the dynamic balance of nature.

When settlers first arrived in Eastern America they found a land with a mixed stand of forest trees. The American forest stretched as far west as the beginning of the plains where grass became the dominant organism in the plant community. Where there is soil, water and sunlight there are plants, but all plants do not like the same growing conditions.

In our own state we can find many areas where there is evidence that plants are changing from time to time. Many areas have been lumbered and then abandoned to allow a new tree growth to start unplanned by man, or fields once cultivated have been left to grow up again with trees. These woods are quite different from the original forest.

If we could somehow look at an abandoned field go through this process we would have seen the field change from grass and weeds to shrubs and small trees then on to intermediate forest types and lastly to the climax forest dominated by beech, oak and maple.

Two hundred years ago, in our forest area, billions of passenger pigeons were thriving on a natural range. This range produced the requirements for feeding, hiding, resting, sleeping, playing and raising young. Grazing animals in the millions could be seen on the plains of America.

The essential difference between a wild animal and a man is that man builds farms and cities to provide himself with the elements of a habitable range whereas a wild animal must accept the random assortment laid down by nature and modified by human activity or move away.

Modern civilization has made it possible to classify American game species with respect to their range requirements. "Range is a word whose meaning is closely related to habitat. Range is the total of all habitats occupied seasonally by a species or an individual within a given geographical area".[1] The four classes of American game are (1) farm, (2) forest and range (grazing animals), (3) migratory and (4) wilderness.

Farm game consist of species which because of their short cruising radius, and high requirement for cultivated land are especially adapted to agricultural areas. Examples of farm game include the cottontail rabbit, bobwhite quail and pheasants.

Forest and range game consist of species inhabiting wild land but compatable with forest and livestock operations. Deer, antelope, sharptail grouse, prairie chicken and wild turkey are examples of this class.

Migratory game consist of species of such long cruising range that they usually leave the area on which they were raised. This group include water fowl, shore birds, migratory doves.

Wilderness game consist of species harmful to or harmed by economic land uses. In order to be preserved they must be in large public game reservations or wilderness areas. Elk, buffalo, moose, caribou, mountain sheep and goats and grizzly bear are in this class.

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1. James B. Trefethen, Wildlife Management and Conservation, p. 24.

The illustration at the beginning of this lesson is a typical situation starting with an open field, but this very same process could well begin with ponds or small lakes which gradually fill up with silt and pond plants over thousands of years to form the soil in which rooted pond plants, reeds and sedges become established. Brush, young small trees and eventually the climax forest would follow.

In grassland areas succession even though only involving grasses has a predictable orderly process also. It involves four successive stages, (1) annual weeds stage from two to five years, (2) short lived grass stages three to ten years, (3) early perennial grass stages ten to twenty years, and (4) climax grass stage reached in twenty to forty years, thus starting with bare or plowed ground, twenty to forty years are required by nature to build a climax grassland depending on moisture available and the amount of grazing.

In artificial fish ponds and reservoirs, the natural succession trend is from bass and other game fish which will thrive when the pond is first constructed, toward undesirable fish as time goes on.

Succession is a continuing process marked by many changes in the vegetation, the fauna, the soil, and the climate of an area with the passage of time. These changes occur together mutually affecting one another with seldom any simple cause and effect relationship becoming evident. The principle of succession is one of the most important in ecology.

If succession begins in an area which has not previously occupied by a plant community the process is known as primary succession. (see Appendix sheet on page 103.) If the plant community development is proceeding in an area from which a plant community was removed by land clearing the process is called secondary succession. Secondary succession is usually more rapid because some organisms are already present. Previously occupied territory is more receptive to plant community development than are the new sterile areas.

Only after the habitat has been modified as far as possible by organisms is it possible for a community to become stable. Again nature with its wind storms and hurricanes can change the composition of the forest community for many years to come. Storms caused by air pressure are of major importance even though they may be only local in extent.

When man has learned to work with the balance of nature and with plant succession to utilize and direct toward his own ends the forces that operate them, instead of trying to prevent these things from taking place, he will have taken a tremendous step toward true conservation of our natural resources.[2]

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2. New Hampshire Department of Education, The Wise Use of Natural Resources in New Hampshire, p. 5.

TEACHING PLAN

PLANT AND GAME CYCLE AFFECTED BY LAND USE

Objective: To provide members with a knowledge of land use and its effect on plant and animal cycles. To develop some appreciation for the constant change in nature.

Discussion Question: What was Eastern United States plant life like when discovered by Europeans? What is "edge" effect? Name four classes of game animals which are classified according to their plant environment? How does nature change a climax stage of development?

References: Eugene Odum, Fundamentals of Ecology, W. B. Saunders, Company, Philadelphia, 1959.

James Trefethen, Wildlife Management and Conservation, D. C. Heath Company, New York, 1964.

Aldo Leopold, Game Management, Charles Scribner's Sons, New York, 1933.

Stephen H. Spurr, Forest Ecology, Ronald Press, New York, 1964.

Leonard Wing, Practice of Wildlife Conservation, John Wiley and Sons, Inc., New York, 1951.

Activities: Develop brush pile and wild life area. Plant a wildlife edge to develop edge effects. Observe stage of development of the woods, fields, and ponds of your area. Record species of plants and animals. Observe plants growing on soil of uprooted trees and describe.

APPENDICES

4-H CONSERVATION IDENTIFICATION

NAME ____________________ TOWN ____________________

ROCKS & MINERALS

GRANITE
1 2 3 4 5 6 7 8 9
BASALT
1 2 3 4 5 6 7 8 9
LIMESTONE
1 2 3 4 5 6 7 8 9
QUARTZ
1 2 3 4 5 6 7 8 9
SHALE
1 2 3 4 5 6 7 8 9
FLINT
1 2 3 4 5 6 7 8 9
CONGOLOMERATE
1 2 3 4 5 6 7 8 9
SAND
1 2 3 4 5 6 7 8 9
MARBLE
1 2 3 4 5 6 7 8 9
CLAY
1 2 3 4 5 6 7 8 9

10

FISH

TROUT (BROOK)
1 2 3 4 5 6 7 8 9
BASS (LARGE MOUTH)
1 2 3 4 5 6 7 8 9
SUNFISH
1 2 3 4 5 6 7 8 9
PERCH
1 2 3 4 5 6 7 8 9
HORN POUT
1 2 3 4 5 6 7 8 9
SUCKER
1 2 3 4 5 6 7 8 9
PICKEREL
1 2 3 4 5 6 7 8 9
SHINNER
1 2 3 4 5 6 7 8 9
CALICO BASS
1 2 3 4 5 6 7 8 9
TROUT (RAINBOW)
1 2 3 4 5 6 7 8 9

10

BIRDS

WOODPECKER
1 2 3 4 5 6 7 8 9
CANADA GEESE
1 2 3 4 5 6 7 8 9
BLUE BIRD
1 2 3 4 5 6 7 8 9
PARTRIDGE (Ruff Grouse)
1 2 3 4 5 6 7 8 9
PHEASANT
1 2 3 4 5 6 7 8 9
MALLARD DUCK
1 2 3 4 5 6 7 8 9
BALTIMORE ORIOLE
1 2 3 4 5 6 7 8 9
MEADOW LARK
1 2 3 4 5 6 7 8 9
BARN SWALLOW
1 2 3 4 5 6 7 8 9
CEDAR WAXWING
1 2 3 4 5 6 7 8 9

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MAMMALS

RABBIT
1 2 3 4 5 6 7 8 9
WHITE TAIL DEER
1 2 3 4 5 6 7 8 9
FOX- RED
1 2 3 4 5 6 7 8 9
WOODCHUCK
1 2 3 4 5 6 7 8 9
BEAVER
1 2 3 4 5 6 7 8 9
SKUNK
1 2 3 4 5 6 7 8 9
GREY SQUIRREL
1 2 3 4 5 6 7 8 9
RACOON
1 2 3 4 5 6 7 8 9
BOB CAT
1 2 3 4 5 6 7 8 9
WEASEL
1 2 3 4 5 6 7 8 9

10

RESOURCES IDENTIFICATION FOR 4-H MEMBERS

NAME ______________________ TOWN ______________________

INSECTS

APHIDS
1 2 3 4 5 6 7 8 9
CUTWORMS
1 2 3 4 5 6 7 8 9
WHITE GRUBS
1 2 3 4 5 6 7 8 9
JAPANESE BEETLE
1 2 3 4 5 6 7 8 9
MAY BEETLE
1 2 3 4 5 6 7 8 9
ELM LEAF BEETLE
1 2 3 4 5 6 7 8 9
OLD HOUSE BORER
1 2 3 4 5 6 7 8 9
PRAYING MANTID
1 2 3 4 5 6 7 8 9
GYPSY MOTH
1 2 3 4 5 6 7 8 9
GRASSHOPPER
1 2 3 4 5 6 7 8 9

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WEEDS

PIGWEED
1 2 3 4 5 6 7 8 9
CHICKWEED
1 2 3 4 5 6 7 8 9
LAMB'S QUARTERS
1 2 3 4 5 6 7 8 9
RAGWOOD
1 2 3 4 5 6 7 8 9
WITCH GRASS
1 2 3 4 5 6 7 8 9
MILK WEED
1 2 3 4 5 6 7 8 9
PLANTAIN
1 2 3 4 5 6 7 8 9
SMART WEED
1 2 3 4 5 6 7 8 9
BURDOCK
1 2 3 4 5 6 7 8 9
CANADIAN THISTLE
1 2 3 4 5 6 7 8 9

10

FLOWERS

RED CLOVER
1 2 3 4 5 6 7 8 9
BUTTERCUP
1 2 3 4 5 6 7 8 9
BUTTER & EGG
1 2 3 4 5 6 7 8 9
WILD CARROT
1 2 3 4 5 6 7 8 9
DANDELION
1 2 3 4 5 6 7 8 9
BLUET
1 2 3 4 5 6 7 8 9
WILD ROSE
1 2 3 4 5 6 7 8 9
VIOLET
1 2 3 4 5 6 7 8 9
HAWKWEED
1 2 3 4 5 6 7 8 9
DAISY
1 2 3 4 5 6 7 8 9

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TREES

ASH
1 2 3 4 5 6 7 8 9
ASPEN
1 2 3 4 5 6 7 8 9
BIRCH (grey)
1 2 3 4 5 6 7 8 9
BASSWOOD
1 2 3 4 5 6 7 8 9
HEMLOCK
1 2 3 4 5 6 7 8 9
WHITEOAK
1 2 3 4 5 6 7 8 9
RED MAPLE
1 2 3 4 5 6 7 8 9
WHITE PINE
1 2 3 4 5 6 7 8 9
PITCH PINE
1 2 3 4 5 6 7 8 9
SUMAC
1 2 3 4 5 6 7 8 9

10

STAGES IN PRIMARY SUCESSION*

Dry Conditons (Xerarch)			Average Conditions (Mesarch)			Wet Conditions (Hydrorch)		
Stage	1.	Dry Rock or Soil	Stage	1.	Moist Rock or Soil	Stage	1.	Water
"	2.	Crustose lichen	"	2.	Usually omitted	"	2.	Submerged Water Plants
"	3.	Folisose Lichens & mosses	"	3.	" "	"	3.	Floating or partly floating plants
"	4.	Mosses and Annuals	"	4.	Mostly Annuals	"	4.	Emergents
"	5.	Perennial Forbes & Grasses	"	5.	Perennialsforbes & grasses	"	5.	Sedges, sphagnum & Mat plants
"	6.	Mixed herbaceous	"	6.	Mixed herbaceous	"	6.	Mixed herbaceous
"	7.	Shrubs	"	7.	Shrubs	"	7.	Shrubs
"	8.	Intolerant trees	"	8.	Intolerant trees	"	8.	Intolerant trees
"	9.	Mid-Tolerant trees	"	9.	Mid-Tolerant trees	"	9.	Mid-tolerant trees
"	10.	Tolerant trees	"	10.	Tolerant trees	"	10.	Tolerant Trees

*Spurr, Stephen H., Forest Ecology, page 179

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