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Scope of Study: This report provides a unit in Ecology which can be introduced in High School Biology. It is to be used as an additional unit in a high school biology course. The major objective is to introduce the basic ecological principles associated with the science of life and give attention to laboratory and field work when one of these principles needs to be illustrated. The report is divided into two parts. The first part provides the general ecological principles, and the second part, the laboratory and field work selected to illustrate these principles.

Findings and Conclusions: This report will aid the students in understanding the importance of ecology and its relationship to other sciences. A high school teacher can do much to direct his students toward gaining some understanding of the basic principles of ecology. The use of the laboratory and field exercises contained in the report will enable the student to demonstrate the basic ecological principles. The writer recognizes the limitations in scope of this unit in ecology and therefore has attempted to select laboratory and field exercises which a biology teacher could use without interrupting the normal school schedule.

ADVISER'S APPROVAL Don D. Dwyer

A UNIT IN ECOLOGY FOR HIGH SCHOOL BIOLOGY

By

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PART I

CHAPTER I

INTRODUCTION

Purpose and Procedure

The purpose of this report is to provide a unit in Ecology which can be introduced in High School Biology. This report is to be used as an additional unit in a high school biology course. The major objective is to introduce the basic ecological principles associated with the science of life and give attention to laboratory and field work when one of these principles needs to be illustrated.

There are three ways in which this report may be used as a workable unit in ecology. The teacher can use whatever plan fits the situation best. It is considered an end of the year unit; but if the teacher choose he may introduce the unit when it is best suited for his class.

One plan is called "the individual plot problem." Each student is faced with the following problem: to carry out a complete ecological study of a 15' x 60' plot of land which includes three differenct ecological communities. A final report of findings is required.[1]

In this problem each student will select and stake out a plot from which he will work out his ecological problem. Each student will be

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[1]Daniel Lee Dindal, Ecology Studies in High School Biology. American Biology Teacher 23(5) (Ohio, 1961), pp. 281-282

given a laboratory or field work sheet that he will follow each time the class goes to the chosen area to be studied. The student will be able to work at his own rate of speed. This will give the teacher the opportunity to determine which students worked while in the field and those which did not. The teacher can check the students' work at the end of the week or at the end of each field trip with a question and answer report which each student must complete before leaving his plot. This will help reduce any foolishness or unnecessary activities that high school students tend to do when getting away from the school building.

A second plan is called the "group study of ecological communities." This plan involves the same type of problem. Instead of an individual student studying a certain plot, a group, consisting of not more than three, will study a plot of a larger area. This plan is practical for a large class (more than fifteen).

A third plan can be used where it would involve the whole class studying a selected area for ecological study. In this plan the class will be divided into three groups. Each group will have certain types of communities to observe and certain organisms to collect or identify. Each group will be responsible for whatever is assigned to them. For example, if one group is assigned the insect community or habitat of a given area they will be responsible for the collection and/or identification of the insects seen in the assigned area.

The procedure and detailed information of each one of these proposed plans for the field problems in this unit are found in Part II of this report. All the assigned communities for each problem are outlined in Part II.

Preliminary Planning

A number of preliminary plans are to be made. Each student will be given a dittoed explanation and instruction pamphlet. All of the field guides which are needed for the identification of plants and animals of the different communities will be placed on reserve in the school library. This will enable all students to have equal access to these guides. If the necessary guides and references are not available in the school library, the community library can help by reserving all available materials it may have on ecology.

Alternate plans should be made for related classroom laboratory work in case of rainy weather. In this situation the students' time can best be utilized by conducting any laboratory work which will need to be done in completing their ecological problem. Also the students can use this time spent in the classroom for research or any other study related to ecology.

Arrangements can be made with the physical education teacher to have the students change into field clothes in the locker rooms. If the teacher feels that this plan will take up too much valuable time, arrangements can be made with the school principal to let the students wear their field clothes to school.

It will be understood that each student or group of students may spend additional time in his community plot. This will include time after school or on week ends.

When studying this unit one will want to spend considerable time in the laboratory. Considerably more field work should be emphasized in order to interpret the knowledge gained when studying the ecological principles.

This unit consists of two parts. Part I is concerned with basic principles in ecology. An attempt is made to state these principles briefly and concisely without complicated details.

Part II is organized for laboratory and field work, and emphasizes the descriptive phase of ecology. The author has tried to make it possible to begin, either with Part I as a formal lecture course to learn the basic principles, and then apply these principles to the study of outdoor habitats through the use of Part II. Or to use Part II whenever a basic principle needs to be illustrated by the field and laboratory work. Thus, it is the intention to make the arrangement flexible and adaptable to various uses and situations.

It is hoped that this report will provide some enrichment to a biology course and aid in supplying information about the science of Ecology for High School Biology.

CHAPTER II

ECOLOGY AND ITS RELATION TO OTHER SCIENCES

Ecology is one of the rapidly advancing frontiers of science. Man has been interested in ecology in a practical sort of way since early history. But it has been just recently that he has recognized it as a distinct field of biology. The word "ecology" is of recent coinage, having been proposed by a German biologist, Ernst Haeckel in 1869.[1]

Ecology is a subject which is both observational and experimental, as opposed to the strictly experimental disciplines of the laboratory work in chemistry and physics. Ecology is the study of organisms in relationship to their environment. This means then that one cannot remove the organisms from their natural environments to study them in the laboratory, it is necessary to go where they are and observe them there. If one cannot perform the desired experiments or make the necessary observations under natural conditions, then it is necessary to duplicate natural conditions in the laboratory where certain factors can be controlled.

Subdivisions of Ecology

Ecology is commonly divided into two major groups, autecology and synecology. Autecology deals with the study of individual organisms or

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[1]Eugene P. Odum and Howard T. Odum, Fundamentals of Ecology (Philadelphia, 1959), pp. vi-vii.

individual species. Synecology deals with the study of groups of organisms which are associated together as a unit. Thus, if a study is made of ponderosa pine, the work would be autecological in nature. If the study were of the forest in which the ponderosa pine grows, the approach would be synecological. In autecology attention is sharply focused on a particular organism with the purpose of seeing how it fits into the general ecological picture. In synecology the ecological picture as a whole is considered.

Synecology can be further subdivided according to the level of organization. Thus, we may speak of population ecology, community ecology, and ecosystem ecology. As a matter of fact, the present tendency is to divide ecology into four subdivisions, without reference to the terms autecology or synecology, namely: (1) species ecology, (2) population ecology, (3) community ecology, and (4) ecosystem ecology.[2]

As true in biology in general, ecology may be subdivided along taxonomic lines, such as, plant ecology, insect ecology, microbial ecology, and vertebrate ecology. Study in these specific fields is profitable since attention is given to the ecology of that group, and to the development of detailed methods.

These subdivisions are useful, as are subdivisions of other sciences, because one specialize within the field of ecology.

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[2]Ibid., p. 8.

CHAPTER III

PLANT AND ANIMAL COMMUNITIES

> Every reflective biologist must know that no living being is self-sufficient, or would be what it is, or would be at all, if it were not part of the natural world...
> Living things are real things....but their reality is in their interrelations with the rest of nature, and not in themselves.
>
> W. R. Brooks, Heredity and Variations: Logical and Biological[1]

One of the many approaches to the study of ecology is the "community" approach. The word community is used in many ways, but in general it may be defined as all of the organisms that exist as interrelated members of a given area. The size of the community will depend upon the degree to which the environment may change in a given geographical area and the ways in which the changing environment affects the organisms which are present. Usually the combination of one or more major environmental factors, such as, moisture, temperature, light, type of substrate, etc., will determine the limitations to which a community will exist. A tropical flower, for example, can exist only where there is abundant moisture. Plant and animal communities may be studied separately, but as realized

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[1]Allen H. Benton and William E. Werner, Jr., _Principles of Field Biology and Ecology_ (New York, 1958), p. 56.

by early ecologists such as Clements, Adams, Shelford, and others, plant and animal communities are interdependent for their very existance.[2]

Factors Determining Communities

There are certain environmental factors which are of prime importance in determining community types. These are such factors as topography, soil, and various factors of the climate such as rainfall, wind, temperature, length of growing season, etc. These are physical conditions which are important in determining the type of vegetation growing in a given locality. The type of vegetation will have a definite effect on the presence or absence of animal life in a certain community.

How Plants Provide An Environment

The effects of the plants upon the place in which they live and their influence upon each other are especially significant. When trees develop in an area, they greatly modify conditions for growth by decreasing light and lessening the force of the wind. The loss of water from the soil through evaporation is decreased due to the covering of mulch by the decaying leaves, and the air is more humid under a leafy forest canopy. The tree canopy will provide an environment for shade-loving plants which thrive in cool, moist, shady places.[3] The shading can provide the right type of environment for various species of fish or amphibians, which could not normally survive where light intensity is very high.

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[2]Ibid.

[3]John E. Weaver and Frederic E. Clements, Plant Ecology (New York, 1938), pp. 1-2.

Topography

Topography describes the general lay of the land, whether the area is hilly, flat, mountainous, etc. Topography will cause a great variation in habitat forms. For example, hilly and mountainous regions are apt to have a wider variety of environmental conditions than flat areas. There is a greater opportunity for variation in moisture, light, and other factors. Each one of these topographical differences will consequently produce a different community.

Variation in topography can cause a variation in vegetation of the same general region. North and south facing slopes in northern hemisphere show there are differences in vegetation and are due to the interaction of light, temperature, and moisture. Although species differences are not great, a south-facing slope supports a much sparser, more widely spaced stand of vegetation than a north-facing slope, for the most part, is due to the amount of light which strikes the surface. The slope which receives the most light will obviously have the highest temperature and therefore be xeric (drier). The north-facing slope would be characterized by having less light reaching its surface, more mesic (between wet and dry), and temperature staying lower than that of the south-facing slope. The type of vegetation growing under the environmental conditions of a north-facing slope would be nearly all mesophytes. The south-facing slope would have vegetation consisting mostly of xerophytes. There would be other varieties depending on the degree of the slope. For example, one can observe moss growing on the north sides of trees which indicates the combination of light, temperature, and moisture are such that this type of plant is able to thrive under these conditions.

Altitude

Elevation can produce a number of changes in community types. As one ascends a mountain, the temperature begins to go down, particularly if the mountain is sufficiently high. Other changes, such as, the amount of precipitation, difference in wind velocity, and in general the environment becomes more rigorous. The changes due to elevation will be great enough to cause the appearance of several different community types from the bottom to the top of the mountain.

There are certain vegetation zones that one would readily notice with increase in altitude, particularly in the Rocky Mountains. By referring to Figure 1, one can see the different community types found in the western United States. All these community differences are primarily the result of change in temperature and moisture due to change in elevation.[4] In Figure 1 there are lines which mark off the vegetation zones of the different community types found in the Rocky Mountains. These zones are characterized by the overlapping of vegetation when one ascends a mountain. The term used to describe overlapping of two different types of vegetation is ecotone. This condition is primarily due to difference in amounts of moisture received in the area.

Climate

The most important factor which determines community types is climate. The climate controls rates of topography changes. It is instrumental in determining vegetation type and associated animal life in any area. The development of the soil is controlled by the climate

[4]Benton and Werner, pp. 56-61

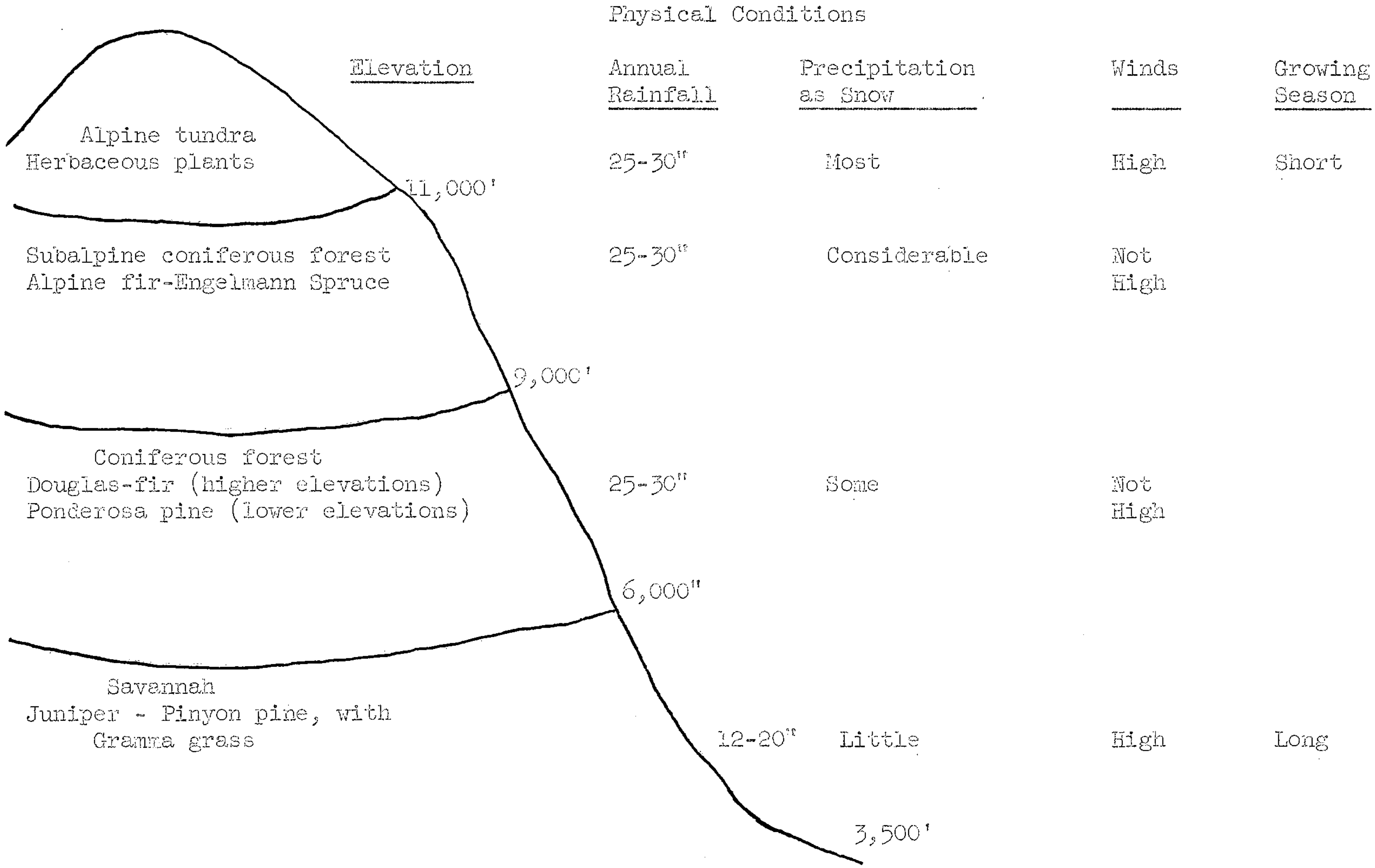

Figure 1. Altitudinal zonation in western United States. Physical conditions will vary with latitude and special conditions such as slope exposure. Taken from: Allen and Werner Jr. Principles of Field Biology and Ecology, p. 61.

and will regulate the rate of repopulation and development of communities in which life has been destroyed.[5]

The rate of topography changes is controlled by climate. Rainfall, temperature, and wind are three essential physical factors which will determine the degree of topography change. The amount of rainfall ordinarily will determine the amount of erosion where seasonal changes of temperature are great enough to cause alternate freezing and thawing than more uniform temperatures where freezing and thawing are not involved. Similarly, winds can vary the amount of erosion. Where land is plowed extensively and winds are strong erosion is considerably higher.

Climate controls the type of vegetation growing in an area. Plants are dependent on several factors of the climate, principal among which are rainfall, temperature, and length of growing season. Each one of these three physical factors are closely interrelated and together will greatly influence the difference in vegetation in a given region. The tropical regions, for example, have a great amount of rainfall and rate of evaporation from the soil is low thus producing a difference in vegetation than areas which have less rainfall and high evaporation rates, such as, deserts. Some plants require a longer period of reproduction than others, consequently, the length of growing season (frost--free period) would have to be longer before the growth and reproduction of the plants could flourish. As mentioned previously, the type of animals present will ultimately depend on the type of plants growing, thus making the climate the ultimate controller of the whole community.

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[5]Ibid.

The importance of climate will be more fully understood when studying ecological succession in the next chapter.

Types of Communities

The continent of North America is covered with three great types of vegetation, namely, forest, scrub, and grassland. Each of these three types of vegetation are in themselves composed of strikingly different communities such as evergreen and deciduous forest, which are found in climates equally different.[6]

Due to the difference in climate in certain geographical regions, along with other physical and biotic factors, the recognition of major units of distinct life-forms prevail in the continent of North America. These major units of distinctiveness in life-forms are called biomes. A biome is a biotic community, characterized by the highest type of vegetation possible under its particular climate. This distinctive life-form is termed climax, which is derived from the same root as climate. The vegetation portion of the biome is sometimes called plant formation. The subdivision of plant formation is termed plant association, recognized only by climax dominants.[7]

The principal biomes of North America include the tundra, coniferous forest (taiga), deciduous forest, grasslands, desert, and tropical rain forest.[8]

The biomes discussed in this report are those which will have

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[6]Weaver and Clements, p. 478.

[7]S. Charles Kendeigh, *Animal Ecology* (New Jersey, 1961), p. 276.

[8]Benton and Werner, p. 67.

significance to the laboratory exercises of Part II. The biomes not related to Part II in this report will only be discussed in minor detail. All other biomes will be considered in respect to its distribution of vegetation and plant association, and the various animals expected to be found in these types of communities.

Tundra Formation

The tundra area is characteristic of severe cold climates of the north and high mountain tops. It lies between the northern limits of trees and the area of perpetual ice and snow in the far north, or above timber line in high mountains.

Vegetation is low, dwarfed, and often matlike, and includes a high proportion of grasses and sedges. Even the woody plants, including willows and birches, are usually prostrate. The herbs are mostly perennial and of a rosette type, producing relatively large flowers. Mosses and lichens grow anywhere and in some habitats form a thick carpet with low herbs.

The summers are very short and its temperatures are very low. Light is continuous throughout the growing season. Precipitation is in the form of snow and varies greatly. Water is often a critical factor because of the drying winds in the summer which produces high evaporation rates and transpiration.[9]

Coniferous Forest Formulation

The coniferous forest is continuous, often dense, forest of needle- or scale-leaved evergreen trees.[10] Coniferous forests are found for the

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[9]Henry J. Costing, The Study of Plant Communities (San Francisco, 1956), pp. 272-273.

[10]Kendeigh, p. 301.

most part, where the seasonal distribution of the rain is similar to that in the deciduous forest region but where annual precipitation and the temperatures are too low to support deciduous forests. An exception to this statement occurs in the southeastern part of the United States where the greater part of the costal plain south of New Jersey and east of Texas, with the exception of the southern end of Florida, is occupied by coniferous forest under a rainfall of 50 inches or more. This is due primarily to altitude.[11]

The amount of rainfall varies in the coniferous forest between 15-40 inches and is mostly summer rain. The temperatures vary from a winter low of about -20°F to a summer high of about 70°F.

The plant associations and their general locations are as follows:

Association	General Location
Pine-Hemlock (Pinus-Tsuga)	Minnesota to New England Appalachian Mts. south
Petran Subalpine Forest (Picea-Pinus), Engelmann and Blue spruces, fir.	Rocky Mts. of Arizona, New Mexico
Sierran Subalpine Forest (Tsuga-Pinus), Mountain hemlock, pine, subalpine larch, and red fir	Cascade Mts. and Sierra Nevada
Petran Montane Forest (Pinus-Pseudotsugo), Ponderosa pine, Douglas fir, and white fir	At lower elevations of Rocky Mts.
Coast Forest (Thuja-Tsuga) Western hemlock, western red cedar, Douglas fir, Spruce, Redwood	Northwest United States up into Alaska

Deciduous Forest Formation

In North America, the deciduous forest is best developed in the

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[11]W. B. McDougall, Plant Ecology (Philadelphia, 1949), pp. 197-198.

Eastern United States, although elements of it are mixed with conifers in the North and West.

Precipitation for this formation in North America varies from 30-50 inches. For the most part rain falls periodically throughout the year with snowfall in the wintertime. The temperatures are between 10°F to 60°F for the coldest months and 70°F to 80°F for the warmest months. The average mid-day relative humidities during July range from 75 per cent in the East to 50 per cent where the formation contacts prairie in the West.[12]

The climax of the deciduous forest is dominated by broad leaf trees which form a close canopy, except where the plant formation verges on prairie, and here the forest gives way to savannas containing scattered groves. All season aspects are well defined. The trees are intolerant of freezing temperatures over winter and hence are shed in the North during the autumnal aspect.

The following principal plant communities of the deciduous forest formation are found in North America:[13]

Association	General Location
Mixed Mesophytic Forest (*Liriodendron-Quercus*), Rich mixture of trees, white basswood and yellow buckeye	Unglaciated Appalachian Plateau
Oak-Chestnut (*Quercus*) Now largely destroyed by blight	Appalachian Mountains
Oak-Hickory Forest (*Quercus-Carya*)	Ozark and Ouachita Mountains Radiating far into the prairie along river valleys

[12]Kendeigh, pp. 293-294.

[13]Ibid.

Maple-Basswood Forest (_Acer-Tilia_)	Wisconsin and Minnesota and southward to northern Missouri
Southern Pine Forest (_Pinus-Pinus_)	Subclimax stands in the south Atlantic and Gulf states. Where fire is prevented this community is succeeded by oak-hickory, beech, or magnolia-oak forest.

Woodland Formation

The woodland formation is intermediate between forest and grassland, or in some places, between forest and desert. Places like north central Arizona the formation intrudes upon former xeric grasslands where the grasses have been overgrazed. The woodland formation is typically southwest. It covers extensive areas in New Mexico, Colorado, Utah, Arizona, Nevada, and California.

Precipitation in this formation ranges from 10 to 15 inches per year, and the temperatures vary with location. In Utah, for example, the winter temperatures reach below zero, whereas, in Arizona the mercury does not reach zero. The same is true of summer high reaching not much above 70°F in the north woodland and not much above 90°F in the south woodland.

The woodland formation consists of trees, usually between 10 and 40 feet high, namely pine (_Pinus_), Juniper (_Juniperus_), and oak (_Quercus_).[14] The oak woodland (_Quercus-Quercus_) association, with digger pine (_Pinus sabiniana_) in certain habitats, is found mostly west of the Sierra Nevada but extends north into Oregon and Washington.

The pinon-juniper (_Pinus-Juniperus_) association occurs from the eastern slopes of Sierras and Cascades across the Great Basin to Wyoming and New Mexico.[15]

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[14]McDougall, pp. 201-202.

[15]Kendeigh, p. 311.

Grassland Formation

The grassland or prairie formation is the most extensive and the most varied of all the plant formations of North America. It ranges from southwestern Manitoba, southern Saskatchewan, Alberta, and British Columbia to the highlands of Central Mexico and from western and southern Minnesota to northwestern Indiana, southern Illinois, central Missouri, and eastern Texas to the coast of California and lower California.[16]

In general, the rainfall is between 25-40 inches. Seventy per cent of the annual rainfall comes between April and September. The wide range of temperature is from -50°F in Canada and the summer temperatures in the south of 120°F.

There are three different climax forms in the grassland formation. These climax perennial grasses may be tall grasses, mid, or short grasses, and bunch grasses forming sod.[17]

Association	General Location
True Prairie (Stipa-Sporobolus) Big Bluestem, Little Bluestem, Indiangrass, Switchgrass	A strip next to the deciduous forest extending north to south. The coastal prairies of Texas constitute a faction of this community.
Mixed Prairie (Stipa-Bouteloua) Association. Needle grass, Wheat grass, Blue grama, Bufflo-grass, Purple three-awn	Mid grasses confined to the moister low areas. Short grasses, to drier hillslopes.
Short Grass Plains (Bouteloua-Buchloe) association. Bufflo-grass, Blue grama, Hairy grama	On the Great Plains east of the Rocky Mountains.
California Prairie (Stipa-Poa) association, mostly mid and bunch grasses	Located in central valley of California almost completely isolated from rest of grassland.

[16] Weaver and Clements, p. 516.

[17] Kendeigh, p. 325.

Desert-like Plains (Aristida-Bouteloua) association. Composed mostly of short and bunch grasses	Southeastern Texas to southern Arizona and extends well down into Mexico.

Because of overgrazing and control of fire, desert and tropical shrubs, such as mesquite, creosote bush, Opuntia cactus, are conspicuous throughout the Desert Plains.

Desert Formation

Extreme desert is considered to be arid wasteland, with practically no vegetation. But deserts also include arid regions which contain vegetation in the form of bushes, shrubs, and trees especially adapted to withstand hot, dry climates. One of the most prominent deserts occurring in the North American continent is located in the southwestern part of the United States.

The average annual rainfall in the desert scrub of North America is not more than 5 inches, and snow is confined to the high mountain tips. Because of the high rate of evaporation the relative humidity is very low. The temperatures range from 50°F to 120°F. Charles Kendeigh describes the association in the following manner.[18]

Association	General Location
Desert Scrub (Covillea-Franseria) association. Creosote bush, bur sage, cactus. The desert scrub has three factions:	
Mohave desert Low shrubs, interspersed with the Joshua-tree	Rolling plains of southwest California

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[18]Ibid.

Sonoran desert Tall trees Succulent cacti Few grasses	Subdivided into Colorado and Arizona
Chihuchuan desert Yucca-like sotol	To the east almost completely separated by mountain ranges
Shadscale (*Atriplex-Artemisia spinescens*) association; Sagebrush (*Artemisia tridentata-Agropyron*) association Shadscale Bud sage Greasewood and some grasses Sagebrush Wheatgrass	Great Basin

CHAPTER IV

SUCCESSION

For every wound the ointment of time[1]

Ecological succession is the orderly process of community change; it is the sequence of communities which replace one another in a given area. Typically, succession begins with pioneer stages which are replaced by a series of more mature communities until a relatively stable community develops which is in equilibrium with the local conditions.[2] All of the communities which will be formed and then replaced until the final or mature community is reached are collectively termed a *sere*, and any one community of a sere is a *seral stage*. The final or mature community is called a *climax*.

Succession, according to Benton and Werner, Jr., has four basic concepts:[3]

1. There is a dynamic shifting in the species composition of the community.

2. The species change is an orderly one, so that it may be predicted what community will follow an existing community.

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[1]Allen H. Benton and William E. Werner, Jr., *Principles of Field Biology and Ecology* (New York, 1958), p. 97.

[2]Eugene P. Odum and Howard T. Odum, *Fundamentals of Ecology* (Philadelphia, 1959), p. 257.

[3]Benton and Werner, pp. 98-99.

3. The sequence of changes of the community types is directional, with each succeeding community type becoming more like the climax type, at least in physical characteristics.

4. The ultimate community type is the climax community.

As one travels along a highway, one can easily see the variations in community types. These variations are major ones. Upon closer inspection one would find smaller variations within a community area. Perhaps there will be a boulder covered with lichens and moss in the midst of a forest community, or a tree which is rotting away on the forest floor. These smaller communities will under go a continuous change, and in time, will develop into a climax community. Ecologists consider them situations in which minute examples of the phenomenon of succession may be demonstrated.[4]

Succession may begin in ponds, lakes, marshes, and other aquatic areas. It may begin on bare rock, wind blown sand, rocky talus slopes, or other situations where this is an extreme deficiency of water. Succession initiated in water is termed a hydrarch, and the different stages of the series or sere constitute a hydrosere. The orderly, sequence of community change on bare areas is termed xerarch succession, and the different stages collectively are termed xerosere. A xerosere occurring in the same climatic climax as a hyrosere will end in a similar mesophytic community.[5]

If succession proceeds from an area which is devoid of plant and animal life it is called primary succession. Succession on bare rock, wind blow sand, and talus slopes are all examples of primary succession.

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[4]Ibid., p. 99.

[5]John E. Weaver and Frederic E. Clements, Plant Ecology (New York, 1938), pp. 60-66.

When normal succession is disrupted by fire, cultivation, lumbering, or any other disturbance that destroys the principal species of an established community it is called secondary succession. When vegetation is destroyed by fire, a community will soon be established and, although the fires communities that develop may not be typical of primary succession, the later stages again are similar.[6]

In secondary areas many of the products of community reaction remain, and succession is rapid. If seedlings and young trees are not destroyed, progress of succession tends to exceed that of the original trend. Soil is already formed in secondary succession, which is another reason for it to proceed at a much more faster rate than primary succession.

Primary Succession On A Bare Rock (Xerosere)

The Lichen Stage

The pioneer stage of succession on a bare rock is that of the lichen stage. Other plants cannot become established because of the extreme deficiency of water and nutrients, great exposure to the sun, and extremes of temperature to which they are subjected. The pioneer lichens can flourish under any of these extreme conditions.

These lichens are able to absorb water from rain very rapidly. This water along with carbon dioxide secreted from certain minerals forms a weak acid that slowly eats into the rock. This very important process helps to corrode and decompose the rock. With this chemical reaction and other forces of weathering, and by mixing of the rock particles with their own remains make conditions possible for the growth

[6]Henry J. Oosting, The Study of Plant Communities (San Francisco, 1948), pp. 240-241.

of other vegetation. The rapidity with which a minute amount of soil will form is controlled very largely both by the nature of the rock and by the climate.[7]

Weaver and Clements describe two lichen stages in primary succession on bare rock.[8] The very first stage is the crustose-lichen stage. This type of lichen can grow under very extreme weather conditions, thus, it will establish itself first and is called the pioneer stage. The stage following the crustose stage is the foliose-lichen. This type of lichen will attach to the substratum at a single point or along a single margin. It will be found on the more weathered portion of the rock and in depressions or slightly less exposed situations. Foliose-lichen is more leafy in structure than the crustose stage, therefore, it may completely overshadow the latter and the crustose species will soon die and decay. The foliose species with its leafy structure has a better chance to collect and absorb water, and collect wind-blown particles, and humus is more rapidly accumulated because of its less rapid oxidation. As growth continues, the lichens will make their environment less suitable for themselves and a new type of invader appears.

Moss Stage

As soon as sufficient amounts of soil is accumulated in depressions and along the margins of the rock, xerophytic mosses appear. The lichens are crowded out by the mosses, which benefit from the soil prepared by the lichens. After the moss plants have become established they begin to

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[7]Weaver and Clements, pp. 66-67.

[8]Ibid.

accumulate wind-blown and water-borne materials and they probably accelerate the disintegration of the rock surface somewhat, and so they start the building of soil.

Probably the most important factor in succession is competition. Because of changes brought about by lichens and moss communities, new species are able to compete with the old species for space. The mosses further contribute their products to the environment, and improve it to the point that other plants may then successfully compete with them.[9] As competition increases the moss stage is nearly eliminated by the more successful plant species and a new stage starts its development. Competition will be discussed in greater detail in a later phase of the chapter.

Herb Stage

As more soil accumulates, seeds of various xerophytic herbs, especially short-lived annuals, are soon able to germinate. Plants such as goldenrods, asters, evening primroses, and milkweeds, as well as a variety of grasses and other weeds, are the herbs which grow in a climax forest area. The roots of these plants continue the process of corroding the rock, and each year the humus from their decaying remains enriches the soil.

The process of rock disintegration is greatly accelerated as tangled network of roots increases and the soil becomes shaded. Evaporation and temperature extremes are decreased, humidity slightly increased, and drought periods shortened.[10] As this stage becomes well developed, the

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[9]Benton and Werner, p. 110.

[10]Weaver and Clements, p. 69.

herbs reduce the light which becomes detrimental to the mosses and lichens and this type of vegetation gradually becomes fewer in number.

Shrub Stage

Just as mosses and lichens provided conditions under which the herbaceous plants could grow, so the herbs now do the same for the woody plants. The soil has been enriched enough for taller woody plants to flourish. These woody plants furnish shade and act as a windbreak, and the moisture conditions of the soil and the air just above the surface are improved.[11] Such xeric shrubs as blackberries, smooth sumac, and sassafras begin to appear. The tendency is that the environment will soon become more mesic, that is, moderately moist, and wet areas will become drier and dry places wetter.

Climax Forest

The first species of trees are relatively xeric. These trees are widely spaced, and are not very tall. But as weathering processes continue and the soil deepens, trees increase in both number and vigor.[12] The effect of shading by the tall trees soon make conditions intolerable for the light demanding shrubs and the more tolerant mesophytic plants replace them. At this point, a new herbaceous vegetation develops in the forest shade, indicating a more mesic situation and a richer soil, and no longer can one find much evidence of a bare rock.

The climax formation will depend on the area which succession occurs. The climax forest may be dominated by hard maple and beech if the climate

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[11]Benton and Werner, p. 111.

[12]Weaver and Clements, p. 70.

is such for the growth of these trees; or it may be characterized by Engelmann spruce and alpine fir if the succession occurs at the higher elevations in the Rocky Mountains.

Primary Succession In A Pond (Hydrosere)

Pond succession is another example of primary succession. It too has distinct stages of growth. The difference is that all pioneer plants are hydrophytic plants and its community is converted from a water community to a dry land community.

The first stages of plant growth are all submerged plants. The plants generally extend out as far as 20 feet and are entirely submerged. Among some of the more prominent plants which grow in the pond are water weed, pondweed, hornwort, etc. Plants such as buttercup, bladderworts and eelgrass help to collect silt washed in from the banks after rain, which in turn will gradually fill up the bottom of the pond. At the same time the growth of the plankton and of other aquatic organisms adds organic matter, and much of this is deposited on the bottom.

As silt and organic matter collects, plants such as water lilies become established. These plants have very large leaves which float on the surface of the water and will tend to shade the submerged plants eventually causing them to die and decay. These floating plants will reproduce along the pond margin and migrate toward the middle of the pond.

The free water is changed to swampy land, the water lilies and similar species give way to sedges and rushes, and these are subsequently replaced by heaths and shrubs. As succession continues the soil is further built up, so that it becomes drier. Varying degrees of wetness may be found depending upon the progress of development and irregularities of topography.

Depressions in the swampy land will make relicts (a community or fragment which has survived some important changes) of the old community and indicators of the former swamp.[13] In time certain species of trees will invade the area, replace the shrubs, and eventually full size forest trees will dominate the scene.[14]

Thus, the area that was once pond becomes transformed into a forest, which one can clearly conceive when one follows the actual processes of development. The various stages are: submerged plant, floating plant, reed swamp, sedge meadow, woodland, and climax forest.

Other Types of Succession

In the preceeding discussion only two typical successional series have been outlined. They were primary succession on bare rock, termed xerarch, and primary succession on water, a hydrarch. Other successions will now be considered in less detail. Students in High School Ecology need only to become familiar with the fundamental idea of succession. The study of xerarch and hyrarch succession will be enough to acquaint the student with dynamic community changes which are occurring under certain prevailing climates.

The following are other types of successions:

Type	Pioneer Stages	Characteristic
Talus slope	Herbs: parsley, borage	Coarse and loose rock fragments which break off from a hill or mountain

[13]Ibid., p. 63.

[14]George L. Clarke, Elements of Ecology (New York, 1954), pp. 432-433.

Type	Pioneer Stages	Characteristic
Sand dune succession	Grasses: Marram grass Wheat grass	Strongly rooted grasses cause wind blown sand to pile up and will sometimes cover a forest.
Succession on River Bars	Herbs and woody species: willow, cottonwood. Regularly followed by elms, ashes, etc.	Sand and silt is deposited in a river as bars or islands. Succession usually occurs rapidly.
Bog succession	Herbs: Submerged and floating plants much like those found in ponds. Sedges, rushes.	Abundant rainfall Evaporation low Little runoff Summers long Vigorous growth

Cause of succession

The dynamic state of communities of plants and animals, including the climax, is due to a number of agencies acting within them and upon them. Some of the agencies are physical, such as, wind and rain; the organisms themselves bring about many of the changes that are involved in succession. These changes are both destructive and constructive. Both the constructive and destructive changes can be brought about by biotic or physical factors, or both. The tendency is as soon as destruction of a community occurs, forces begin to work to rebuild toward the climax stage.

Some of the physical factors which will destroy life directly or alter the environment enough so that the old community cannot tolerate the new conditions are active valcanos, earthquakes, fire, flood, drough and severe storms.

Biotic factors are not as strong as the physical factors to cause succession. Man occasionally introduces a destructive agency by which communities will be altered. The American chestnut was one of the dominant trees in the forest biome of eastern North America in early days of the country. Then a fungus, the chestnut blight was accidentally brought in, and in less than a half a century the species was almost wiped out. This is a good example of man being a destructive agency causing a climax community to be altered.

Role of Competition in Succession

When two or more plants make demands, for light, nutrients, or water and the demand exceeds the supply, competition always occurs. This is essentially the meaning of the word competition.

Competition exerts a controlling influence in succession.[14] As vegetation develops on a bare area the first competition which exists between plants is in the soil. The roots of plants will compete for water and those which are the better competitors, that is, those plants which can tolerate less water and continue to grow, will be the survivors of the community.

As the bare area becomes covered with vegetation the taller plant gradually gains the upper hand, partly because it receives more light for growth. This can be illustrated in the different types of grassland. Short grasses, like bufflo, and grama grasses, are not abundant in true prairies because of unsuccessful competition for light.[15] Thus, water and light play a large part in determining the type of vegetation which will get started and grow in a certain habitat.

Competition is closer between species which utilize the same food materials, than between those which do not. A grass will compete more

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[14]Weaver and Clements, p. 164.

[15]Ibid.

with a grass, than will a grass compete with a herb.

The effect of competition on invading plants is very important before a community will become stabilized, that is, before a community will become a climax community. Vegetation will become stabilized when the establishment of invading plants is no longer possible. This halting of invading plants is the result of competition. The plants which are the better competitors are able to keep other species of many vegetation forms from entering the area. Hence, the final stage of development is reached, once one type of vegetation can no longer be displaced by another.

Rate of succession

If succession is to be recognized as universal and occurring in all habitats, it becomes necessary to ignore time to some extent.[16] A more mesic habitat in a given climate will progress faster to the ultimate formation than one which is xeric in nature, especially if the habitat is bare rock. The two habitats will eventually support the same successional sequence of communities, but one habitat will progress faster than the other because of certain climatic conditions, such as, wind, water, humidity, etc. The soil would be another factor which would influence the rate of succession of a certain habitat. Seed sources available to the area would play its part in the development of a new community. Oversupply of seeds, producing an overstocking of certain species of plant would cause the delay of development of the next stage because of competition.

It should be clear that the rate of succession is extremely variable. Primary succession is extremely slow compared to secondary succession.

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[16]Oosting, p. 248.

An example is that of succession on bare rock, which must wait until soil develops through either the disintegration of the rock or until wind blown soil materials accumulate on the rock. In contrast, secondary succession would be much faster in the early stages of development because soil is already formed, especially on fields abandoned after cultivation.

PART II

FIELD AND LABORATORY WORK

Introduction

This section contains laboratory exercises in ecology that will be used when working in this unit. Most of the problems are designed to be worked in the field, not in the laboratory. The field trips are devoted to the study of ecological communities, with emphasis on the successional relations between them, and on the correlations with environmental factors. Some problems are to be set up in the laboratory to acquaint the students with certain ecological principles which he will later encounter in the field. These laboratory exercises may also be used in case of bad weather on the days students are to go into the field.

The field exercises are in numerical order. It is intended that the student follow the exercises in numerical order so there will be some organization in his plan of study. They are selected problems in field biology and the teacher can use any exercise for special emphasis on a certain aspect of ecology.

EXERCISE I

A record of certain physical and edaphic factors of the environment is important when studying ecological communities. The following exercises are to be used to measure environmental factors of the assigned plots and will be one of the first exercises students will do when working on an ecological problem in the field.

Measurement of Environmental Factors[1]

1. Temperature

The most useful records of temperature are those made continuously over long periods. Since this method is seldom applicable in field ecology, the measurement of temperature is usually confined to comparative methods, with one or several determinations made in each of two locations, as soil vs. air, or north face of a hill vs. south face and the like. For such purposes, the ordinary thin-walled mercury bulb thermometer is a suitable instrument. The only precautions to be observed are: 1. Be sure that sufficient time is allowed for the mercury column to reach a steady level--usually one to two minutes. 2. Be very careful in inserting the bulb into the soil, especially if the latter is hard or contains stones. It is best to make an initial opening with a twig or sharp stick. For most purposes, the soil temperature should be measured at a depth of 1 inch. 3. In taking air temperatures, hold the bulb in the shade.

2. Humidity

Relative humidity of the atmosphere may be measured by the wet and dry bulb psychrometer. This instrument consists of a pair of matched thermometers, one of which is provided with a wick around the bulb. The thermometers are mounted in a device, which provides for the circulation of air over their bulbs. In a sling psychrometer, this is merely a rod which may be revolved rapidly about a pivot. The cog psychrometer is a

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[1]J. T. Curtis, Plant Ecology Work Book (Minnesota, 1950), pp. 10-13.

modified egg-beater, which revolves the thermometer bulbs in a single plane. The most accurate instrument is the handaspirated psychrometer, which employs the venturi effect to draw a stream of air over the stationary bulbs. It may be used in very small spaces.

In all types, the wick covering one of the thermometer bulbs is wetted with distilled water (the 'wet bulb'). The instrument is then operated by rotation or aspiration until the wet bulb temperature has reached a minimum value, as determined by frequent inspection. At this point, both dry bulb and wet bulb temperatures are recorded. Relative humidities are then calculated from the dry bulb temperature and the difference between the wet and dry bulb temperatures, by means of a relative humidity table (refer to J. T. Curtis, Plant Ecology Workbook, p. 13).

3. Soil Moisture

Measurements of soil moisture, like those of temperature, are most valuable when conducted over the period of at least one full growing season. However, single measurements on any one day may be useful for comparative purposes. The procedure to be employed is as follows: Collect the sample with a trowel or a soil auger, place the soil in a small soil can, filling it about one half full. Take the sample to the laboratory, where the soil plus the container should be weighed on a triple-beam balance (total wet weight). Place the can (with the cover removed) in an oven at 105 degrees centigrade for 72 hours or more. Obtain the weight of the dry soil plus the container (total dry weight); finally obtain the weight of the container alone. From these figures, calculate the amount of water originally present according to the following formula:

$$\frac{\text{Total wet weight} - \text{total dry weight}}{\text{Total dry weight} - \text{weight of container}} \times 100 = \%\ \text{water content}$$

This formula gives soil moistures on a dry weight basis; values above 100% may be recorded for certain highly organic soil.

4. Soil Acidity

The acidity of the soil may be measured in the field with sufficient accuracy for most purposes by the use of a colorimetric method employing a mixture of organic dyes which change color according to the relative acidity of soil solution. The samples to be tested should ordinarily be obtained from the A_1 and A_2 horizons of the soil separately, where these can be readily detected in the field. In the case of prairie soils, a single sample from a depth of 1.5 inches will give useful values.

Place a small portion of the sample in one of the depressions of the porcelain test plate provided in the Truog Soil pH Kit. Add a few drops of the indicator solution, cover lightly with barium sulfate powder and match the color which appears with that of the color chart in the booklet provided with the kit. A careful reading of the directions in the booklet will be helpful. The indicator solutions degenerate with age and should be readjusted or replaced every three months. The mixture of dyes appears to be differentially absorbed by highly organic soils, such as peats, and should be used only with great caution on such soils.

EXERCISE II[2]

ECOLOGY OF A SEALED COMMUNITY

A sealed community is one that is independent of the atmosphere. The purpose of these observations of a small sealed community is to help students find the answers to the following questions:

1. Can organisms survive without an outside supply of air?

2. What is the function of the chemical indicator?

3. What is the relationship of the plants and animals to each other in a sealed community?

4. Can animals alone, or plants alone, survive in a sealed community? Why or why not?

5. Why do we use pond water instead of distilled or tap water?

6. What organisms might be present in clear pond water?

<u>Equipment and Materials</u>

At least 4 soft glass test tubes, 6 x 3/8" or longer

Test tube rack

Bunsen burner, with hot flame

Small pond or aquarium snails

Elodea, Cabomba, or a filamentous alga

Brom-thymol blue solution

<u>Procedures</u>

I. Preparing the tubes

1. Take the open end of the test tube between the thumb and first two fingers of the left hand, and the closed end between the thumb and

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[2] American Institute of Biological Sciences, Biological Sciences Curriculum Study, <u>High School Biology</u> "<u>Green Version</u>." (1960) pp. (2) 3-1 - 3-3.

first two fingers of the right hand. Hold the tube parallel with the table top. Use the right hand to rotate the tube in a Bunsen flame just above the blue cone, Figure 2 (1a); keep the heat confined to one area of the test tube, which should be a spot a little over half way up the tube. Heat until the flame around the glass is orange and the glass has a tendency to sag.

2. Remove the tube from the flame and in one motion pull the tube into an hourglass shape, Figure 2 (1D), leaving the constricted part wide enough for a snail to pass through. Place the tube in the test tube race and allow it to cool at least ten minutes. Make four such tubes.

II. Preparing the "acquariums"

1. In each of the four tubes put in clear pond or aquarium water until the lower portion is about half full. Add 5 to 10 ml of Bromthymol blue to each tube. To tube No. 1 add one small snail; to tube No. 2 add one small snail and one piece of Elodea (or filamentous algae); to tube No. 3 add Elodea or algae; do not add anything to tube No. 4. This is the "control." Figure 2 (1C). What organisms might be present in this "Control"?

2. Dry both the inside and outside of the constricted parts of the tubes <u>completely</u>. Use <u>great care</u> not to allow water to wet this portion of the tube. Again bring the tube into the flame, and heat the constricted portion near the top, being careful not to heat the liquid Figure 2(1D). Rotate it and pull gently until you can pull off the top of the tube, to seal the "aquarium." Caution: <u>Do not</u> allow the liquid to touch the hot part of the tube.

3. Stand the sealed tubes in a test tube rack until cool, then test the seal by turning the tube upside down. If water tight, place it in a medium light, <u>not</u> in direct sunlight. Make observations each morning and afternoon, and record any observed in the color of the indicator and condition of the plants and the snails (reference Figure 3).

<u>Questions</u>

1. What can be concluded from your data?

2. Now answer question 1-6 proposed at the beginning of the experiment.

3. Is tube No. 4 a true control? Why or why not?

Procedure for making sealed tubes.

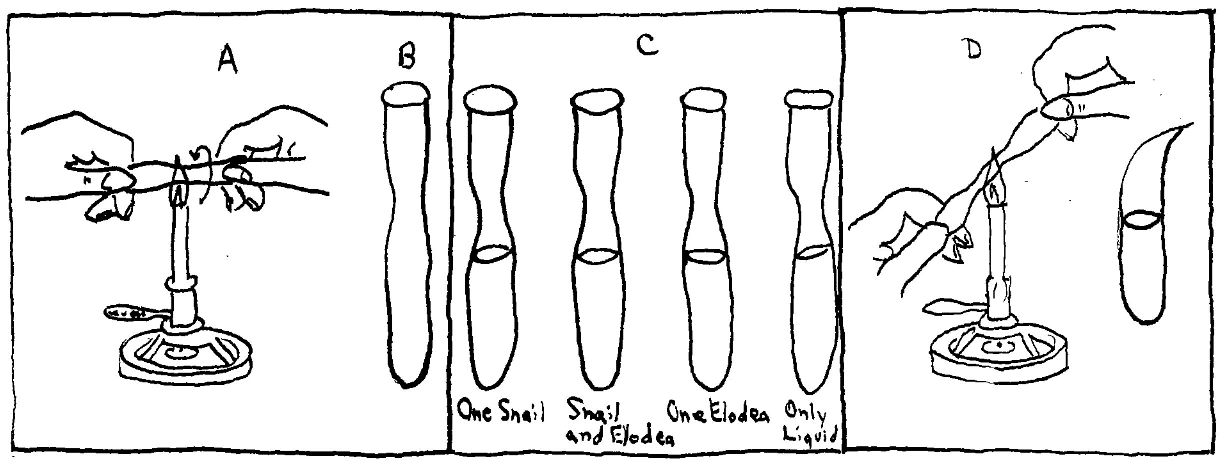

Figure 2.

FIGURE 3

GAS EXCHANGE CHART

Date	Time	Tube I Snail	Tube II Snail & Plant	Tube III Plant	Tube IV Indicator only
	a.m.				
	p.m.				
	a.m.				
	p.m.				
	a.m.				
	p.m.				
	a.m.				
	p.m.				

EXERCISE III[3]

A STUDY OF TERRESTRIAL COMMUNITIES

PLANT COMMUNITY

Introduction

The purpose of the field and laboratory work described below is to show the diversity of plants and animals in nearby fields or forests. We will also measure the abundance of the more common organisms, calculate their densities and attempt to evaluate their function in the community. Finally, we may, if the habitats are available, study the distribution of plants and animals in a many layered community.

Selection of Site and Construction of Quadrats

The first step in this exercise is to pick a study area that is convenient to your school. If the class is large enough you may want to study two sites; one might be a simple community while the second is more complicated. Then you must pick a precise site for study.

Materials

A 10 meter long plastic clothes-line, rope clothes-line, or heavy cord on which you have marked 1/2 meter intervals.

Procedure

Select your sample site and use the 10 meter line to measure the boundaries of your sample quadrat (square-shaped areas within which you will count and study the organisms). Now determine by general observation how many layers of organisms your community has (tree canopy, understory trees, shrubs, herbs, soil). For the vegetation you may wish to use three different sized quadrats, as follows:

1. Tree quadrat. A square ten meters on each side, within which

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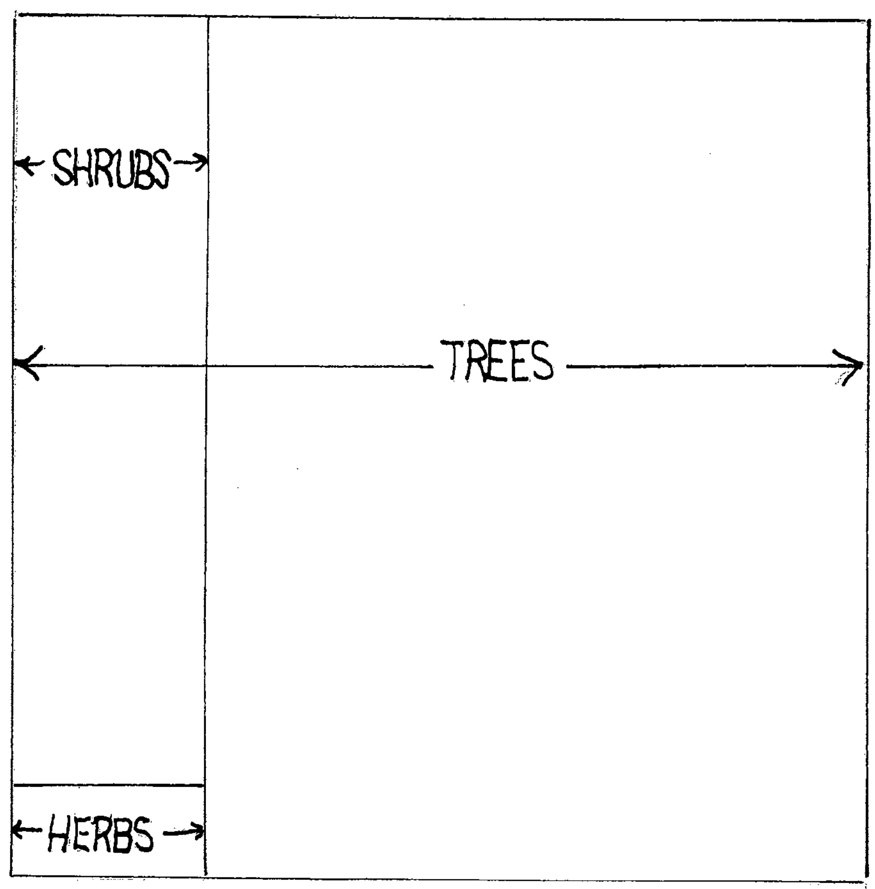
[3]Biological Sciences Curriculum Study, High School Biology "Green Version" (1960), pp. 4-1 - 4-3.

you count all trees that are more than four inches in diameter at breast height (d.b.h.).

2. Shrub and sapling quadrat. The size should be 2 x 10 meters and within this you count all shrubs (low woody plants) and all young trees less than four, and more than one, inches (d.b.h.).

3. Herbaceous plants and tree seedlings. This quadrat should measure 1/2 x 2 meters and here you count all herbs and tree seedlings. You can also estimate the amount of the ground that is (a) bare, (b) covered by fallen leaves (litter) or (c) covered by lichens and mosses.



The quadrats which are appropriate for your habitat should be marked off using stakes and string. If you use all three kinds of quadrats this arrangement would appear like the diagram above.

Area Tree Counts or Tree Quadrats

Counting all of the trees in a definite area is a standard procedure in small forests, while in a larger forest definite quadrats may be set up. By dividing the number of each diameter class (given below) of each species by the total number of trees counted, one obtains the frequency. The size of the area may be varied, depending upon the type of forest. The area is always larger than that employed for herbaceous plants since trees do not mature so close together. A quadrat 10 meters on a side has been found convenient in temperate regions, although local conditions may make some other size more useful. In many studies the figures are expressed on the basis of certain unit areas as per hectare, per acre, per tenth acre, or other unit. A very common practice, particularly in forestry, is to use areas 66 feet long and 66 feet wide (equals 1/10 acre) in which the height, diameter, and the kind of trees are all taken.

Where statistical studies are planned, any definite area may be charted in accordance with the following simple procedure: the area on the ground having been laid out, strings or small ropes at suitable intervals are run through the area. A team of two students charts on cross-ruled paper the exact location of each tree, giving the name and diameter. Such areas are recharted at later periods to show the history of the area. Meter quadrats may be located within these areas to record the ground plants as well.[4]

Classification of Trees As to Their Diameter and Height

(1) Less than a foot.

(2) More than a foot, but less than 1" in diameter.

(3) 1" - 3" in diameter.

(4) 3" - 9" in diameter.

(5) 9" - 15" in diameter.

(6) Over 15" in diameter.

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[4]Frank C. Gates, Field Manual of Plant Ecology (New York, 1949) p. 32.

EXERCISE IV[5]

POINT-FRAME METHOD

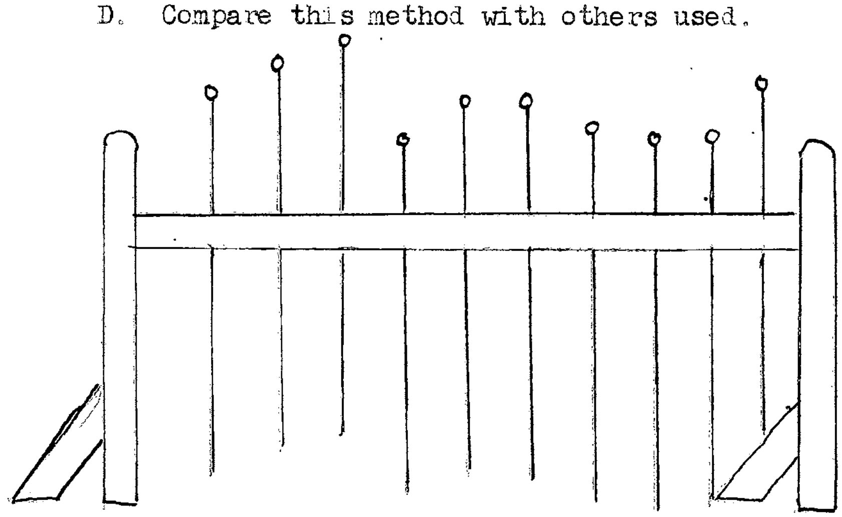
A framework containing pins (figure below) is used to sample vegetation lower than the frame. As the pins are pushed through the holes to the ground, each plant species hit is counted. This method has been used most widely in grasslands but can be used in other types of low vegetation as well. The most satisfactory recording of results seems to be the number of hits for each species per 100 points taken.

Procedure: A. Students set up the point-frame ten different times. At each sampling place, push each of the ten pins in turn through the hole until it touches the ground. Record opposite each species in your list the number of hits from 100 pins. Count only those species actually touched by the pin.

B. Make a list of species with those with the highest number of hits per 100 at the top.

C. To what quantity previously discussed is this number most comparable?

D. Compare this method with others used.



Apparatus for taking point quadrats. A pair of side arms may be provided to tilt the frame 45 degrees.

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[5]Edwin A. Phillips, Methods of Vegetation Study (1959), pp. 39-40.

EXERCISE V[6]

A STUDY OF TERRESTRIAL COMMUNITIES

Field Collection and Study of Animal Communities

The second part of our field studies concerns the animals and their functions in the community. There are four parts to the field work and teams should be assigned so that all the jobs can be done. The four parts are:

(1) Collection of soil samples to be taken to the laboratory where the very small animals will be removed;

(2) Collection of the macroscopic animals from the soil surface in the field;

(3) Collection for the flying insects and related invertebrates;

(4) Collection or observation of the vertebrates.

The site for these studies of animals should be the same as that studied earlier for plants, so that later all the organisms of the community can be related.

Collection of Soil Samples

The next step in the community study is to collect soil and leaf litter samples from which we can extract minute animals. One team may collect the layer of undecayed plant leaves from a quadrat ¼-meter on each side. These leaves should be sealed in a small plastic sack (and properly labeled) for transportation to the laboratory. After removing the undecayed leaf litter from the plot, cut a core sample of the mineral soil down to a depth of 8-10 centimeters. This core can be conveniently taken by using an orange juice can of about 5 cm in diameter. Be sure to seal this sample in a plastic sack, and label. It would be best, if time permits, to take several of these soil samples. When you return to the laboratory each sample should be placed in a funnel, the neck of which is suspended just above a small container of formaldehyde. Above the funnel a small light

[6]Biological Sciences Curriculum Study, High School Biology "Green Version" (1960).

bulb should be fixed so that it is several inches from the sample material. This light and heat, plus evaporation produced from the light, forces many of the organisms in the samples to move downward into the preservative. This method is especially satisfactory for the collection of mites and small insects like springtails. It should be noted that after the soils have been heated for about 7 days, there is little likelihood that any more animals will be obtained.

Collection of Microscopic Soil Animals

Another procedure in our habitat analysis would be to capture and count the microscopic animals in the soil and leaf litter. A convenient sample quadrat marker might be made from a clothes hanger bent to form a circle, a used bicycle rim with the spokes removed, or a hula hoop. Any of these will give a convenient, standard boundary for the sample. The device is thrown down at random in the habitat. The students from one team then capture and preserve all animals that they see within the enclosure. Two samples can be taken within each hoop: (1) the animals found in the organic materials (litter) on the soil surface, and (2) the animals captured in the mineral soil (say from 0-10 cm depth). The bottles containing these samples should be plainly marked with a soft pencil as to the kind of sample, as well as date, location, and team.

Collection of Flying Insects

Study of the flying insects can be done by use of a sweeping insect net. You might take 48 sweeps with this net by making one sweep with every step you take in a straight line. This sample may be considered roughly equal to covering 1 square meter. Quickly close the net and place it inside a large plastic sack into which you pour a few drops of 3:1 mixture of gasoline and chloroform. (DANGER: EXPLOSIVE!) After a few minutes the contents of the net can be sorted and all the animals placed into a jar with preservative. Label it!

Collection or Observation of Vertebrates

The vertebrates of a habitat are more difficult to study. Turning over rocks, logs, or metal objects on the surface of the soil while you walk through the area may result in a collection of amphibians and reptiles. If you move logs or stones be certain that you return them to their original position so that you don't ruin the habitat for the organisms that live there.

If binoculars are available, you may wish to catalogue the kinds and relative abundance of birds in your habitat. If possible you might also keep records on the layer in which you see different species. For example, you might record oven birds in the shrub layer 4 times, and on the floor 2 times, while the red-eyed vireo might be seen 9 times, always in the tree canopy.

It is even more difficult to study the mammals. Some idea of the mammals present can be obtained by studying their tracks. If soft sand, mud, or snow are not present you might add sand on a trail to cover an area of several feet. On this you could study any tracks left by animals using the trail. The small mammals can be killed with small mouse traps or with some modification to catch the animals alive. Shrews can frequently be caught by burying a tall can so that its top is flush with the soil surface and by baiting it with some meat.

When you have finished your animal collecting trip, you will have collections of animals from the soil surface (litter), the mineral soil beneath the surface, of flying insects on the low vegetation and of vertebrates. These organisms will next be used by your class to study the diversity of animals and the classification of animal groups. However, after your study of animal classification and diversity, we will want to return to a discussion of the plant and animal communities. Therefore, it is IMPORTANT that the animals from each of the kinds of samples be kept separate. Later, we will want to count the various kinds of animals in each of the samples.

DATA SHEET FOR STUDY OF ANIMAL COMMUNITIES

Kinds of Animals	Types of Samples: SOIL EXTRACTION		SOIL MICROSCOPIC FORMS		FLYING INSECTS, ETC.
	Mineral Soil	Leaf Litter	Mineral Soil	Leaf Litter	

DATA SHEET FOR STUDY OF ANIMAL COMMUNITIES

VERTEBRATES

KINDS	LOCATION WHERE OBSERVED
Amphibians	
Reptiles	
Birds	
Mammals	

EXERCISE VI

THE STUDY OF SECONDARD SUCCESSION BY THE DENUDATION QUADRAT METHOD[7]

A denudation quadrat ideally is a sample plot from which all preexisting plants are removed. In practice such quadrats are extremely difficult to prepare because of the great numbers of small seeds in the soil at all times. Hence the usual procedure is to remove all vegetative parts of plants, including roots and rhizomes. Various treatments may be applied to the denuded quadrats to study their effects on the resulting succession.

Prepare three denuded quadrats, each one meter square, in an abandoned field or haymeadow. Apply 50 grams of 6-12-8 commercial fertilizer to one quadrat. Sow 10 grams of oats on another quadrat, covering the grains lightly by raking. Allow the third quadrat to remain untreated. Stake out a fourth quadrat in a nearby non-denuded area to serve as a control.

Secondary successions proceed rapidly by comparison with primary successions but slowly by comparison with a school semester. Accordingly, it will be necessary to make your observations on similar sets of quadrats, prepared by earlier generations of students. Determine which species are present in each quadrat. Classify the species as to annuals, biennials, or perennials. Which had the greatest effect, additional cover or additional nutrient? If a sufficiently long series of quadrats exists, can you estimate the time necessary for the denuded quadrats to return to their original condition?

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[7] J. T. Curtis, p. 22.

EXERCISE VII[8]

A FIELD AND LABORATORY STUDY OF VARIATION IN PLANTS

Introduction

The purpose of this phase of the laboratory work is to enable students to recognize differences and likeness in plants and to learn about the intense competition for life that exists among plants.

What are some of these kinds of plants? How do they reproduce, obtain water, and compete for existance? Which of the plants are commercially valuable in medicine, agriculture, or as a source of clothing and shelter? Which of the plants might prove valuable if more could be learned about them? Which are poisonous, either from being eaten or from skin contact?

Finding answers to problems like these requires research, and progress from research in science comes largely as a result of scientists working individually or together, reporting the results so that everyone may benefit. This laboratory section is organized in a similar fashion, so that much can be learned in a limited time by utilizing the talents and skills of every member of the class.

Materials

1. Various forms of selected plant groups.

Procedure

A. The class may be divided into teams of no more than 4 students, or a student may work alone. Each team or individual will select one of the plant groups listed on page 53 or one suggested by the teacher.

1. Consult reference manuals to learn how to recognize a member of this plant group. Record the principle characteristics for field reference.

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[8] Biological Sciences Curriculum Study (1950), Ex. 4.3, pp. 1-5.

2. Collect a number of different plants that belong to this group (ten or twelve). The collecting may be done after school or over the weekend if class time field trips cannot be arranged.

3. As you collect each specimen, carefully record the following information:

(a) Locality where found.

(b) General description of plant, including its size, leaf structure, prevalence in the area, color and kind of flower, or whatever information seems of value.

(c) Kind of terrain; open meadow, hillside, desert, mountain top, etc.

(d) Approximate elevation.

(e) Whether the plant grows in the shade or in direct sunlight.

(f) Soil characteristics; hardpan, soft loam, sand, etc.

(g) General description of other vegetation in the area.

4. Find both the common and scientific name of each plant from picture guides to the local flora of by consulting your instructor or some other person who has had experience in plant identification.

B. The results of your work are to be presented in the following manner:

1. Construct a plant "key" along the lines of the "Sample Dichotomous Key" using only the characteristics that you have observed, including the general kind of habitat, the structural characteristics of the plant, and other information that may be of help in accurate identification.

2. From a consideration of the different plants collected by your team, write an "ecology report" on the particular plant group giving the soil, water and sunlight requirements of this group. Try to determine how these plants reproduce and how they are able to flourish in their particular environment. This will require careful observation and critical examination of the plant in all its relationships to the physical and biological factors that surround it. In addition, consult reference manuals for information on the commercial importance of the group, if any.

3. Prepare all written material on ditto masters so that other members of the class can receive a copy.

A Few Suggestions For Plant Groups

1. Evergreen conifers.
2. Deciduous trees.
3. Individual families of dicots, e.g., composities, legumes.
4. Grass families.
5. Ferns, club mosses, horsetails.
6. Mosses, liverworts.
7. Algae.
8. Fungi.

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