Conservation
SOURCE BOOK

By Iowa Conservation Education Council

Iowa State University Press, *Ames*, Iowa

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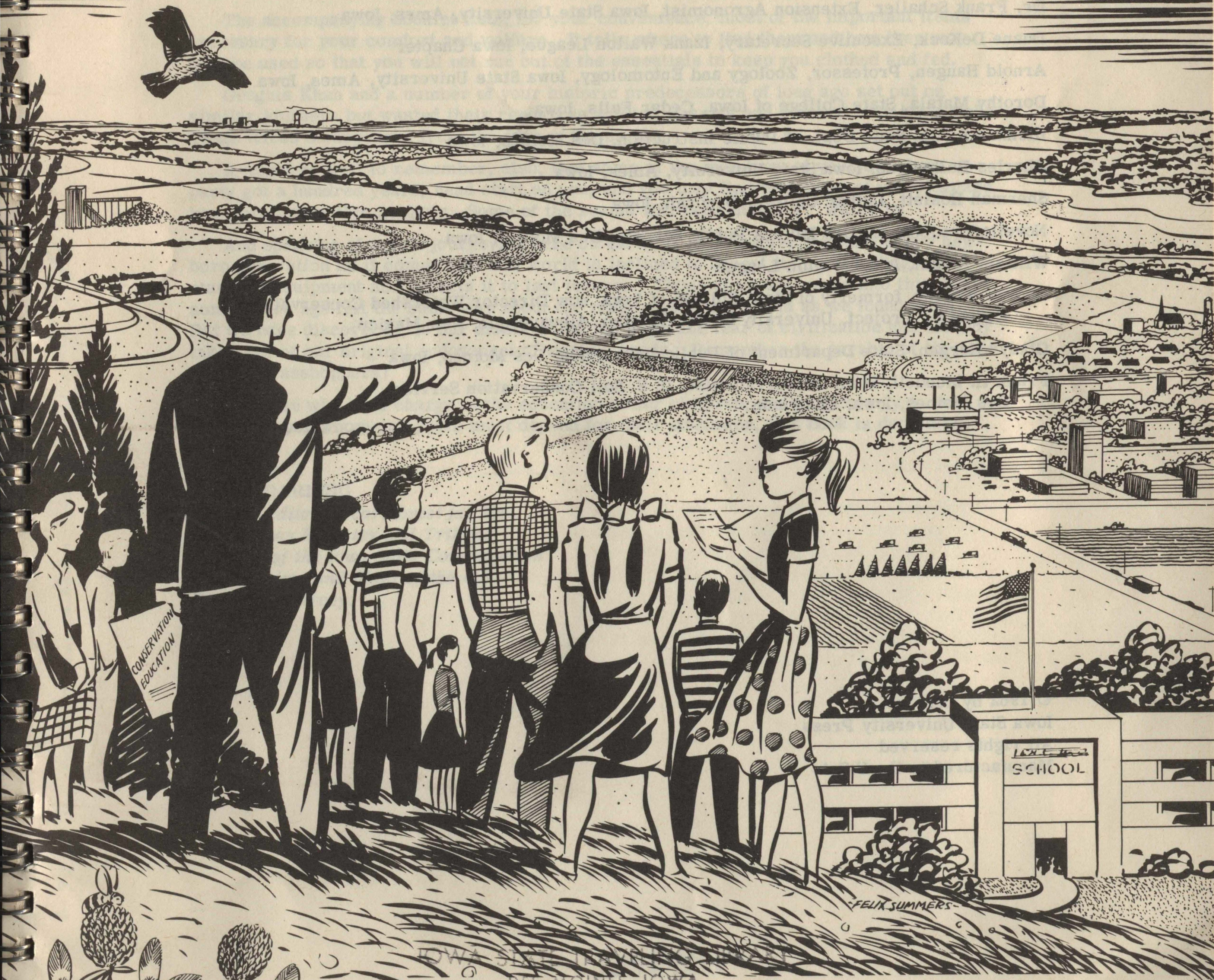

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Foreword

Maybe you won't like it, but you are going on a very long, long journey. Your traveling bags, your trunks and lunch basket have already been packed to last you until the end of time. Mother Nature has seen to that, and it is quite likely that you will have little opportunity to pick up much of anything extra along the way. Since your family and your children, and your children's children for many generations, are going along, it seems like a wise suggestion that you keep an eye on your luggage.

The accompanying booklet lists, for your convenience, most of the important items necessary for your comfort and welfare. It tells where to find them and how they may best be used so that you will not run out of the essentials to keep you clothed and fed.

Genghis Khan and a number of your historic predecessors of long ago set out on similar journeys but wasted their resources and left deserts and starvation in their wake. Their tribes disappeared from the face of the earth.

It might be well to remember, also, that some of the members of your own Iowa party got a hundred years, head start on you, and you may find that some of your luggage has worn pretty thin in spots. Some of the seams will need mending. Watch it!

And speaking of man's journeying here on earth, it is characteristic that every newborn generation as it comes into this world is inclined to accept its surroundings as standard equipment and expects it to last forever. Those of us who came into this world some years ago felt the same way about the resources of the world as we found them. But we have discovered, to our dismay, that the wear and tear of civilization has already taken toll of our original endowment of worldly goods. Remember the parable of the ants and the grasshoppers!

To those who have charge of the education of our children, and particularly to the teachers upon whom our youth must depend for their education, this book is dedicated.

JAY N. DARLING
Former editorial cartoonist for the
Des Moines Register and Tribune,
member of the Iowa State Conservation
Commission, and Chief of the U.S.
Biological Survey.

Preface

Conservation of natural resources is as basic to continuation of our American way of life as democracy itself. The high standard of living we enjoy in this country is due in large part to the abundance of God-given natural resources.

One of the more common definitions of conservation of natural resources is, "Use without abuse," or "Wise use of our resources." Fortunately, the conservation and improvement of our natural resources, and at the same time use of them to meet our present day to day needs, go hand in hand. For example, as we maintain and improve our soil and protect it from erosion and floods, we not only meet our present day needs but also turn these resources over to the next generation in a higher state of productivity.

Because of many requests for information covering conservation and use of our natural resources, the Iowa Conservation Education Council undertook the preparation of this book. It is primarily for teachers and leaders to help them acquaint their students with the value of our heritage of natural resources and impress on them the importance of conservation as it affects them, the community, the State, and the Nation.

The material was prepared by experts in their fields. Among these individuals are soil scientists, botanists, geologists, and others who have had years of experience in research and teaching. This material is to provide background information, guides, suggestions, references, and examples.

The Council is deeply grateful to all of those who had a part in the preparation of this material, particularly to Dr. Margaret Black of Drake University, Richard Smith of the State Department of Public Instruction and Dr. F. W. Schaller for editing; and to the following people who prepared the individual chapters: Dr. Frank Schaller, Dr. Wendell Bragonier, and Charles Ballantyne, of Iowa State University; Dr. Wallace Akin of Drake University; Dr. Arnold Haugen of Fish and Wildlife Service, U. S. Department of the Interior; Edwin C. Alberts of the National Park Service; Douglas Wade, formerly editor, Journal of Soil and Water Conservation, now supervisor of Conservation Information Service of the Saskatchewan Department of Natural Resources, Regina, Saskatchewan, Canada; Bernard Clausen of State College of Iowa; Jack Musgrove, curator, Iowa State Department of History and Archives; and Dr. Margaret J. Black, Drake University. The Council is indebted to Felix Summers, Soil Conservation Service, for the illustration on the front cover.

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Frank H. Mendell
State Conservationist (Iowa)
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1. Soil

PEOPLE DEPEND ON THE SOIL

Soils are a primary source of food, clothing and shelter. People depend on soils for most of their food except that which comes from rivers, lakes and oceans. Clothing comes largely from cotton and wool, which are attributed directly or indirectly to soil. Most homes in America are built of wood, a product of the soil.

The United States contains some 1,903 million acres of land. Much of this land is mountainous or desert, so there are only some 479 million acres that can be farmed. The United States population is now about 180 million and will probably be 240 million by 1980. As the population grows, cropland is used for roads, airports, building sites and for many industrial uses. There now are approximately 2 acres of cropland per person, but with a growing population the amount per person is decreasing each year.

Two tasks loom ahead relative to soils. First, there is the task of conserving the soil, and second, the task of improving its productivity because every year that goes by the soil will need to produce more than it did the year before. Conservation is not simply a desirable practice, CONSERVATION IS A MUST.

Soil Influences Land Use

Soil plus climate is a dominant factor influencing land use. For example, Iowa has a large acreage of productive soil and a kind of climate favorable to the production of feed grain, especially corn and oats. Iowa leads all states in production of corn and oats. It ranks third in production of soybeans and hay. Furthermore, Iowa ranks first among all states in cash receipts from the sale of livestock and livestock products.

The land area of Iowa is nearly 36 million acres, 94 per cent or 34 million acres of which is in farms. Of the land in farms, about 26.4 million acres are in cropland and 3.3 million acres in permanent pasture. About 2.0 million acres are in woodland. About 2.1 million acres are in other uses such as houses, lots, roads, parks, etc. (See Fig. 1.1)

You can see from the use of land that Iowa is mostly a farming state. There are some 175,000 farms in Iowa with an average size of about 194 acres. Nearly one-third of the farms are larger than 220 acres. Farmers, of course, make their living directly from the farm. But many townspeople also depend directly or indirectly upon agriculture for their livelihood. The real wealth of Iowa is in its soil and climate.

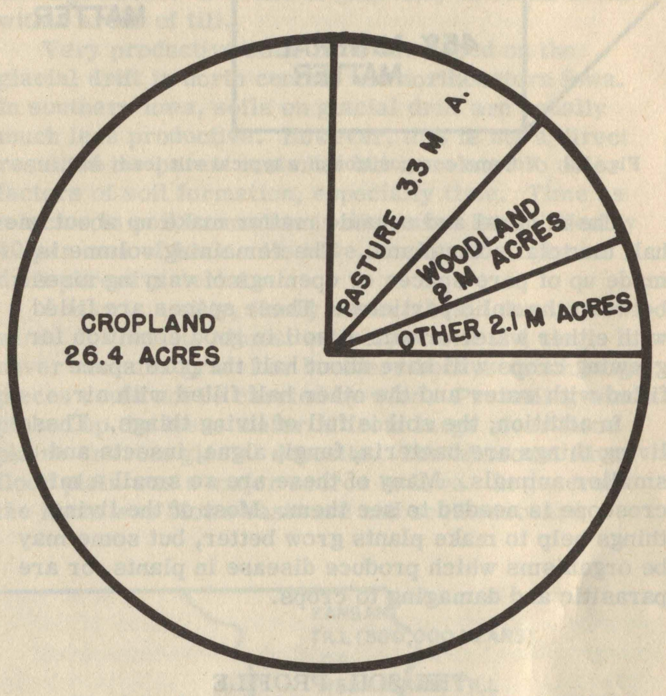

Fig. 1.1. Acreage of Iowa farm land used for cropland, pasture, woodland and other uses (buildings, lots, roads, wasteland, etc.).

Iowa is well supplied with good soil. It has a warm growing season and usually enough water to grow bountiful crops. If soil is to last a long time and continue to grow good crops it is necessary to maintain fertility and control erosion. When this is not done production from the soil declines.

WHAT IS A SOIL?

Soil is the loose surface material of the earth in which plants grow. Nature worked thousands of years to make the soil. Soils continue to develop and change very slowly year after year.

Soil as seen in our fields is made up of four main parts. These are (1) mineral matter, (2) organic matter, (3) air and (4) water. (See Fig. 1.2) Mineral matter comes from partially decomposed rock materials of the earth's crust. Organic matter is the remains of plant and animal life and is mixed with the mineral matter.

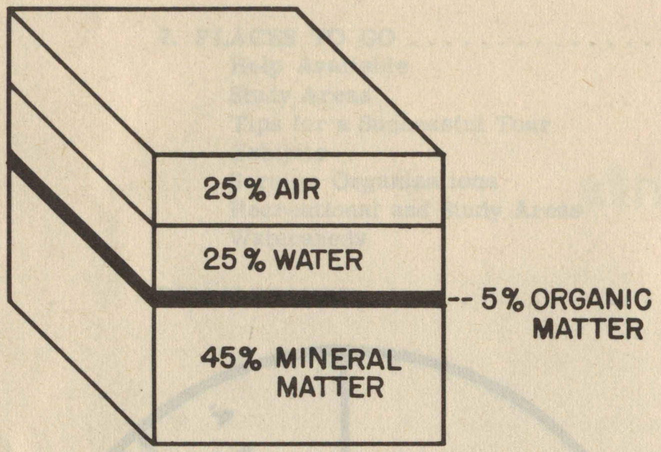

Fig. 1.2. Volume composition of a typical silt loam soil.

The mineral and organic matter make up about one-half the total soil volume. The remaining volume is made up of pore spaces or openings of varying sizes between the solid particles. These spaces are filled with either water or air. A soil in good condition for growing crops will have about half the pore space filled with water and the other half filled with air.

In addition, the soil is full of living things. These living things are bacteria, fungi, algae, insects and smaller animals. Many of these are so small a microscope is needed to see them. Most of the living things help to make plants grow better, but some may be organisms which produce disease in plants, or are parasitic and damaging to crops.

THE SOIL PROFILE

Soils have distinct layers or horizons from the surface downward. These horizontal soil layers can be observed quite easily by examining a fresh road cut or by digging a hole in almost any soil. The layers or horizons are noticeable because of rather sharp color differences. They are present because of soil-forming processes which have developed the soil over a period of many years.

Most soils have three main horizons which are designated by capital letters A, B and C. (See Fig. 1.3) The A horizon is the surface layer. It is the layer in which most plant roots are formed and where plant residues are returned to the soil. It is usually higher in organic matter than other layers. Most of the bacteria and fungi are here also. As a result the A horizon is usually darker in color than the other layers.

Beneath the A horizon is a layer which usually contains more clay than the topsoil and is lighter in color. This is called the B horizon or subsoil. These two horizons are referred to as the solum, the Latin word for soil.

Below the B horizon is the material from which the soil developed. This is called the parent material or C horizon. Together the A, B and C horizons make up the soil profile. To observe the profile the soil must be examined to a depth of 3 to 4 feet.

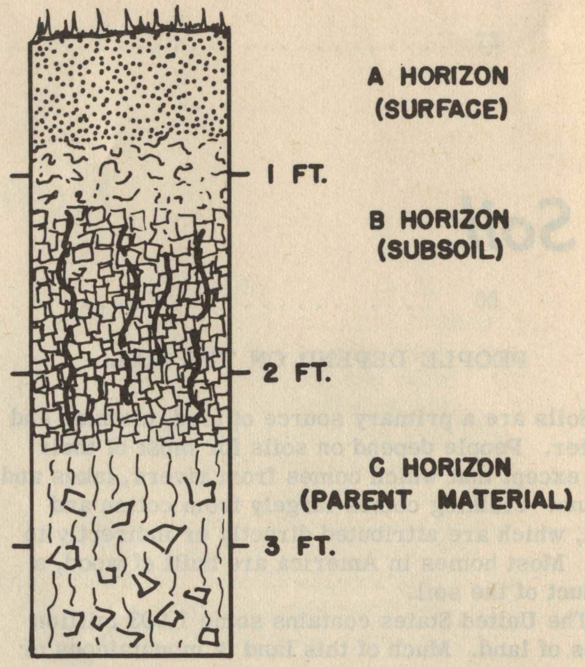

Fig. 1.3. Sketch of a prairie soil profile.

Soil horizons are best observed on level to gently rolling uplands. Here the A horizon will vary in thickness from a few inches to about fourteen inches. The B horizon may be a few inches to about two feet thick. The C horizon is usually several feet in thickness.

Soils do not always have three distinct horizons. Sometimes the topsoil or A horizon is absent because of removal by erosion. Also there are a few soils in Iowa which have no B horizon usually because of their location on steep "knob like" slopes. Here the A horizon merges with the C horizon. Soils of the bottomlands where floods have left thick deposits of sediment often lack distinct horizons, or the horizons are buried beneath silt deposits.

HOW SOILS ARE DEVELOPED

Soils are what they are because of their heredity and environment. They started from a particular rock material and developed slowly over many years in a manner related to their natural surroundings. Thus each soil or soil profile is the product of several factors. These factors are called *factors of soil formation* and are five in number as follows:

1. Parent material
2. Climate
3. Living organisms (mainly vegetation)
4. Topography (lay-of-the-land)
5. Time

The kind of soil at any one place is the result of the five factors working in combination at that place.

Soil Factors Described

Parent Material

Soil parent material is the loose and partly decayed rock from which soil is formed. It provides the skeleton or framework of the soil. In addition the decaying rock pieces furnish many nutrient chemical elements essential to the growth of plants.

There are five important soil parent materials in Iowa. These are:

1. Ground-up rock material left by glaciers, called *glacial drift.*
2. Finely pulverized rock material moved and deposited by wind, called *loess* (pronounced luss).
3. Rock materials or sediments moved and deposited by running water, called *alluvium.*
4. Rock materials which have accumulated at the bottoms of steep slopes, called *colluvium.*
5. Outcrops of limestone, sandstone, and shales, called *sedimentary rocks.*

Glacial drift, loess and alluvium are the principal parent materials in Iowa. Over 95 per cent of the soils have developed from them. Less than 5 per cent of the soils have developed from sedimentary rocks and colluvial material. Figures 1.4 and 1.5 show the distribution of the glacial drift, loess and alluvium in Iowa.

Glacial drift is of two main kinds, *glacial till* and *outwash.* Glacial till is the material left in place by melting ice. It is an unsorted mixture of clay, silt, sand and gravel with occasional boulders. Most of the till in Iowa is moderate to fine in texture (size of soil particles), though it all contains some sand. Outwash is material laid down by water which flowed from melting glacial ice. It has been sorted by the water and may be mostly gravel, mostly sand or mostly silt. Most outwash deposits in northern Iowa include sandy or gravelly layers. Glacial till occurs in large areas. Outwash is generally in small areas within areas of till.

Very productive soils have developed on the glacial drift in north central and northeastern Iowa. In southern Iowa, soils on glacial drift are usually much less productive. However, this is not a direct result of the parent material but is related to other factors of soil formation, especially time. Time as a factor in soil formation is discussed later. Nearly 40 per cent of Iowa soils have developed on glacial drift parent material.

Loess is a silty, floury material laid down by wind. It consists almost entirely of silt and clay. It never contains gravel or boulders because such large pieces could not be carried by wind. Prevailing winds picked up the loess material from large river flood plains or from glacial deposits. The Missouri River flood plain was a major source in Iowa. In general, the loess was blown eastward and southeastward

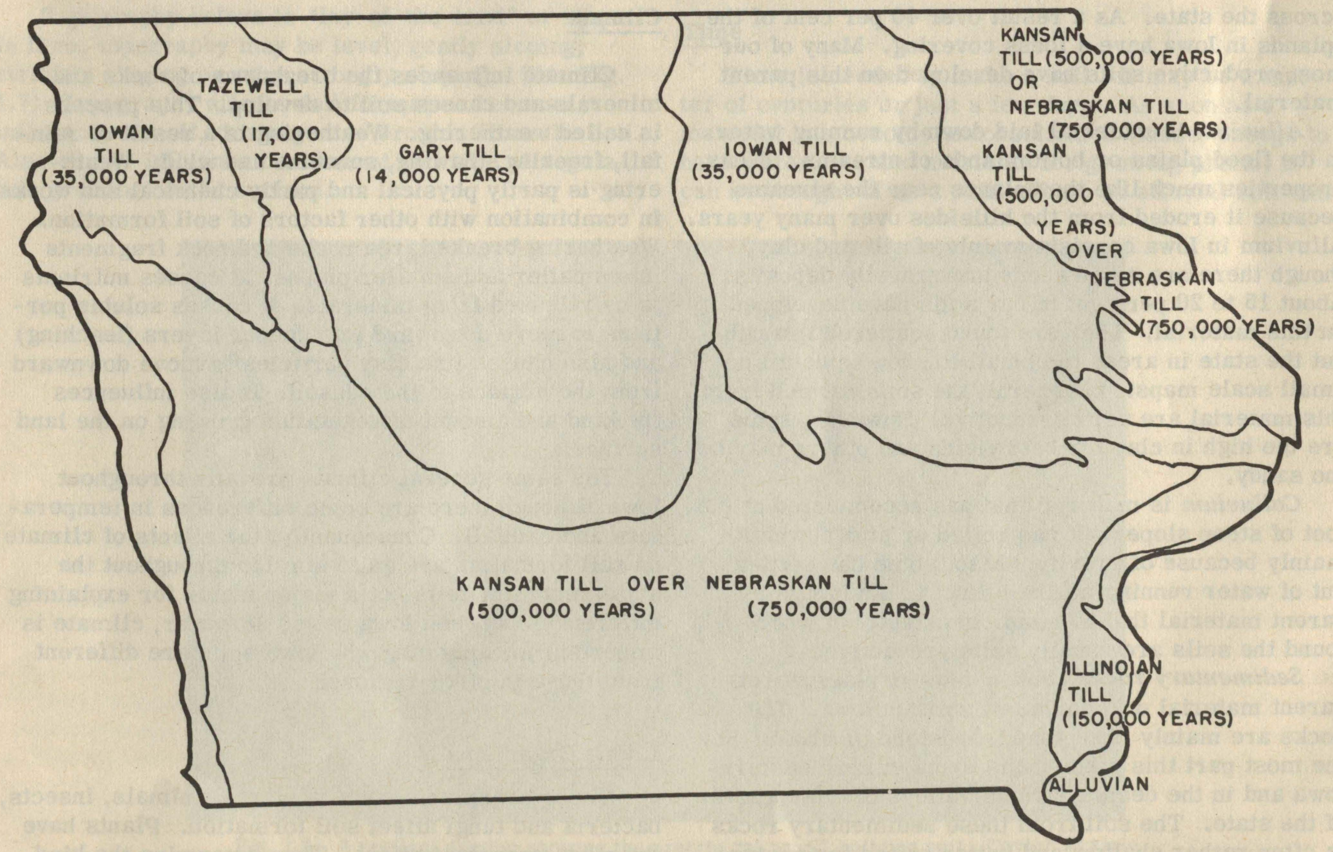

Fig. 1.4. Glacial deposits of Iowa and their ages.

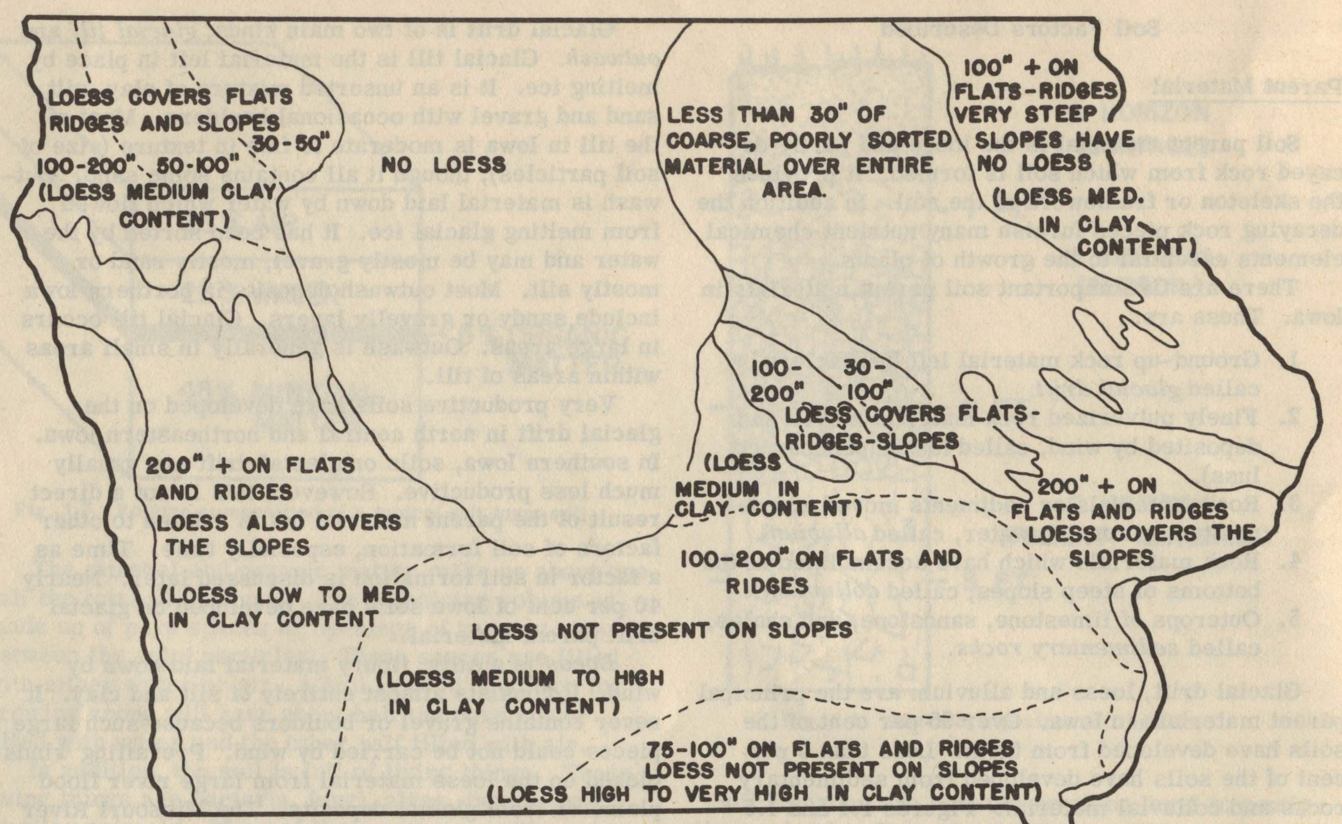

Fig. 1.5. Loess deposits in Iowa.

across the state. As a result over 40 per cent of the uplands in Iowa have a loess covering. Many of our most productive soils have developed on this parent material.

Alluvium is material laid down by running water in the flood plains or bottomlands of streams. It has properties much like the uplands near the streams because it eroded from the hillsides over many years. Alluvium in Iowa consists mainly of silt and clay, though there are some sandy and gravelly deposits. About 15 to 20 per cent of our soils have developed on this material. They are found scattered throughout the state in areas too small to show in detail on small scale maps. In general, the soils formed from this material are very productive. However, some are too high in clay for best yields and others may be too sandy.

Colluvium is material that has accumulated at the foot of steep slopes. It has rolled or slid downhill mainly because of gravity. Also, some has settled out of water running off the hills. Colluvium is a parent material that is minor in extent, but where found the soils are usually quite productive.

Sedimentary rocks broken down in place, furnish parent material only for a few soils in Iowa. The rocks are mainly limestone, sandstone or shale. For the most part this material is found in northeastern Iowa and in the deeper stream valleys of other parts of the state. The soil from these sedimentary rocks is often rather shallow and better suited for pasture than cultivated crops.

Climate

Climate influences the breakdown of rocks and minerals and causes soil to develop. This process is called weathering. Weathering is a result of rainfall, freezing, thawing, sunshine and wind. Weathering is partly physical and partly chemical and works in combination with other factors of soil formation. Weathering breaks large rocks and rock fragments into smaller and smaller pieces. It causes nutrients to be released from minerals. It causes soluble portions to move downward into deeper layers (leaching) and also causes fine clay particles to move downward from the surface to the subsoil. It also influences the kind and amount of vegetation growing on the land surface.

The same general climate prevails throughout Iowa although there are some differences in temperature and rainfall. Consequently, the effects of climate on soil formation are quite similar throughout the state, and climate is not a major factor for explaining differences between Iowa soils. However, climate is important in explaining why Iowa soils are different from those in other regions.

Living Organisms

Living organisms such as plants, animals, insects, bacteria and fungi affect soil formation. Plants have the most important effect. They determine the kind and amount of organic matter in the soil. Animals and insects burrow in the soil and cause mixing of soil materials. This tends to slow down the rate of horizon formation. Bacteria and fungi affect soil formation mainly as they help decompose organic matter.

In Iowa, soils have developed under two types of native vegetation — deciduous-hardwood forests and tall-grass prairie. As a result we have forest, or timber soils, and prairie soils. Prairie soils cover over three-fourths of the state. Timber soils are found mainly on rolling to strongly sloping uplands along rivers and large creeks. The largest areas are in eastern Iowa.

Prairie cover has resulted in dark-colored soils that are high in organic matter. The prairie grasses were very vigorous and developed abundant fibrous roots in the top foot of soil or deeper. The grasses brought large quantities of plant nutrients to the surface. As the tops and roots decayed, large amounts of organic matter and plant nutrients accumulated in the surface soil. Highly productive soils resulted.

Under forest cover, organic matter was added to the soil largely by leaves, twigs and fallen logs. Trees do not have as large a quantity of fibrous roots as do grasses, and their plant parts have different kinds and proportions of plant nutrients. Since forest vegetation is mainly on the surface, it decays rapidly and leaves only a small residue in the soil. Thus, forest soils are lighter in color, lower in organic matter and less fertile than prairie soils.

Topography

Topography refers to "lay-of-the-land" or slope. In Iowa, topography may be level, gently sloping, strongly sloping or very strongly sloping. (See Fig. 1.7) Topography affects soil formation because it influences runoff, drainage and erosion from the soil. Also it may influence the amount and type of vegetation growing on the surface.

In general, strongly to very strongly sloping land has high rates of water runoff. The amount of water absorbed and retained is limited and soil drainage is generally good. On sloping land there is considerable erosion which results in a constant removal of surface material. Plant growth on steep slopes is somewhat restricted because of moisture shortages and undue exposure to sun and wind. Consequently, soils formed on these slopes tend to have a rather thin surface layer which is light to dark brown in color. The subsoils are well aerated (porous) and have a bright yellowish-brown to brown color.

In contrast, level and gently sloping lands lose very little rain by runoff, and erosion losses are small. Most of the rain enters the soil where it influences profile development and encourages abundant plant growth. As a result, soils on level and gently sloping land tend to have thick dark brown or black surface layers. The subsoils tend to be gray in color because of inferior drainage and aeration.

On some gentle to strong slopes, soil characteristics are intermediate in nature between the level and very strongly sloping soils.

Flat or level lands are scattered all over Iowa. Many flat lands are alluvial in origin. The biggest acreage of gently sloping land is in northern Iowa. Strongly sloping lands may be found in many parts of the state but largest acreages occur in southern and southeastern parts. Strongly sloping lands are found principally along the Missouri, Mississippi, Des Moines, Iowa, Cedar, Sioux and other rivers.

Time

Time is needed to make a soil. It may be a matter of centuries or just a few days. As soon as a material has become unconsolidated (loose) enough to have water, air and nutrients for growing plants, it can be thought of as a soil. Thus, an alluvial soil can

Fig. 1.6. A vertical section showing the prairie "at work" building soil. Cayler Prairie in early July — Dickinson County.

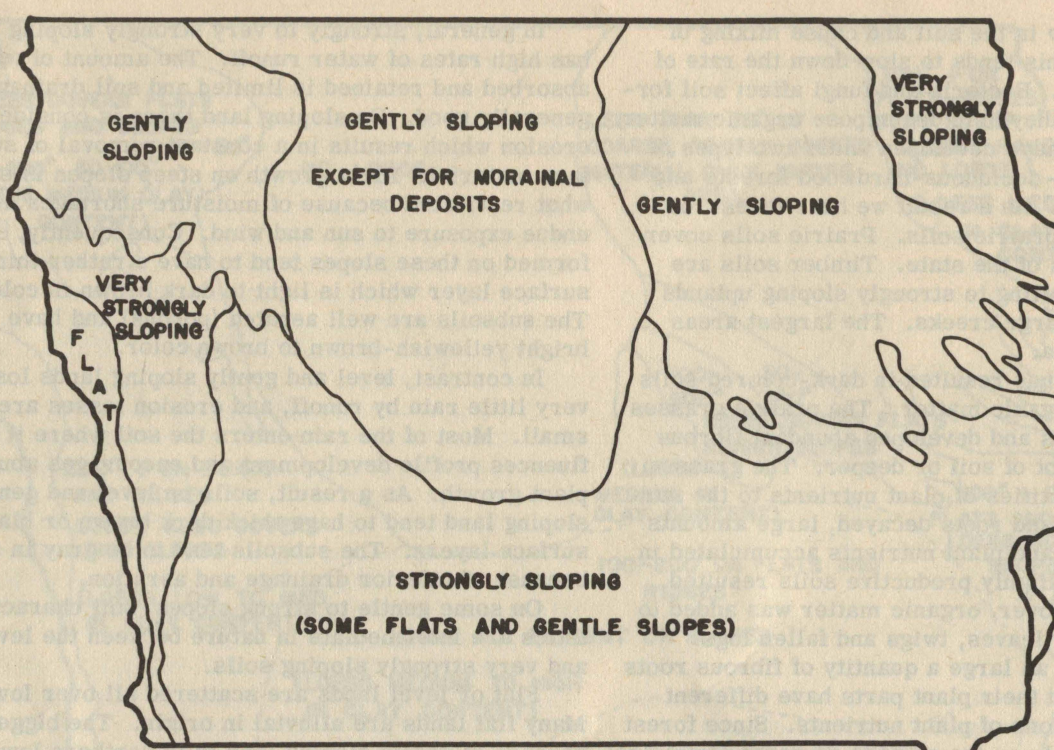

Fig. 1.7. Topography in Iowa.

be formed in just a few days, when a flood lays down sediment over an area. On the other hand, it takes centuries to develop soils with well defined horizons such as are found on many uplands in Iowa.

In general, the longer a soil is exposed to soil-forming processes the greater is the degree of weathering. This means that rock fragments and minerals become finer and finer as soils increase in age. The horizons become well defined and the subsoil becomes high in clay content.

Some of the oldest soils in Iowa are found in the southern part of the state. These old soils developed from glacial till which was laid down nearly half a million years ago. Till soils in northern Iowa have been exposed from 13,000 to 35,000 years. Loess soils range in age from 17,000 to 160,000 years. The youngest soils in Iowa are some of the alluvial or bottomland soils.

SOIL CHARACTERISTICS

The soil development processes just discussed have interacted in various ways to produce soils with widely differing characteristics. These characteristics are a natural part of the soil and are used for identifying and describing soils. Also, they are very important as an aid in knowing how to use and manage different soils.

Soil Color

Color is a feature widely used in recognizing soil types. But more important, it is an indicator of certain physical and chemical characteristics. To understand this we must know what causes color in soil.

Color is due mainly to two factors — humus content and iron compounds. (See Fig. 1.8) Humus or organic matter is dark brown or almost black. When its content in soil is high it coats the mineral particles and masks all other colors. This is why we have dark-colored topsoils. Thus, brown to dark gray and black colors in soil usually indicate a high humus content.

Material	Color
Organic matter	Brown to black
Unoxidized iron compounds	Gray
Oxidized iron compounds	Red
Oxidized and hydrated iron compounds	Yellow
Mixed unweathered minerals	Gray

Fig. 1.8. Materials in the soil which have major influence on soil color.

Iron is an important color material because iron appears as a stain on the surfaces of mineral particles. About 5 per cent or more of mineral soils is iron, so there usually is plenty of iron available to produce color. The color provided by iron depends on its association with oxygen. In the presence of oxygen the iron rusts and has red and yellow colors. In the absence of oxygen there is no rusting and a gray color exists.

Red and yellow colors indicate good aeration in the soil. In surface soils which usually are well aerated we could have yellow and reddish-brown shades, if the humus content is low. However, more commonly in Iowa, shades of gray and dark brown to black occur in the topsoils, as humus masks the colors from iron to a greater or lesser degree.

Color is an important indicator of aeration and drainage in subsoils. Here humus is low and iron compounds largely determine the color. Bright yellows and browns indicate good aeration and drainage. Dull grays usually indicate poor aeration and drainage. Also, under conditions of imperfect drainage, soils may be mottled in color; that is, they may have spots of gray or reddish-brown within a dominant color.

There are other minerals in the soil which have a range of colors. But the minerals in greatest quantity, such as silica and alumina, are gray in color. Consequently, mixtures of other minerals are usually gray and are easily masked by the stronger colors of iron and humus. The usual color combinations in Iowa soils are dark brown to black with gray, red or yellow as their intermediates.

Texture

Texture refers to the size of soil particles. All soils have particles. They are classified on the basis of size into gravel, sand, silt and clay. (See Fig. 1.9)

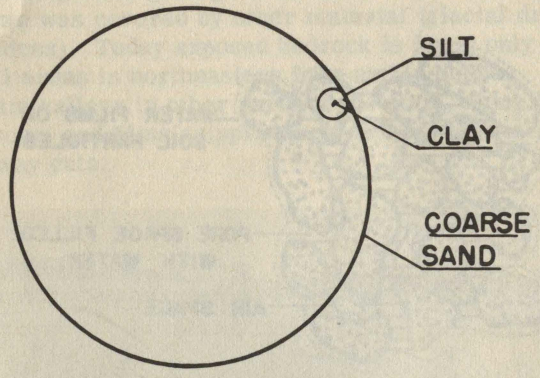

Fig. 1.9. Relative size of sand, silt and clay. Enlarged 60X.

Gravel may range from pebbles down to about 1/12 inch in diameter. Sand grains can be seen easily and feel gritty. Silt particles can be seen with a magnifying lense or under a microscope. When dry they feel like flour. Clay particles are very fine and can be seen only under a high-powered microscope. When wet clay is sticky and plastic it can be molded and will dry into a hard mass.

Very few soils contain only one particle size. It might be true of some sands. Nearly all soils have a certain proportion of sand, silt and clay. The last part of the soil type name, for example "Muscatine silt loam" gives the texture of the surface layer. The subsoil and parent material may have the same texture as the surface layer, but usually they are different.

Soil texture can be determined in the field by feeling the soil. Of course some experience is necessary for accuracy. It also can be determined in the laboratory by separating and weighing the different sized fractions.

Group	Class names
Coarse textured	Sand, loamy sand, sandy loam
Medium textured	Very fine sandy loam, silt, silt loam, loam
Moderately fine textured	Sandy clay loam, clay loam, silty clay loam
Fine textured	Sandy clay, silty clay, clay

Fig. 1.10. Textural classes.

When soils are mapped, the horizons are placed in one of 13 textural classes. These are sand, loamy sand, sandy loam, very fine sandy loam, silt, silt loam, loam, sandy clay loam, silty clay loam, clay loam, sandy clay, silty clay and clay. In this listing the classes are arranged in order of increasing fineness. (See Fig. 1.10)

Texture is a permanent soil property and it greatly influences productivity. Soils with a high proportion of large particles (sandy soils) cause trouble. Likewise, soils with a high proportion of very fine particles (high clay soils) cause trouble. Sandy soils do not hold enough water for good plant growth and they are a poor storehouse for plant nutrients. They must receive frequent additions of water and nutrients to be productive. The main problem with high clay soils is their low permeability, which is the result of their large number of very small pores. This means that high clay soils will often be so wet that root development is hindered. Also they are often difficult to work because they easily become too compact or cloddy.

The most productive soils are usually medium in texture. Examples are silt loams and loams. Such soils are good storehouses for plant nutrients and they have a high proportion of water available to plants. Conditions generally are very favorable for root growth.

Productive soils must have favorable texture in both the surface and subsoil layers. Most soils have a finer texture in the subsoil than in the surface layer. This is due to the processes of soil development. In some soils the subsoil is quite fine textured. Water enters and moves very slowly in the profile. Root growth and development may be hindered. A few soils may have coarse sand or gravel layers near the surface. This limits water-holding capacity and drouthiness is a problem.

Soil Structure

Soil structure refers to the arrangement of soil particles. In most soils, particles of sand, silt and clay will cling together and form larger units. These units are called aggregates or crumbs. The aggregates are held together by films of clay and organic matter. Clays have stickiness and other properties which in a sense glue the individual particles together and make them stable. Also various substances from decomposing organic matter have a similar effect.

Structure is important in soils because it influences water intake, effects ease of tillage and is responsible for pore space and cracks in the soil through which water and plant roots can move easily. This is especially important in medium- to fine-textured soils which could be very dense and compact if no structural units were present. Structure in this sense means that the spaces between the aggregates are the large pores where excess water rapidly drains away, leaving these filled with air. This insures adequate oxygen for plant roots, speeds up decomposition of organic matter and releases available nutrients faster.

Structure in topsoil has always received a great deal of attention. It has important effects and can be destroyed or improved by management practices. It is important because of its relation to (1) seedbed preparation, (2) erodibility, (3) aeration and (4) water absorption versus runoff.

Topsoil structure is developed by tillage. It also can be destroyed by too much tillage. It is also formed by freezing and thawing, by wetting and drying and by action of plant roots. Thus, there are many chances to form aggregates in the soil and this is no great problem. The problem is to get the aggregates stable so they will not be easily broken up by rain or by ordinary tillage. About the only way to improve aggregate stability is to make sure soil has a supply of actively decomposing organic matter. As organic matter decomposes, certain products bind particles together. Thus, a good way to improve or maintain topsoil structure is to keep crop yields high to provide deep and abundant root growth and large amounts of organic residues to return to the soil.

Structure of the B horizon (subsoil) is also important. Here again the rate of water absorption and movement through the profile depends largely on the soil structure. There must be adequate-sized pores and cracks between structural units if water is to move satisfactorily. Furthermore, root penetration will be limited unless the same conditions exist.

There is not much a farmer can do to improve structure of the subsoil. Deep plowing, subsoiling or chiseling frequently are tried, but have been of little help. Where benefits have been observed, they usually are short-lived. The costs of subsoiling generally are too high for the yield increases received.

Well-fertilized, vigorous crops with strong root systems will improve subsoil structure to a significant extent. When the roots of crops die and rot they leave channels for movement of air and water. Cracking of soil by wetting and drying, and freezing and thawing also helps subsoil structure. But in general, if subsoil structure is poor, the yield potential of the soil is reduced accordingly. This means that our soils have a built-in natural structure. We can't do much about it, yet it markedly influences the potential productivity of the soil.

Soil Moisture

The production of any agricultural crop depends upon a supply of water during the growing season. This water is drawn from the soil moisture supply, which depends largely on rainfall for replenishment.

In Iowa we are concerned with too little water at certain times. But often our problem is too much water. Thousands of acres in the state have drainage systems and some additional acres are drained each year. In some soils there is too much water in the spring and too little during the summer period.

Water-Holding Capacity of Soils

The capacity of a soil to hold water is of great practical importance. In each growing season, there are days and even weeks when there is no rain. During these periods plants must draw on water stored in the soil for their moisture supply.

Water is held in soil by a mutual attraction between soil and water. This attraction is what prevents all the water from draining out due to the pull of gravity. Stored water is distributed through the pore system of the soil and over the surface of the soil particles. The fine-textured soils have greater particle surface and more pore space than coarse-textured soil. For this reason, clay soils usually hold the greatest amount of water and sands the least amount. Figure 1.11 shows how water is held in soil.

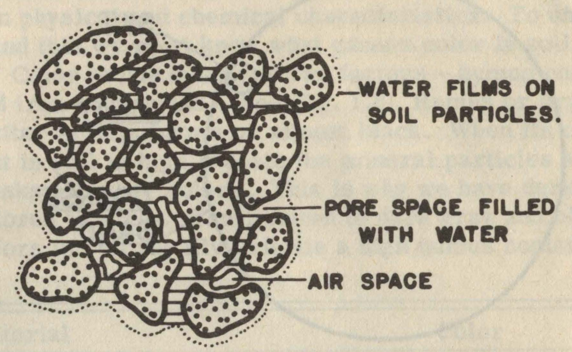

Fig. 1.11. Water is held as a film around soil particles and in pore spaces between particles.

The maximum amount of water which can be held by a soil against the pull of gravity is termed the *field capacity*. More specifically, field capacity is the moisture content of the soil when downward drainage into drier soil below has virtually ceased. This condition develops in about 2 or 3 days after a rain on a well-drained soil.

Not all the water at field capacity is available to plants. This is because the mutual attraction between soil and water is so great that a certain portion of moisture is held with a force greater than the absorptive power of plants. When the moisture content of the soil reaches this point, plants can no longer obtain water. They wilt. This percentage of soil moisture is called the *wilting point*.

Soils have an upper limit of water usable by plants (field capacity) and a lower limit (wilting point). The difference between the two (field capacity minus wilting point) equals the amount of soil water available to plants and is called the available moisture content. It should be pointed out that plants can use water above field capacity if it is retained in the soil long enough. In general, this is not important except in soils which have a water table relatively near the surface (3 to 5 feet).

The available moisture content varies with different soils. Size of soil particles, that is, soil texture, is responsible for most of the difference. Variations in organic matter content and soil structure influence the quantity of water held. Sandy soils hold up to about 1 inch of water available to plants in each foot of soil depth. This means 5 inches or less of water reserve in the top 5 feet. Most Iowa soils will hold about 2 inches per foot or 10 inches of water available to plants in the top 5 feet.

GEOLOGY OF IOWA

The parent materials of Iowa soils are best understood with some knowledge of the geology of Iowa. All of Iowa was under the sea in ancient geological times. Proof of this lies in the fact that all major bedrock of Iowa is sedimentary (deposited in water). The bedrock is mainly limestone, sandstone and shale.

During later geological times most of the bedrock in Iowa was covered by other material (glacial drift and loess). Today exposed bedrock is found only in small areas in northeastern Iowa and in deeper stream valleys in other parts of the state, along the Missouri and Mississippi rivers, and along some highway cuts.

Glaciers in Iowa

Glaciers invaded Iowa many centuries ago and at one time or another covered the entire state. (See Fig. 1.4) Changes in world-wide climate brought glaciers into being. In parts of what is now Canada, according to one theory of glaciation, the snow lasted from one winter to the next. Year by year it increased in thickness and expanded to cover an even larger area. With increased thickness, the snow gradually changed to ice, and the ice finally became so thick that it started to spread, thus forming an ice cap, continental glacier, or ice sheet. At the time of maximum extent, the ice covered more than 4 million square miles. The development and spreading of these continental glaciers in turn further affected world-wide climate.

The glacial ice apparently moved out in all directions from centers in Canada. In doing this, it froze into the soil and subsoil of the country over which it moved, and dragged it along. This subsoil had been formed by weathering of the bedrock of the country, and by stream wear. The bottom of the moving ice became heavily loaded with this soil and subsoil of the country through which it moved. When a change of climate came about and the ice was slowly melted away, this ice-borne material was left as a blanket over the country. Most of it became the till. Wherever material was carried along by streams of melt-water, however, deposits of stratified sand, silt and gravel accumulated, clearly water-laid. This is the sorted drift called outwash.

According to the latest ideas, the onset of glacial ice began over 500,000 years ago. All of Iowa was covered by the first glacier, called the Nebraskan, and in this part of the continent the ice extended to

Fig. 1.12. Glaciers invaded Iowa many centuries ago, covering the land surface with ground-up rock material called glacial till from which many of our soils developed. Sometimes it left large boulders, too, as shown in this picture from northeast Iowa.

about the line of the present Missouri River. A change of climate in the course of 10,000 or 20,000 years resulted in the disappearance of the ice sheet. There followed a long interval when the climate was much like that of today. Another change of climate in the other direction brought on another glacier. The second one, called the Kansan, also extended as far as the Missouri River in this part of the continent and covered all of Iowa.

Another change of climate, fading of the glacial ice and an interval of present-day climate followed. Then a third time of glaciation occurred, this one called the Illinoian. It covered the greater part of Illinois and reached into southeastern Iowa. Still other changes in climate and the last of the big ice sheets, the Wisconsin, spread southward.

Several advances and disappearances of the Wisconsin ice are recognized. (See Fig. 1.4) The first, called the Iowan, covered much of the northern half of the state. The second, the Tazewell, named from a locality in Illinois, came only into parts of northern Iowa. The third, the Cary, formed a lobe which extended as far south as Des Moines. Finally, the Mankato advanced over part of the area of the Cary, and very recent studies indicate that it did not reach into Iowa.

Origin of Loess

The loess is believed to have been deposited from about the time of the Iowan ice until the last stage of the Wisconsin glaciation. Some of the surface being barren at such times, the wind would tend to pick up particles from the dried-out surfaces and drop them in vegetated areas. Plant stem impressions are often found in loess. Figure 1.5 shows the location of loess deposits in Iowa.

Much of the loess material apparently came from the Iowan drift plain and from the flood plains of large rivers. For example, during periods when the ice to the north was melting, the Missouri Valley would be filled from bluff to bluff with surging meltwater. As the floods subsided with the coming of fall and winter, the plain would be left covered with a deposit of alluvium. As this alluvium dried, the wind would pick up the finer material and carry it out over the surrounding countryside. Apparently the valleysides of that time had some vegetation and that vegetation caught much of the material. The loess is thickest along the Missouri River and diminishes in thickness toward the southeast. This is related to the direction of the prevailing winds.

Loess did not come all at once as a deep layer left by a single storm but as many thin layers of dust left by successive windstorms. The thick deposits were built up slowly, perhaps over a span of several thousand years.

CLASSIFYING AND NAMING SOILS

Soil profiles exist for every different combination of the five factors of soil formation (climate, vegetation, topography, parent materials and time). Also there are many variations of each individual soil-forming factor; therefore, many different kinds of soil profiles exist. Over 200 different soil profiles are mapped in Iowa. Soil profiles are identified and classified according to the horizon present and their characteristics.

Soil Types

Names such as Clarion loam, Marshall silt loam, Tama silt loam, Grundy silt loam and others are familiar to many people in Iowa. These are names of well-known Iowa soils and are called soil types. A soil-type name can be considered a shorthand term which briefly describes one particular soil.

The soil-type name has two parts. The first part such as Clarion sets the soil apart from other soils because of certain characteristics such as the number, kind, arrangement, color and clay content of its various horizons (profile). It is called the series name. The second part such as loam describes the texture of the topsoil or A_1 horizon. It is called the class name. Thus, the series and the class names are combined to give the soil-type name.

Once soil types have been clearly identified and defined, it is possible to separate and map the different kinds of soil on a farm. This gives the farmer an inventory of his soil resources. He then knows the kinds of soil he has, and the characteristics and properties of each. This kind of information is essential to good farming. It helps in putting the right crops on the right soils. It helps in planning fertility, moisture and erosion control practices. It is a basis for developing drainage and irrigation systems. Knowing about the soil is important when buying, selling or renting land.

Great Soil Groups

Soil types that are much alike can be classified together into broader groups. This is similar to the way that species of plants or animals are grouped together into genera, families and orders. Soil types which have the same horizons in their profiles are classified together into great soil groups. These great soils groups number 36 in the United States. Thus it is evident that some great soil groups contain literally thousands of different soil types.

In Iowa all of the soil types are classified into 9 great soil groups. The largest group of soils in Iowa is the Brunizems, followed by the Gray-Brown Podzolic soils, Humic Gley soils, Planosol soils, Alluvial soils, Chernozem soils, Regosol soils, Lithosol soils and Bog soils.

The general distribution of the great soil groups in Iowa is shown in Figure 1.13. In most areas there are also other great soil groups in addition to those designated. However, the great soil groups indicated are the ones which occupy most of the area.

Brunizem Soils

Brunizem soils are the dark-colored soils which

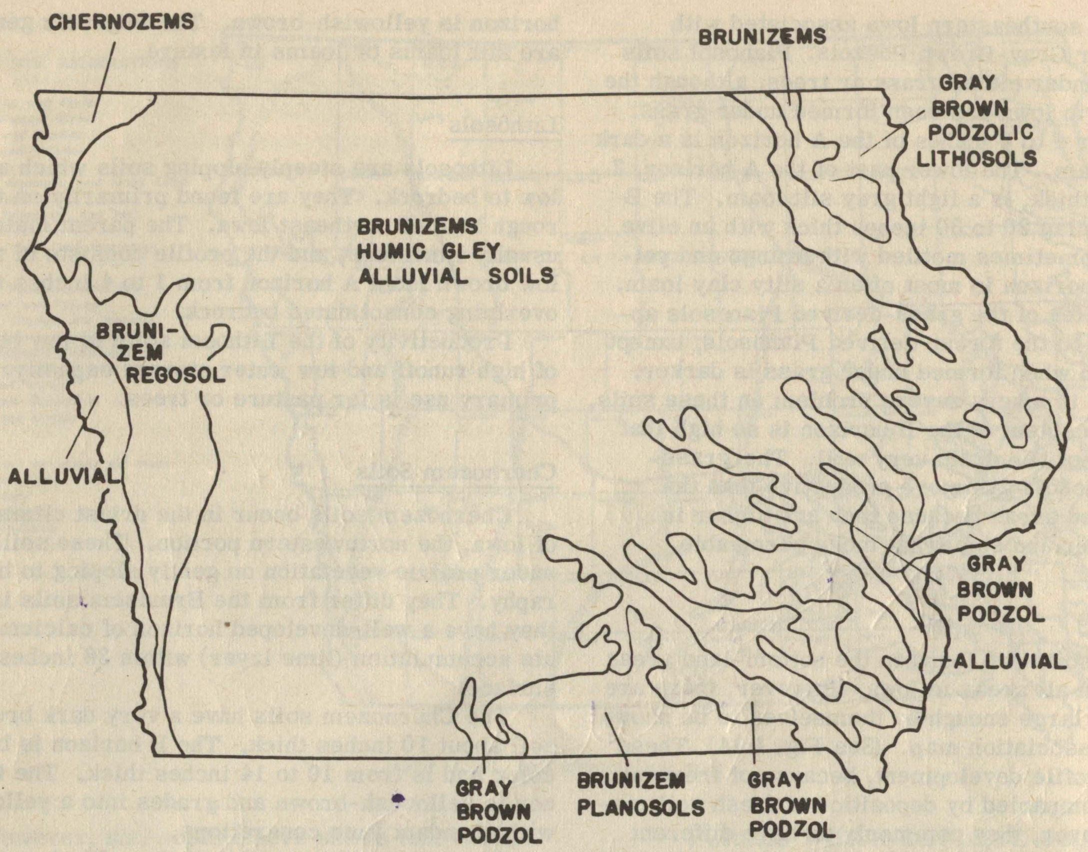

Fig. 1.13. Great soil groups in Iowa.

developed under prairie grass vegetation on gently sloping to rolling topography. They represent the largest group of soils in the state and include major soil types in 68 per cent of Iowa.

The profile of the Brunizem soils consists of a very dark brown to very dark grayish-brown A horizon (topsoil) from 8 to 15 inches deep; a grayish-brown to yellowish-brown B horizon (subsoil) from 15 to 24 inches thick; and a light yellowish-brown C horizon (parent material). The principal texture of the A horizons of these soils is normally a loam or silt loam. Texture of the B horizon usually is finer (more clay) than that of the A or C horizon.

Generally speaking, the Brunizems are well drained both internally and externally. They are usually high in productivity, although some are less productive because of much clay in the subsoil.

Erosion is often a problem because the Brunizems occur on 2 to 14 per cent slopes. On slopes less than 2 per cent or more than 14 per cent, other great soil groups occur instead of the Brunizems.

Gray-Brown Podzolic Soils

Gray-Brown Podzolic soils are forested equivalents of the grass-derived Brunizem soils and occupy about 10 per cent of the state. They occupy sloping areas (4 to 18 per cent slopes) along the major streams in eastern and southern Iowa.

The Gray-Brown Podzolic soils have thin dark brown surface layers 1 to 4 inches thick, changing to a light brownish-gray at 5 to 8 inches deep. The B horizons are yellowish-brown and range from 14 to 30 inches thick. The C horizon is a light yellowish-brown. The major textures are loam and silt loam in the A horizon, silty clay loam and clay in the B horizon and silt loam and clay loam in the C horizon.

The Gray-Brown Podzolic soils are naturally lower in organic matter, more leached and have more clay in the subsoils than the Brunizem soils. Consequently, the productivity is lower than the Brunizem soils, generally speaking.

Humic Gley Soils

Humic Gley soils occur in the area where prairie grass was the dominant vegetation. They are found in the poorly drained areas on flats and in depressions. These soils were often water-logged during portions of the year under natural conditions. However, most of the Humic Gley soils can be tile drained, and, once drained, rank high in productivity.

The surface layers usually are black in color and range from 14 to more than 20 inches thick.

The B horizon is olive gray and is from 4 to 20 inches thick. The C horizon is light olive gray and is often mottled with yellow and orange colors.

Texture of the A horizon varies from silt loam to clay loam. The B horizon commonly has clay loam to clay texture while the C horizon has a clay loam texture.

Planosol Soils

Soils of the Planosol group occur on flat areas in southern and southeastern Iowa associated with Brunizems or Gray-Brown Podzols. Planosol soils are formed under either grass or trees, although the largest area in Iowa has been formed under grass.

The upper 4 to 8 inches of the A horizon is a dark brown silt loam. The lower part of the A horizon, 2 to 10 inches thick, is a light gray silt loam. The B horizon is a clay 20 to 30 inches thick with an olive gray color sometimes mottled with orange and yellow. The C horizon is most often a silty clay loam.

The profiles of the grass-derived Planosols appear similar to the forest-derived Planosols, except the A horizon when formed under grass is darker.

Drainage is a very severe problem on these soils, and the clay content of the B horizon is so high that the soils do not tile drain very well. The grass-derived Planosols are more productive than the forest-derived areas because they are higher in organic matter and somewhat more permeable.

Alluvial Soils

Alluvial soils are found in the bottom-land areas of streams in all areas in Iowa. However, there are only 2 areas large enough by themselves to be shown on the soil association map. (See Fig. 1.14) These soils lack profile development, because of frequent flooding accompanied by deposition of fresh soil material. However, they commonly do have different layers which is a result of the different deposits laid down during overflow of the streams.

The characteristics of the alluvial soils as to color, organic matter, texture and drainage are determined by the nature of the deposits laid down by the stream from time to time. Some alluvial soils have several differently textured layers within the profile while others may be of a uniform texture. Colors vary from dark to light, drainage from good to poor and texture from clay to sand. Once an alluvial soil no longer floods and receives fresh deposits, it will begin to form distinct horizons like soils in the uplands.

The alluvial soils vary in productivity from among the highest in the state to the lowest. The most common hazard on alluvial soils is flooding, and frequently drainage is a problem.

Regosols

The Regosol soils occur on steep or very hilly land (slopes of 14 per cent or more) and occur in small areas in most counties in Iowa. They have no B horizons and the A horizon is either thin or is not present. The characteristics of these soils are primarily those of the unweathered loess or glacial parent material. The largest area of these soils occurs in the hilly areas of western Iowa. Where erosion is controlled, these soils may be fairly productive for crops as well as for pasture.

Regosol soils are light colored because of the low amount of organic matter. The A horizons, when present, are brown in color and the parent material or C horizon is yellowish-brown. The Regosols generally are silt loams or loams in texture.

Lithosols

Lithosols are steeply sloping soils which are shallow to bedrock. They are found primarily on the rough land of northeast Iowa. The parent material is usually limestone, and the profile consists of a shallow brown loam A horizon from 1 to 4 inches thick overlying consolidated bedrock.

Productivity of the Lithosol soils is low because of high runoff and low water storage capacity. The primary use is for pasture or trees.

Chernozem Soils

Chernozem soils occur in the driest climatic zone of Iowa, the northwestern portion. These soils formed under prairie vegetation on gently sloping to hilly topography. They differ from the Brunizem soils in that they have a well-developed horizon of calcium carbonate accumulation (lime layer) within 36 inches of the surface.

The Chernozem soils have a very dark brown topsoil about 10 inches thick. The B horizon is brown in color and is from 10 to 14 inches thick. The C horizon is yellowish-brown and grades into a yellow zone with abundant lime concretions.

The texture of the entire soil profile is a silt loam. The productivity is relatively high when adequate moisture is available.

Bog Soils

The bog soils are the areas of peat and muck in north central and northeastern Iowa. They occupy poorly drained depressional spots in this area. Their total area is about 160,000 acres.

Muck is decomposed organic matter mixed with mineral material. Peat, however, is comprised of partially decomposed plant remains in which portions of the stems and leaves can still be recognized. Peat is usually much thicker than muck and maybe as deep as 25 feet, whereas muck is usually not thicker than 5 feet.

Beneath the organic matter in bog soils the mineral material is olive gray in color because of very poor drainage. There is a great range in productivity of the bog soils. If drainage is improved and such nutrients as phosphorus and potassium are added in a fertilization program, the bog soils can produce high yields of field crops and truck crops.

Principal Soil Associations in Iowa

The pattern of soils in most of Iowa is one of intermingled areas of two or more soil types. Single areas of one soil type may cover less than an acre or more than 1,500 acres. Because soil types are so intermingled in almost every field in Iowa the location and extent of each can be shown only on large-scale

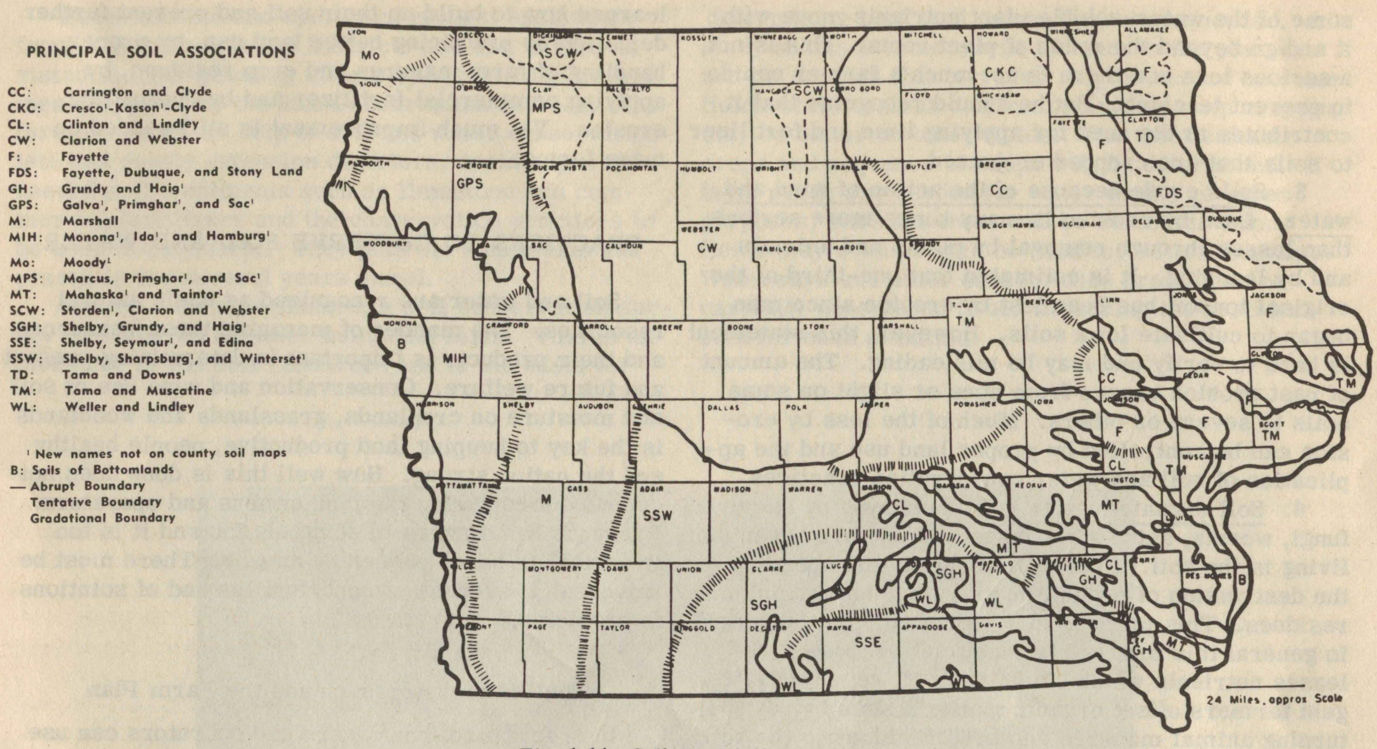

Fig. 1.14. Soil association map.

maps. However, soil studies have shown that certain combinations of soil types form patterns that are repeated from township to township and often from county to county. These combinations of soil types can be shown on maps of small scale. Such combinations are called *soil associations.*

Soil association areas in Iowa are shown in Figure 1.14. There is a total of 21 such areas.

Within each soil association area, soils have a wide range of productivity. This range generally is from the most productive to the least productive. However, some soil association areas have a much larger proportion of productive soils than others. Also, soil association areas vary in size from 650 square miles to more than 10,000 square miles.

Names of the soil association areas have been derived by placing together the names of 2 or 3 soil series which occupy major areas within each soil association. The Clarion-Webster soil association area is an example. Sometimes a single series name is used if that soil is by far the most important. An example is the Fayette soil association area. It should be emphasized again that many other soils besides just those indicated in the soil association name occur in each area.

On the soil association map, Figure 1.14, each area is indicated by symbols which are identified at the left of the map. Boundaries between the different areas are of 3 types: solid lines are used when the boundary is distinct and is well located; broken lines indicate boundaries which are not definitely located; short parallel lines show boundaries which are indistinct and the change in the soils is very gradual for a distance of several miles.

FORCES WHICH DEPLETE SOILS

When the early settlers came to Iowa slightly over 100 years ago, they found hardwood timber growing along the larger streams. The vast areas between the streams were covered with prairie grasses. There was little, if any, unprotected land. Soil stayed where nature had placed it.

Today most of the land in Iowa is farmed and the picture has changed. Man has plowed up most of the grass. The greater part of the timber has been cut down and the unplowed grassland often has been seriously over grazed. Rainfall and runoff water have been cutting away at the earth's surface because the highly protective mantle of grass and woods has been destroyed. Soil waste has been accelerated by poor methods of farming.

How Our Soils Are Depleted

There are four main ways in which soils become depleted:

1. Nutrients are removed by the growing of crops and animals. For many years livestock and grains have been shipped from Iowa farms, taking with them calcium, nitrogen, phosphorus, and other soil mineral elements. Soil tests show that today about 63 per cent of the soils need lime, 72 per cent are low in nitrogen, 66 per cent are low in phosphorus and 36 per cent are low in potassium. Fertilizers are needed to offset these losses and to maintain good crop yields.

2. Nutrients are lost through leaching. Leaching is caused by rain falling on the land and then soaking down through the soil. As the water moves downward

some of the water-soluble plant nutrients move with it and go beyond the reach of plant roots. This is not a serious loss and there is not much a farmer can do to prevent leaching. But he should recognize that it contributes to the need for applying lime and fertilizer to soils that are cropped or grazed.

3. Soils erode because of the action of wind and water. Loss by erosion is many times more serious than losses through removal by plants and animals and by leaching. It is estimated that one-third of the original topsoil has been lost by erosion since man began to cultivate Iowa soils. However, this statement is hard to verify and may be misleading. The amount of past erosion ranges from none or slight on some soils to severe on others. Much of the loss by erosion can be controlled by proper land use and the application of soil and water conservation practices.

4. Soil organic matter is broken down by bacteria, fungi, worms, ants, other insects, and other organisms living in the soil. Plowing and cultivation speed up the destruction of organic matter or plant and animal residues. This process may be called "soil burning." In general this process is beneficial because it releases nutrients which plants use. However, intelligent farmers offset organic matter losses by returning animal manures and crop residues to the soil. Organic matter is important since it helps keep soil in good tilth. Tilth refers to the physical condition of soil in respect to its fitness for the growth of plants. A soil in good tilth works easily, makes a favorable seedbed, can absorb water easily and is more resistant to erosion.

Preventing Depletion

Much progress has been made in the past 20 years in preventing soil depletion. Many farmers have learned how to build up their soil and prevent further depletion by practicing better land use, by proper handling of farm manures and crop residues, by applying commercial fertilizer and by controlling erosion. Yet much improvement is still needed on many farms.

PRACTICES TO CONSERVE SOIL AND WATER

Soil and water are recognized as basic natural resources. The manner of managing these resources and their products is important in determining present and future welfare. Conservation and wise use of soil and moisture on croplands, grasslands and woodlands is the key to keeping land productive, people healthy and the nation strong. How well this is done does not depend entirely upon the land owners and operators. Everyone has a share in doing the job and it is too important to be by passed by anyone. There must be universal awareness of opportunities and of solutions to problems.

The District Approach and the Farm Plan

In order that farm owners and operators can use their farm lands to secure the greatest production and at the same time conserve soil for continuous use, conservation practices must be fitted to the needs of the land. This requires careful planning, often called "Farm Conservation Planning." This is a development of farm plans by farm owners and operators in cooperation with Soil Conservation Districts in Iowa. Soil Conservation Districts are organized under state law to develop and carry out a soil and water conservation program at the local level. Every county in Iowa has an organized Soil Conservation District.

Fig. 1.15. The most serious damage to land occurs through erosion by water or wind.

Farm owners and operators request assistance from Soil Conservation Districts and are in turn assisted in their planning efforts by technically trained men employed by the Soil Conservation Service. The farmers, with the help of soil and water conservationists and county extension directors, decide upon the needed soil treatments such as limestone and commercial fertilizers and the conservation practices to be used in each field. They plan the treatments and practices for several years ahead.

Before a farm is planned, a soil conservation survey is prepared for each individual farm. This is an inventory of the soil resources and is the basis for determining best land use and practices needed. A study of this inventory will indicate to the planners and the farmer that terraces may be needed on some fields while contour cultivation and/or strip cropping may be better on other fields. The most suitable crops and sequence of crops will be determined. If farm ponds are needed for water supply or other purposes, sites for them will be selected. Some fields may even need to be tiled for better drainage. Waterways and other conservation practices are carefully considered to aid in making the best decision for each situation.

Fig. 1.16. Strip cropping is being used in this field. Alternate strips of meadow and grain crops planted on the contour help reduce runoff and erosion.

Fig. 1.17. Dense grass in drainage ways can carry runoff water from cropped fields without erosion damage.

THE WATERSHED APPROACH

A watershed is simply an area of land from which a stream gets its supply of water. It may be as small as a few acres or it may be as large as the area drained by the Mississippi River.

Wherever we live we are within a watershed area. Each farm, country home or city business is within the boundaries of some watershed. It takes many small watersheds to make up larger ones. A watershed is more than a combination of hills, valleys and streams. It is a community of people, animals, plants and soils that receives a common water supply.

Water Can Be A Problem

Water is a friend when it is properly controlled and developed for use. It can be an enemy if it runs off the land too fast causing floods, removing topsoil and cutting gullies. Soil and debris carried by excess runoff clog streams and lakes. This spoils fishing and recreation. Flood waters can do damage to water supplies, power plants, homes, towns and cities, roads, bridges and farm crops.

When water does this kind of damage it cannot be stopped by one or two individuals. It becomes a job for a whole community. It is a job which depends upon many people working together on a watershed basis.

Watershed Programs

Today, watershed programs are in existence and others are developing throughout our country to achieve control of water and conservation of soil. Such programs begin where the raindrop falls. Good land use and the application of soil conservation practices such as contouring, terracing, strip cropping and grass waterways are of first priority in order to hold more of the water where it falls. Water that soaks into the ground can't run off and it is available for growing crops and to replenish underground supplies.

Under today's watershed programs small dams and large dams may be necessary in addition to land practices in order to catch and hold water. Excess water which runs off the land during heavy rains can be held temporarily behind dams to prevent floods. Then it can be released and allowed to drain away slowly without damage. In some areas it may be desirable to hold water in permanent pools or lakes behind dams to provide farm or community water supplies or to create lakes for fishing, boating, swimming and other recreation. Every citizen of the community benefits from such programs.

Watershed development stresses the protection and development of all natural resources in a watershed. The soils are conserved on farm land, floods are minimized, damage to streams and reservoirs is prevented, wildlife is protected, fishing and recreation are enhanced. The entire drainage area is treated according to the capabilities of the land and the desires of the people involved.

Laws have been passed by federal, state and local governments to encourage watershed development. As a result, money and technical assistance are available to help share the cost and work of communities and individuals in carrying out watershed programs.

In most cases, full responsibility for starting watershed projects is in the hands of local people. By working through soil conservation districts people can learn about the benefits of watershed programs and how their problems can be solved in the most efficient manner.

SUMMARY

Soil is a primary source of food, clothing and shelter. Consequently, everyone depends upon the soil and has reason to be concerned about its use and conservation. Today, the soil produces abundant

Fig. 1.18. Watershed development stresses the protection of all natural resources in the watershed — cropland, pasture land, forest land, roads, bridges, wildlife and recreation areas.

Fig. 1.19. A farmstead below Council Bluffs flooded by the Missouri River in 1952. (SCS photo)

crops which amply meet the needs of the American people. It must continue to grow good crops in the years ahead for a population which is increasing rapidly. This it can do if used wisely and managed to maintain fertility and prevent erosion.

Soil is complex and of many kinds. A thorough understanding of soil is necessary to achieve wise use and proper management. This chapter presents information needed for such understanding and appreciation. It describes the origin and development of Iowa soils. It describes how different soils are identified, named and mapped. It discusses soil characteristics and their importance to productivity and management. It discusses forces which deplete soil and practices which can be used to improve productivity and conserve soil and water. The farm plan, soil conservation districts and the watershed approach are discussed to show their role in accomplishing good land use and soil management.

Farmers and others who manage or control soil resources have the major responsibility for their use and care. However, they alone cannot assume all the responsibility. Part must be shared by all of the people if the public wishes to achieve wise use and conservation of land and water. The general public must know enough about soil to appreciate its value, and to recognize when land is being used and managed properly and when it is being mistreated. The wise use and management of soil resources depend both on a well-informed general public and well-informed farmers. Working together it is possible to insure a long-time productive and profitable agriculture and at the same time achieve the goals of both individuals and the general public.

TEACHING ACTIVITIES

There are many activities or projects which can be used to make the study of soils interesting and understandable. They may be accomplished in the out-of-doors or in the classroom. They may be simple or complex depending upon the time available, age level and other considerations. A few activities are listed here as examples. Check the reference list in Chapter 7 for other examples and ideas.

1. Show that soils contain living organisms and minerals. Bring into the classroom a shovelful of topsoil preferably from under a heavy sod or from the woods. Spread the soil on open newspapers. Carefully sort the soil separating out plant life, animal life and minerals. Place the different materials in bottles or other containers. You should find such things as worms, grubs, insects, plant roots, fragments of plant stems and leaves. You will find mineral material such as pebbles or gravel, pieces of rock, coarse sand and fine soil. Sort these materials by size.

2. Show differences in soil texture. Collect several samples of different types of soil. Obtain a sand or sandy soil. It will feel coarse and gritty when wet or dry. It cannot be molded into different shapes even when moist. Get a soil high in clay. Show that it is

Fig. 1.20.

sticky and plastic and can be molded when moist. Get a silty soil. Show that it is soft and smooth like flour. It is not sticky when wet but feels mealy and cannot be molded like clay. Get a soil of loam texture. It has approximately equal parts of sand, silt and clay. Consequently, it has a combination of their characteristics. It is best for growing crops.

3. Show that soils vary in their ability to grow plants. Secure a number of flower pots or cans that will hold at least a quart of soil. For one project use 3 containers filling them as follows: (1) sand, (2) clay, and (3) loam. For a second project use 2 containers filling one with good topsoil and the other with subsoil from the same location. For a third project use 2 containers filling one with a deep, dark-colored topsoil and the other with a shallow, light-colored eroded topsoil. Plant the same kind and number of seeds in each container, water carefully and observe the growth over a period of several weeks. Work out ways to keep records of the observation.

4. Show that plant cover reduces soil erosion. Fill two shallow boxes with soil. Cover one with sod. Leave the other bare but place 2 or 3 small flat stones on the soil surface. Tilt the boxes so water will run off. Then apply water from a sprinkling can to simulate a hard rain. Examine the soil and the water that runs off. Did the sod protect the soil? Are the small stones on pedestals? Was there a difference in the color of the runoff water?

5. Take a field trip. This might be a walk around the school ground or a visit to a nearby field or other area. Here are some examples of what might be done or observed on such a trip. (1) Walk around the school ground after a rain and observe what water does to the soil. (2) Note differences in the color and growth of grass on the school lawn. (3) Dig a small hole in a flower bed or other suitable area and note color and depth of topsoil. Examine the subsoil. (4) Collect samples of soil from a variety of places to illustrate the effect of such things as erosion, slope and kind of vegetation. Save some samples for further study in the classroom. (5) Take a trip to a road cut or other excavation and note different layers of soil. (6) Visit a greenhouse and observe how soils are treated to get high yields. (7) Visit a nearby field or farm. Observe the soil, look for conservation practices and note what the farmer is doing to grow good crops.

6. Invite someone who knows about soil to talk to the class. He might discuss the nature of soil, its use and conservation. This might be a county agent, a soil conservationist, vo-ag teacher or farmer. Arrange for the specialist to take the class on a field trip.

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2. Water

DEPENDENCE ON WATER

Sixteen hundred gallons each day — that was the 1959 per capita consumption of water in the United States. Obviously, each of us does not actually use that much water. The average person drinks only about half a gallon each day and uses another 60 to 180 gallons for various domestic chores such as cooking, washing, bathing and waste disposal. The greatest part of this 1,600 gallons of water goes for irrigating crops or for use in the industries of our nation.

The demand on water supplies in the United States is estimated by the Geological Survey to be in the neighborhood of 63,000 billion gallons a year, or between 170 to 180 billion gallons a day. This annual consumption is equivalent to about 194 million *acre feet* — that is, enough water to cover almost 194 million acres to a depth of one foot. This amounts to about 4 per cent of the total annual precipitation over the United States, or about 13 per cent of the precipitation remaining after losses from evaporation and transpiration by plants are considered.

Growing Crops

The above figures do not include the greatest single use of water in this country and in the world — growing crops with natural rainfall. For example, a conservative estimate of the water used by an average annual Iowa corn crop indicates that it is about 370 times as much as the water used annually by all of the cities and towns in the state.[1] This does not include water used by many major industries which have water-supply systems of their own.

Irrigation

The greatest single use of the water that is removed by man from surface and underground supplies in the United States — as separate from that removed by growing plants from natural water supplies in the soil — is irrigation. For growing crops in areas where natural moisture supplies are inadequate, about 75 billion to 100 billion gallons a day, or 229,000 to 308,000 acre feet, are consumed in this country.[2] Even in humid states such as Iowa, there has been an increase in irrigation to supplement the natural rainfall, particularly during drought years.

Industrial Use

Industries throughout the country are the second largest consumers of water, using about 70 billion gallons of fresh water daily in addition to some use of salt and brackish water for cooling purposes. Some industrial processes require extremely large quantities of water: 18 gallons of water to refine a gallon of oil, 10 gallons of water to refine a gallon of gasoline, 60,000 gallons of water for a ton of wood pulp, 65,000 gallons to produce a ton of steel. A large paper mill will use more water than does a city of 50,000 inhabitants.[3] Communities wishing to attract new industries are realizing that adequate industrial water supply is at the top of the list of assets which is considered before new plants are located.

Domestic Use

Domestic use of water in the homes of the nation has been assigned the highest priority. The Public Health Service estimates that the average water requirement is about 137 gallons daily for each person, with a range of from about 60 gallons a day for each person in communities with 500 or fewer people to about 180 gallons a day in cities with a population of 10,000 or more. This is a small amount of water relative to the total quantity available. In Iowa, for example, the total daily water consumption in municipalities amounts to about 145 million gallons, an amount equivalent to less than one-tenth of an inch of water a year spread evenly over the state.[4] This amount is a very small fraction of the annual average of 31.2 inches of precipitation received.

Annual Water Use in Iowa

The amount of water used for various purposes in Iowa is shown in Figure 2.1. Not included in this 635 billion gallons annual consumption is the quantity of water used by crops in Iowa, an estimated 12,500 billion gallons, or 20 times the total for all other

[1] Data on municipal use from Iowa State Department of Health, 1959, unpublished data.
[2] U. S. Department of Agriculture, 1956, *Water*, The Yearbook of Agriculture, p. 36.
[3] *Ibid.*, p. 37.
[4] Municipal consumption from Iowa State Department of Health, unpublished data.

uses.[5] If distributed uniformly over the state the 635 billion gallons would be equivalent to only .65 inches of water, while crops normally use or transpire 20 to 22 inches each year from land planted to crops, or just over 13 inches if this amount is prorated over the whole area of the state.

At present, and probably for the immediate future, most of the water used by crops comes from natural precipitation in the form of rain and snow. However, as the result of a series of dry years and the development of lightweight irrigation equipment, a marked expansion of irrigation has taken place in the humid states, including Iowa. In 1960, it was estimated that more than 500 irrigation systems were in operation in the state. The largest concentration of irrigators is on the Missouri River bottomlands between Council Bluffs and Sioux City where water is readily obtained from shallow wells on the flood plain. However, many other areas of the state have irrigation systems in operation making use of water from streams and wells.

	Gallons Used Annually (billions)	Per Cent
Industrial use (includes consumptive & non-consumptive use)	525	82.6
Municipal	55	8.7
Agricultural	55	8.7
	635	100.0

Based on: G. M. Browning, 1958, "Water Requirements of Agriculture," *Iowa's Water Resources*, Iowa State University Press, Ames, 1958.

Fig. 2.1. Estimated Annual Use of Water in Iowa.

SOURCES OF OUR WATER SUPPLY

Oceans are the ultimate source of all water. From the oceans, by way of the *hydrologic cycle*, (Fig. 2.2), water reaches the land in the form of rain, snow, sleet or hail. However, we do not obtain most of our water directly from precipitation, but rather from wells and springs — called *ground water*, or from lakes and streams — called *surface water*. Water used by growing plants also is obtained from moisture that soaks into the soil and is absorbed by root systems of plants.

The Hydrologic Cycle

To understand the origin of water which is used at a given place on the earth's surface, it is necessary to understand the broad concept of the hydrologic cycle. For millions of years total water contained in the earth's oceans, ground water supplies, rivers, lakes and the atmosphere has been relatively constant. Although this total quantity of water has changed little throughout eons of geological time, the pattern of distribution over the face of our planet has varied radically from age to age, century to century and year to year. Climates may change over thousands of years as indicated by the ice ages and the increasing aridity of some deserts, and every year some areas suffer from drought while others are plagued by floods. The uncertainties of weather which determine the amount of water brought to a given place such as Iowa during a year is the result of variations in circulation of the atmosphere which is the great mover of water from oceans to the land.

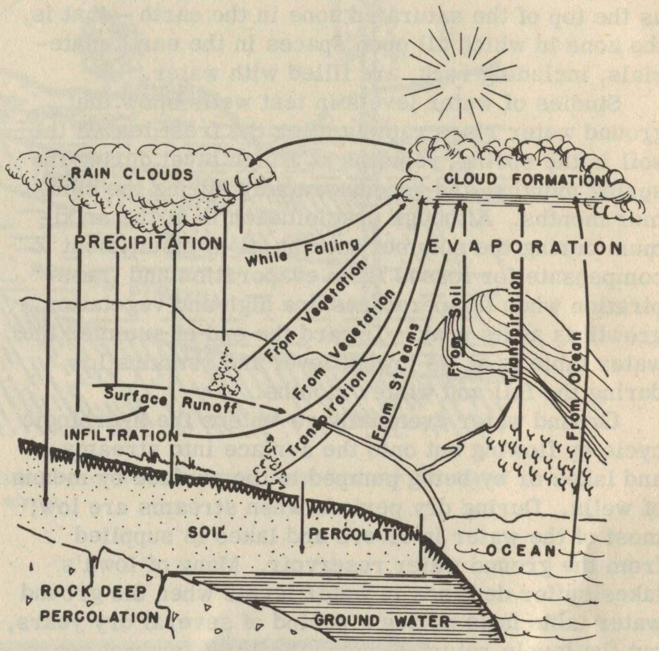

Fig. 2.2. The hydrologic cycle — an unending circulation of the earth's moisture operating in and on the land, the oceans and the atmosphere.

As indicated previously, the greatest reservoir of water for the earth is the ocean. The energy necessary for lifting this great quantity of water from the ocean in the form of water vapor comes from the sun.

The sun's heating is much more effective in tropical latitudes. Most of the moisture falling on Iowa, for example, comes from warm tropical waters in the Gulf of Mexico and the Caribbean Sea. This evaporated water, in the form of water vapor, is carried inland in great masses of tropical maritime air. When cooled, water is released onto the land in the form of rain or snow.

When the rain or snow reaches the surface of the land, several things may happen to it. If the ground is dry, large quantities will soak into the soil and become soil moisture or ground water. If rain falls faster than the ground can soak it up, it runs downhill over the surface and is called *runoff*. Runoff may replenish lakes and streams directly, but it also may create problems of erosion and flood when it occurs in quantities too large for drainage systems to handle.

[5] Browning, George M.: "Water Requirement of Agriculture," *Iowa's Water Resources*, Iowa State University Press, Ames, 1956.

What happens to water that enters the ground is less obvious. Some of it remains in the root zone of plants where it adheres in thin layers to soil particles and becomes available to plants. If soil moisture is taken up by plants it is eventually *transpired* from leaves to the atmosphere as water vapor. Some may return to the atmosphere directly by way of evaporation from the surface of the soil or from lakes and streams. If so much water enters the soil that it cannot be held in the space between the soil particles, it will drain downward under the pull of gravity until it reaches the *water table* where it becomes a part of the ground water supply. The water table is defined as the top of the saturated zone in the earth — that is, the zone in which all open spaces in the earth materials, including rock, are filled with water.

Studies of water levels in test wells show that ground water rises rapidly after the frost leaves the soil in the spring, remains at a high level during the spring months, and recedes rapidly during the summer months. Although precipitation is at the maximum during the summer months, it is insufficient to compensate for losses from evaporation and transpiration when temperatures are high and vegetation growth is at its peak. Toward the end of summer the water table is at its lowest level and remains low during the fall and winter months.

Ground water eventually re-enters the hydrologic cycle by flowing out onto the surface into streams and lakes or by being pumped to the surface by means of wells. During dry periods when streams are low, most of the water in rivers and lakes is supplied from the ground water reservoir. Many of Iowa's lakes suffer declines in water levels when the ground water table falls during a period of several dry years, but the levels return to normal after a few wet years.

Water Supplies

Water supplies for domestic, farm, industrial and urban use are obtained from two principal sources — wells and surface supplies. A few farms and communities depend on springs. Figure 2.3 indicates the relative importance of each of these sources of water in cities and towns of Iowa. Undoubtedly, wells also are the primary source of water for farm use, although no figures are readily available for the whole state.

Source	Number of Municipal Water Systems Supplied	Per Cent of Total Systems	Amount in Millions of Gal. Day	Per Cent of Total Quantity
Wells	556	93	105.9	73
Surface Sources	42	7	38.6	27
Springs	2	--	--	--
Totals	600	100	144.5	100

Iowa State Department of Health, 1959
Unpublished data

Fig. 2.3. Sources of Water for Cities and Towns in Iowa.

Although surface supplies are used by only 7 per cent of the municipal systems, they account for a considerably larger percentage of the total consumption because several of the communities using surface water are large in size.

Ground Water

Ground water is a very important source of supply for most farms and a majority of cities and towns in Iowa. Except for some areas in the southern part of the state, Iowa is well endowed with underground supplies. The amount of water present and the amount that can be obtained from wells depends on a number of things, including the total amount of open space in the rock or other earth material and the size of the individual spaces. A clay or shale may hold large quantities of water in their small pore spaces, but a well into either will yield very little water since the water does not readily flow out of the material. On the other hand, a well into sand, gravel, or coarse sandstone will yield large quantities of water because water flows rapidly to the well replacing that which is pumped out.

Except for a few springs, wells are the major means of access to ground water. Wells generally are classed according to depth and type of water-bearing strata (aquifer) into which they penetrate. The most common type of well for farms, and for many towns and even cities, is the shallow well — less than 100 feet deep. Shallow wells are dug into surface deposits of unconsolidated material such as glacial drift, sand and gravel. The water level in a shallow well is determined by the water table of the area. Some shallow wells dug into sand and gravel, particularly along streams, may yield very large quantities of water.

A well is referred to as "deep" when it exceeds 100 feet. It may be drilled into loose materials as are most shallow wells *(deep unconsolidated aquifers)*, or into rock *(deep consolidated aquifers)*. Many deep wells in sands and gravels penetrate old valleys which were filled by the glaciers. These generally furnish large quantities of water. Deep wells into rock are often of the *artesian* type. This means that the water in the water-bearing strata is under pressure and rises in the well shaft above the level where it enters the well. In many Iowa wells the pressure is great enough to raise the water above the surface of the ground and a *flowing artesian* well results. Figure 2.4 shows how an artesian well works on the principle that "water seeks its own level." In the artesian system the aquifer must be sealed by a water-tight layer such as shale or clay so that pressure can be built up. Also, the area where water enters the aquifer must be higher than the well so that a *head of water* can be built up — just as water pressure is maintained in a city water system by pumping water into a water tower where it is above the level of the water faucets in the town. The water will not rise as high as the intake area because of the loss of some head by friction between the water and the rock through which it flows.

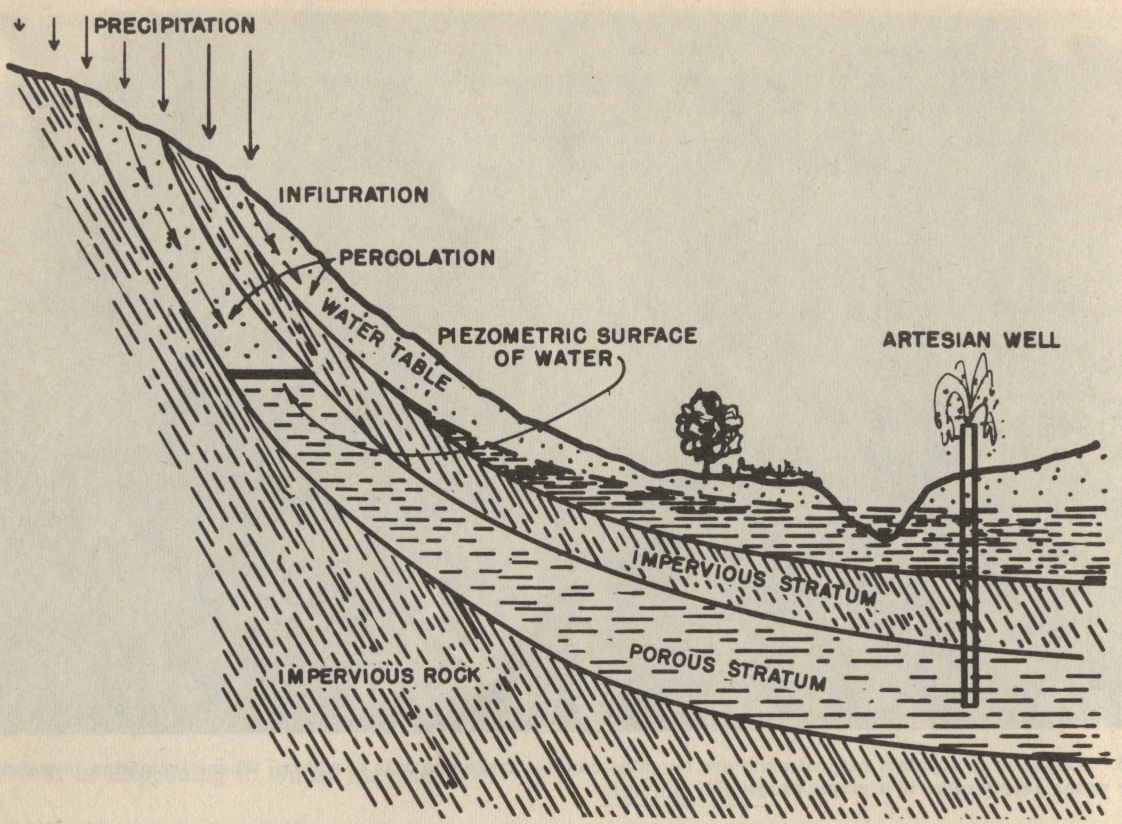

Fig. 2.4. Artesian flow is a result of water being confined below an impervious layer under hydrostatic pressure. The pressure is caused by the weight of water above.

Fig. 2.5. Farmers are using many farm ponds for stock watering, domestic supplies, recreation and even irrigation.

Fig. 2.6. Irrigation to supplant natural moisture supplies can use large amounts of water. Where irrigation is widely used, an adequate water supply often is a major problem.

Surface Water Supplies

Streams, natural lakes and artificial lakes are the sources for surface water supplies. In Iowa a number of cities use water from the larger streams, including the Mississippi and Missouri rivers. Surface water must undergo filtration to remove materials such as silt which are suspended in the water, and purification by chemical treatment to kill bacteria which might endanger health.

Natural lakes are an important source of water in some areas. In a state such as Iowa where natural lakes are few in number, it is a minor source of supply. However, many Iowa communities depend on artificial reservoirs for their water needs, and more and more farmers are turning to farm ponds for stock watering, domestic supplies, recreation, and even irrigation. Southern Iowa has seen a great development of large reservoirs for cities and towns, and ponds for farms, thus reflecting the greater difficulty of obtaining good ground water supplies in that part of the state.

Surface water supplies also are a major source of water for irrigation. In Iowa, many streams are bordered by remnants of old river bottoms called terraces, and by level flood plains. Some of these level areas have sandy soils which suffer from drought almost every year and which can benefit from irrigation where it is economically feasible. Some of the areas of heavy soil also are irrigated where drainage will permit. When a stream is used for this purpose, the needs of the downstream users must be carefully considered so as not to lower the flow at critical times to such a point as to endanger other stream uses.

SEWAGE DISPOSAL

Streams serve the dual purpose of supplying urban water needs and removing waste products from the sewers of the community. Sewage disposal is one of the major uses of streams. The natural action of oxygen in the water plus bacteria which attack organic impurities can render large quantities of sewage harmless. However, this function of a stream is limited by the quantity of water. Many streams become loaded with more organic wastes than they can handle and become *polluted.* Pollution not only endangers health and interferes with the stream's function as a source of water, but will cause death to fish and wildlife and render a stream valueless for recreation.

A major step which will aid a stream in removing waste is *sewage treatment* before it is dumped into streams. This removes solid materials from the sewage and permits bacterial and chemical action to render a large part of the sewage harmless before it enters the stream. Effective treatment may take care of as much as 90 per cent of organic wastes in sewage, and reduces the load on the stream, thus making pollution much less likely. Many Iowa communities have modern, up-to-date sewage treatment plants, but, unfortunately, many still dump raw sewage into our streams, thus reducing their value for the multitude of uses which may be desirable downstream.

Fig. 2.7. Wastewater treatment plants help to prevent stream pollution. These plants remove solid materials from sewage and permit bacterial and chemical action to render most of the sewage harmless before it enters the stream.

WATER SUPPLIES AND CONSERVATION PRACTICES

What Is Happening to Water Supplies?

Questions often asked are: Is our water supply running out? Isn't the water table falling dangerously low all over the country? Do we face national water shortage? These questions cannot be answered simply, but they reflect concern of the public about water supplies as well as indicating misinformation about water problems.

Actually, water supplies probably are as large now as they were in the past, although there are many areas of acute water shortage in the United States. Generally, these shortages are the result of overuse and quality reduction and not because of a general reduction in the quantity of water available.

In the remaining paragraphs of this section the situation for each major source of water will be summarized and some of the possibilities for improvement will be indicated.

Improving Water Supplies

The increasing demands on all sources of water have resulted from a number of factors, chief of which are (1) the rapid growth of population and (2) the increase in per capita consumption at a rate which is twice that of the increase in population. In addition, periodic deficiencies due to fluctuation in rainfall from year to year have emphasized the problem and spotlighted the critical areas.

The farm well that may have been adequate when a bucket or hand pump was used, can prove to be inadequate to meet the demands of the new electric pump which must supply a modern kitchen, plumbing, and an automatic washing machine. When the well goes dry it is often blamed on the lowering of the water table, when, in reality, it is the result of overuse.

Ground Water

Estimates by the Iowa Geological Survey indicate that this state's ground water reservoirs have not declined materially in 50 years, although some critical areas — southern Iowa for example — may suffer shortages during dry periods. Furthermore, indications are that the supply is not likely to diminish in the near future. However, greater demands on ground water in the cities, towns and on the farms may produce shortages by overtaxing the supply.

Shallow ground water supplies are more susceptible to variation from land use practices than deep supplies. Land drainage for agriculture is necessary where the water table is near the surface and interferes with crop root development. Unquestionably, drainage has been beneficial to agriculture and has lowered the water table only a few feet at the most. However, it has resulted in much reduction of wildlife due to destruction of habitat. In some areas the water table has been lowered by gully erosion. Since the gully acts as a drainage ditch, and if it is deep, it can cause drastic declines in the water table in its vicinity. Both drainage and gully erosion may affect water levels in shallow wells but probably have little effect on deep aquifers.

Gully control structures and farm ponds have some beneficial local effect on water tables as well as contributing to the surface supply. Other soil conservation practices such as terracing and contour farming increase the infiltration of water into the soil and aid in maintaining soil moisture and ground water levels.

Other conservation methods specifically designed to replenish ground water are based on the intimate relationship between ground water and surface water.

When streams and lakes are full, ground water is replenished. When streams are at low levels, they are maintained by outflow from the ground water reservoir. Therefore, anything that helps store water above or below ground during high stream flow will benefit ground water resources.

In some areas studies have shown that underground water supplies can be recharged by spreading water over suitable areas and allowing it to sink into the aquifers. Also, some recharge of underground strata has been accomplished by the use of recharge wells through which water is pumped into underground reservoirs. However, these methods must be adapted to local conditions and careful study must precede their use. Another important practice is to make more of our underground water available by improving its quality through treatment designed to remove undesirable chemicals.

More Information Needed

There is a pressing need for an expansion of the program for collecting basic data on ground water supplies. Dr. H. G. Hershey, State Geologist for Iowa, lists the following questions which should be answered by an inventory of ground water resources:[6]

(1) How much water is being used and for what purposes?
(2) What are the quantities and qualities available?
(3) Where can it be obtained?

The first could be answered by a survey of present uses, and by careful record keeping and reporting to a state agency by users such as industries and municipalities. Numbers 2 and 3 could be answered by surveys of underground aquifers, by studies of existing wells and by test drilling.

One of the pressing needs in Iowa is for an expanded test-drilling program to determine potential underground supplies such as buried pre-glacial river channels. Such a test-drilling program has been in operation in northern Missouri and has proven very successful in locating producing aquifers in an area that is generally short on good ground water supplies. Since the geology of this area is quite similar to that of southern Iowa where ground water supplies are limited, a comparable program should prove beneficial. Test drilling might be of value as well in other parts of the state too. From the results of surveys such as those suggested above, we should be in a better position to answer questions about future ground water needs of the state and the potential for meeting them.

Surface Water

Demands on surface water supplies are continually increasing with the growth of urban areas and industries. The ability of a stream to furnish dependable water supplies is limited largely by the low-flow stage of the stream. Plans for use must take minimum flows into consideration. Some uses actually reduce the flow of water in the downstream channel and are called *consumptive uses*. If water is used but returned to the stream and is again available to downstream users it is referred to as a *nonconsumptive* use. A surprisingly large part of water use can be classified as nonconsumptive.

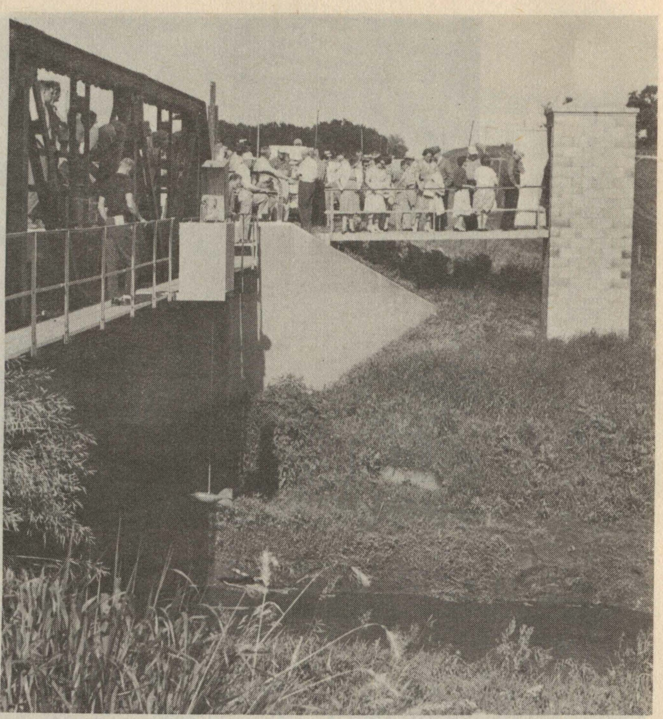

Fig. 2.8. Stream gauges such as this one in Davids Creek, Audubon County, are used to collect basic data on water supplies and runoff.

It has been estimated that over 90 per cent of the water "used" by cities and industries is ultimately discharged to streams and can be used again.[6] Nonconsumptive uses include cooling water for industries and the larger part of the water used by municipalities which is returned to the streams in sewage. However, some nonconsumptive uses may deplete water quality and limit downstream use because of pollution. Also, water used for cooling may become relatively warm and may raise the temperature of a stream into which it is discharged sufficiently to damage wildlife. This is especially true at low flow. Many industries are able to make more efficient use of water for cooling by circulating the water through cooling towers and reusing it.

Methods for increasing surface water supplies are more obvious than those for ground water. Dams may be constructed to store water during periods of high flow for future use. Treatment of sewage will prevent polution of streams with organic materials, and proper land use will reduce the amount of silt which lowers the quality of many rivers. Also, legal control of consumptive uses such as irrigation will

[6] Hershey, H. G.: "Ground Water," *Iowa's Water Resources*. Iowa State University Press, Ames, 1956.

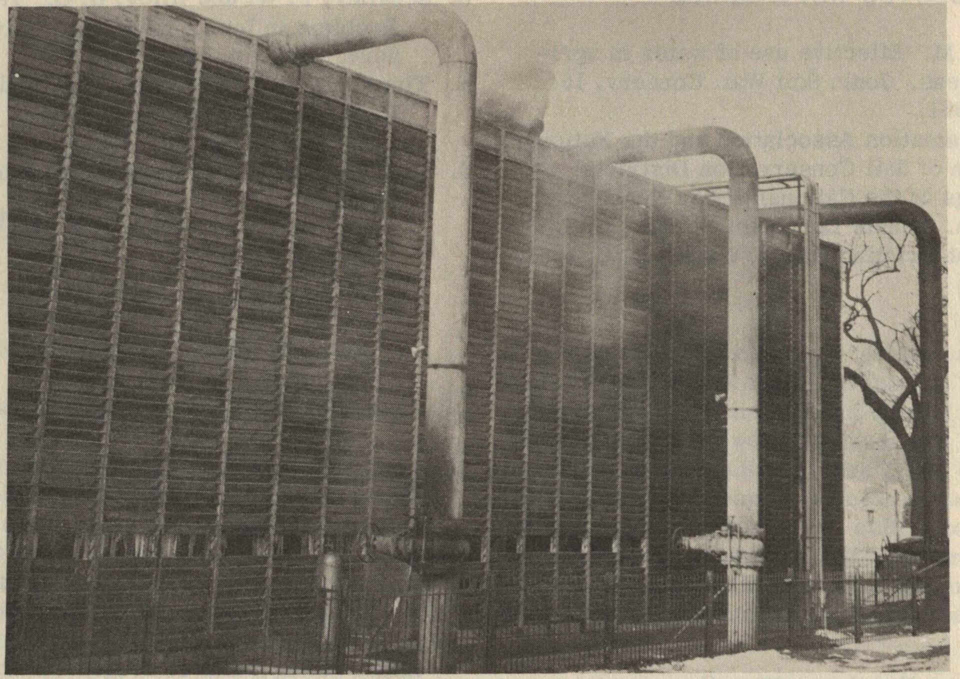

Fig. 2.9. Industry uses large quantities of water for cooling. This cooling tower is used in conjunction with an electric generating plant.

assure maintenance of sufficient levels of flow to protect established uses and fish and wildlife.

SUGGESTED TEACHING ACTIVITIES

1. Visit a town or city water plant. Find out how your community obtains and purifies the water. Does the water come from a well or surface source? If it comes from a well, learn all you can about the well. How deep is it? What kind of rock formation supplies the water? If a reservoir or lake is the source, get a map of the watershed, observe its size. Inquire about the kind of cover on the land — amount of cropland, grassland and forest. Is there an erosion problem that might be causing excess siltation? How much water is used by your community?

2. Visit a sewage disposal plant. Tour the plant with a guide, ask questions. Make a chart to show step by step what happens to the waste water from the time it enters the treatment plant until it is discharged — usually into a stream. Note the important role of bacteria in the treatment process. What use is made of the solids removed from the sewage?

3. Make a model or drawing of a watershed. First learn what a watershed is and write a definition. Visit a small watershed, observe its boundaries, note where runoff water flows through the watershed and where it outlets or leaves the watershed. Note the fields, roads, buildings, gullies, erosion control practices and other features of the watershed.

Now make a drawing of a small watershed showing the main stream or waterway and its tributaries. Draw in roads, farm buildings, ponds, terraces, trees and other features that illustrate what a watershed is and why it is important.

A small model of a watershed can be made using sand, paper maché, plaster of paris or other material that can be molded. Keep it small. Show hills and valleys with a main stream and a few tributaries. Put in one or two farmsteads, some conservation practices and a forest area. Add other things that are suitable and simple to do.

4. Make a bulletin board display to show water as a friend or foe of man. The following are some illustrations that can be used:

(1) Friend: quenches thirst, cleans our clothing, floats boats, provides swimming and fishing, waters our crops, develops electric power, moves wastes, fights fires.

(2) Foe: floods farms and cities, cuts gullies, erodes fields, destroys bridges, washes out roads.

5. Demonstrate that all fresh water originates as precipitation in a pure condition. Collect rain water in a clean container or melt some clean snow. Collect water from a stream or pond. Boil or evaporate small samples of rain water, pond water and tap water and observe the residues. How does the residue vary for each sample? Why? How does pure water from precipitation become impure? Point out the importance of testing drinking water from wells or other sources that might be unsafe.

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3. Plant Life

MAN'S DEPENDENCE UPON PLANTS

Green Plants, the Energy Factories for Life

Green plants are the only organisms able to convert the sun's energy into food which can be used to sustain the life of all other organisms on the earth. If there were no green plants, there would be no other living things, except for a few microscopic bacteria which secure energy from inorganic chemicals. The importance of green plants is not recognized by many people, neither is the degree to which green plants are dependent on the soil for minerals and on the air for carbon dioxide. Loss of the soil through unwise management practices means not only loss of the minerals needed by green plants but also loss of one of the most important sources of carbon dioxide — the soil-inhabiting microorganisms which release this gas as they consume food.

The process by which a green plant converts the sun's energy to food is known as photosynthesis. Although some of the details of the process are not yet completely understood we know that water (H_2O) and carbon dioxide (CO_2) are combined by a living plant in equal quantities in the presence of light and the green pigment chlorophyll to produce the sugar glucose. Oxygen is released as a by-product. We know the process cannot take place if any of these essentials is missing.

Air contains an average of .03 per cent carbon dioxide which is probably inadequate for maximum food production. Plant physiologists have demonstrated that food making is increased if more carbon dioxide is provided while the other factors are held constant. Some scientists think there may have been more of this gas in the earth's atmosphere during the period when the plants were growing which made our coal and oil deposits.

To green plants we are indebted for not only the energy in the deposits of coal, petroleum and natural gas, but also for life itself. Not until an organism evolved which was capable of converting the sun's energy to food was any independent life possible. When this occurred, no one knows, but the fossil record begins about two billion years ago, and the first life must have appeared long before that. Possibly primeval organisms derived their energy from the oxidation of sulfur or some similar element or were able to utilize the energy-containing compounds present in the oceans. Perhaps many different forms evolved before the chlorophyll molecule appeared and cells formed which could use the sun's energy for combining carbon dioxide and water to form sugar. These green cells were the basis for life as we know it today. Descendants of these green cells evolved over millions of years and became the plants of today. Preservation, improvement, cultivation and utilization of these green plants and their products so man and the other animals may have adequate food is one of the major concerns of the world today.

How Plants Are Used

Long before the dawn of history man began to use plants. He ate wild fruits, roots, inner bark, nuts, leaves, buds and flowers. He used wood for heat, light and shelter, for tools, clubs, arrows, spears and bows. He learned to bend and twist, sharpen and shape, cut and carve this useful and plentiful natural product. With the advance of civilization man has continued to adapt wood and other plant products to his needs. These needs, in the past and now, are food, shelter and clothing.

What foods are produced in the Hawkeye state? Corn the most important crop is king on eleven million acres. Most of the golden harvest is used as feed for herds of prime beef and pork. Many bushels find their way into processing plants for conversion into corn starch, corn oil, corn meal, corn flakes, popped corn, candied corn and parched corn. Corn stalks are used for fodder, fiber board, bedding and humus. Corn cobs are converted into the miracle chemical furfural, the starting point of nearly all plastics including nylon and rayon. Alcohol is distilled from corn and from it many useful substances are made, such as synthetic rubber. New uses for products from this important plant are being discovered every year.

The second most important crop in Iowa, and one in which Iowa's production (200,000,000 bushels) usually leads the nation, is oats. This interesting grass plant fits neatly into the rotation program by serving as a nurse crop for legumes which restore nitrogen to the land after one or two crops of corn. The legumes also provide pasture and hay for livestock, and when plowed under, the roots and stems restore some of the humus lost during the years of corn. The oat crop is planted in the spring along with the legume and is ready for harvest before the legume seedlings are adversely affected by its presence. No other crop fits as well into the farmer's plans in the Corn Belt and is as resistant to the parasites that attack corn. The oat crop is used for livestock feed and is processed into a variety of products, most common of which are breakfast foods. Several chemicals are obtained from the hulls among which is furfural, important in the manufacture of nylon and plastics. Furfural also is used as a selective solvent in purifying lubricating oils; it extracts harmful carbon and sulfur compounds. More motor oil is treated with furfural than with any other solvent. The use of furfural for removing the color from crude wood rosin has changed the entire industry. It is interesting to note that the discovery of oat hulls as a source of this valuable chemical was made by accident during experiments being conducted to find a way to make oat hulls digestible for cattle.

The third most important crop plant acreage-wise is soybeans. A relatively new plant in Iowa, the soybean has been grown in the Orient for about five thousand years. The Chinese use the beans for food and make medicine out of them. The first record of the plant in the United States is in 1804 when James Mease wrote that it was adapted to Pennsylvania and recommended it be cultivated. Until chemical processes were discovered for obtaining oil from the beans, however, the plant was used principally as a hay and green manure crop. Acres planted annually increased rapidly from the early 1920's when successful processing began. Today, Iowa produces more than thirty-five million bushels, most of which are processed for oil and high protein livestock feeds. Many industrial uses for products from soybeans have been found. They range from soy flour, adhesives and sizings for paper and cloth, to fertilizers, insect sprays, paints, oleomargarine, shortening, salad oil and packing oil for fish. In addition to the high cash value of the beans, the farmer also realizes profits from the nitrogen left in the soil by the root nodules of the nitrogen-fixing bacteria. Thus, soybeans have come to be Iowa's third most important crop.

Other crops which enable Iowa to maintain a top position in agricultural production in the nation are: forages, wheat, sorghum, barley, bluegrass seed, timothy seed, vegetables (principally sweet corn, potatoes, onions, carrots, tomatoes, melons, cucumbers and cabbage), and popcorn.

With 25 per cent of the grade 1 land in this country, Iowa produces more plants and feeds them to more animals than any other state in the Union.[1] Yet thousands of tons of this precious soil wash into the Missouri and Mississippi rivers every year. Wise land management can reduce such losses to negligible levels so Iowans can continue to produce in abundance.

Since more and more industrial uses are being found for the plant products of Iowa farms, it is reasonable to say Iowa's wealth comes largely from the soil and the plants that will grow therein. To assure a future free from want the soil and plant resources must be managed so they will continue to support a healthy populace, Iowa's greatest resource.

VEGETATION OF IOWA, PAST AND PRESENT

From raw materials ground fine and left by receding glaciers, from the action of interminable winds whipping fine particles into century-long windstorms, from the bottoms and shores of age-old seas have come the soils of Iowa. These soils consist of materials ranging from coarse gravel and sand to particles microscopic in size which were washed and sorted by the action of water until they became stabilized by green plants. These plants grew in great abundance for many centuries and their partially decayed remains became mixed with the mineral substrates on which they grew. The organic matter accumulated and was modified by the inconspicuous but nonetheless important bacteria, fungi and algae until soils renowned as some of the world's richest were formed. About 14,000 years were required for the latest transformations from glacial trash heaps to black prairie soils. Each year the cycle was repeated with variations. Plants, water, wind; plants, snow, wind; plants, ice, wind; until with the aid of trampling and browsing, burrowing and chewing animals these soils became the great central prairies of North America.

The native plants of Iowa comprise three principal groups: The Appalachian forest plants, the prairie plants and loess bluffs plants. To some extent the groups overlap, but the principal associations can be recognized readily. All of the factors responsible for determining which plants grew in which habitats are not known; much research remains to be done.

Appalachian Forest Plants

The broadleaf deciduous forests, best developed in the eastern United States, enter Iowa along the Mississippi. They extend westward to Nebraska but there they are confined to sheltered stream valleys and their bordering slopes. The number of species of trees, shrubs and woodland herbs is much less in Iowa than in the states to the east. Rainfall is one of the most important factors limiting these woodland species. The decrease in Iowa from more than 37 inches in the Mississippi Valley to about 24 inches in the northwestern part of the state approximates one inch for every 25 miles traveled and is reflected in the species of plants found. In the east and central parts elms, ashes, walnuts, soft maples, birches, poplars and willows tend to grow in the lowlands. The moist, lower portions of the bordering slopes support hard maples, basswood and hop hornbeam, while the oaks and hickories occupy the drier upper slopes. As one drives westward across the state he finds the

[1] National Resources Board Report, U.S. G.P.O., 1934. The Board grouped all land in the United States into grades based on productivity. Grade 1 land is described as excellent land for the staple crops climatically adapted to the region in which it lies.

Fig. 3.1. Hepatica, an early spring wildflower found in upland forests.

Fig. 3.2. Dogtooth violet, or fawn lily. Single white drooping flowers rise between two green leaves mottied with brown.

Fig. 3.3. May apple grows in large colonies of umbrella-like plants in rich woods.

Fig. 3.4. Pasque flower, sometimes called crocus. It is the earliest spring wildflower on dry, stony prairie hillsides.

Fig. 3.5. Shooting star, a native of damp prairie sites.

Fig. 3.6. Fringed gentian, a rarity found in undisturbed lowland prairie.

oaks, for example, becoming fewer in number and lower and lower on the slopes — until in western Iowa they are growing mostly in the valleys, and the species requiring more water are limited to the flood plains or are not present.

The forested areas have the usual early spring wild flowers, such as hepatica (Fig. 3.1), bloodroot, Dutchman's breeches, isopyrum, dogtooth violet (Fig. 3.2), wild ginger, true and false Solomon's seal, early meadow rue, columbine, bellwort, violets, toothwort, bluebell, geranium, jack-in-the-pulpit, May apple (Fig. 3.3), and Virginia waterleaf or hydrophyllum. Later in the season, other flowering plants appear, although not in such profusion as in early spring, probably because moisture is limited.

Iowa forests are of fairly recent origin, since most of the areas in which they occur were glaciated. Migration of the forest species probably occurred from the east and south as the glaciers melted. Recent evidence indicates the forests in Iowa may still be increasing in extent.

The Prairie Plants

Iowa uplands, particularly in central and western Iowa, were covered with prairie vegetation when the white man first settled the Midwest. Until the glaciers receded, however, the prairie vegetation apparently was confined to the south and west by the cool climate. After release of the naked drift plains, the prairie plants migrated rapidly into the area and held it against invasion of forest vegetation since that time. Little and big bluestem, prairie dropseed, porcupine grass, switch grass, slough grass and Indian grass are among the principal prairie grasses. Legumes and composites are the principal herbs: Legumes include ground plum, rattlebox, lupines, locoweeds, wild sweetpea, partridge pea, false indigo, red and white prairie clovers, *Psoralea* species including *pomme de prairie,* vetch, tick trefoil, hog peanut and groundnut; Composites include black-eyed susan, sunflowers, compass plant, prairie thistle, blazing star, golden aster, goldenrod, a variety of *Aster* species, pussy's toes, rosinweed, ragweed, wormweed, beggar-ticks, yarrow, white sage and wild lettuce.

The state of Iowa owns three prairie preserves open to the public. They are the Kalsow Prairie in Pocahontas County near Manson, the Hayden Prairie in Howard County near Lime Springs and the Cayler Prairie a few miles west of the Lakeside Laboratory on Lake Okoboji in Dickinson County. Other pieces of prairie may be found along railroads, in abandoned schoolyards, in unused or abandoned cemeteries and along highways. Most of the plants listed above may be found growing on these areas. Many of them are beautiful and give the prairie a characteristic appearance throughout the growing season.

The Loess Bluffs Plants

During retreat of the glaciers, great quantities of dust blew out of the river trenches of the Mississippi and Missouri. This material formed long hills with steep sides and bluffs on the sides facing the wind. These are most noticeable along the Missouri River. On these hills, many plants from the western Great Plains became established and persist to the present. They include yucca, locoweeds, skeleton weeds, cactus and grama grasses. This bluffs flora is well developed in Waubonsie State Park and may be seen elsewhere along the Missouri to north of Sioux City.

DEVELOPMENT OF EARTH'S GREEN MANTLE

How Plants Grow

Plants do not die of old age in the same sense that animals do. This statement is based on the fact that seed plants possess regions in which the cells maintain their ability to divide for an indefinite period; animals do not. These regions of growth are found at the tips of all the branches and roots. In addition, broad-leaved plants possess a growing region between the wood and the bark known as the cambium. In this area, new layers of cells are formed by which stems increase in diameter each year. These layers are also the source of cells which cover a wound such as that left when a branch is removed or the bark broken. The cambium layer also makes possible grafting and budding.

Growing points of trees are enclosed in buds formed each year in the axils of leaves. Each spring certain of these buds are stimulated to produce extensions of the branches on which develop new leaves, flowers and buds for next year. A person trained to recognize the scars left by the bud scales each year is able to determine the age of a given branch precisely. With many evergreens it is possible to determine the age of the tree by counting the whorls of branches from the tip to the base, because a new whorl is started each year at the distance of a year's growth from the last whorl.

Seeds are essentially dormant growing points with a supply of stored food. When a seed starts to grow, the food becomes soluble, and moves into the growing points where it is used for energy for cell division and growth.

Annual plants produce seeds and die each year. But for most of these the cause of death is not old age, but environmental factors or parasites. If kept under suitable conditions of moisture and temperature and free from diseases and insects, they will live several years or perhaps indefinitely.

How Plants Live Together — Plant Communities

Long before man began to live in communities, plants were living in communities over almost the entire surface of the earth. In fact, there is little evidence that plants ever live any other way. A plant community exists when different kinds of plants live together. In addition to flowering plants a community has various nonflowering plants such as fungi, bacteria, mosses and ferns, as well as animals ranging from one-celled forms to the vertebrates.

These plant communities differ in a great many ways. They vary in *general appearance*. For example, an upland prairie is different from a marsh and an oak-hickory forest is not at all like a linden-maple community. They differ also in *the plants* making up the community. Sometimes this difference in species of plants may be very apparent, as between the plants of grassland and of forest communities, mentioned above, and sometimes it may be noted only after very careful study. This difference in species, in the size, number of individuals and their arrangement may be considered to be a difference in the structure of the communities. A third difference is that of *environment* which is the sum total of the habitat factors of the community. Although plant communities are the products of their environment, it is often difficult to determine the specific differences in environment that cause observable differences in the structure and appearance of the communities.

Plants living in even the most dense communities usually have very little direct contact with each other. They affect each other through their utilization of the factors of the habitat. Such habitat factors as temperature and moisture of the air affect all of the plants in the community in about the same manner. Other factors, as degree of light intensity, soil water and soil nutrients, often become limiting in the community for certain plants because use by some of the plants affect and often prevent their use by other plants. Communities differ greatly in the manner in which these exhaustible factors are utilized. In a community made up of plants which have almost identical habitat requirements, as a dense, pure stand of foxtail, there is a high degree of competition for these factors. This is because the plants are utilizing the same factors, at the same levels above and below ground at the same time.

In the greater proportion of all of the plant communities covering the earth, competition is reduced as a result of the utilization of exhaustible resources on a somewhat complementary basis. There may be 200 or more different species of plants, as in the Iowa prairie community, each of which varies to some extent in specific factors being utilized, especially soil nutrients. There may be as many as 8 or more strata of plants in an oak-hickory community which are utilizing exhaustible factors at as many or more levels above ground and at almost as many levels below. The entire habitat is being used. In the oak-hickory community and especially in the prairie, the plants are at the peak of their development and use factors at several different periods of the growing season from early spring to late fall. A community made up of many plant species which differ greatly in factor requirements, size and habit of growth, and season of maximum development, tend to occupy a site more completely and utilize it more fully at a lower competitive level than does a community of only a few, like or similar species.

Fig. 3.7. Much of Iowa was covered with prairie vegetation when the white man arrived. Prairie grasses, legumes and composites were the principal types of vegetation.

Within the prairie community, for example, four or five different species of grasses seem to exert control because they have sufficient size, numbers and duration. These are the dominants. There are also subdominants of all degrees. Most of the subdominants of the prairie lack duration, although several of them have sufficient size and numbers, and at their period of full growth and development, look like dominants. In forest communities the dominants must all be in the top story of the layered community. As in the oak-hickory, forest communities are usually named for the dominants.

Dynamics of Plant Communities

The plant community is not static but dynamic. In time, the original or pioneer community occupying an area is replaced by one community after another. This process is known as plant succession. It occurs everywhere except in a very few locations where the climate of the region will support only the first stage of community development.

The first community which invades and occupies an area is followed by one which can invade and occupy the same area. When a primitive community has reached full development, it can no longer hold the area against invaders of the next community or stage of succession. The reason for this is that succession from one stage to the next results in improved growth conditions and an improved community, in that the degree of utilization and occupancy of the area is gradually increased. In other words, plants can make greater changes in a community, especially in the development of soil, than they can endure under competition with plants which are better adapted to the improved area.

The better adapted plants grow well under the improved conditions of soil depth and structure, soil moisture and nutrient conditions and can therefore, under the same climatic conditions, make food more rapidly than the original plants of the community.

Thus provided with a greater supply of food they make more growth and can, as a result of increased vigor, absorb more water and nutrients than could the original plants. Invasion of the area by each succeeding plant community is governed by the same principles and follows the same processes as described here. Each community takes over the area from what may be considered to be a less efficient community.

Finally the site is occupied by a plant community which, under the climatic conditions of the region, cannot be replaced by another. A comparatively permanent balance within this community and between the community and the physical environment has been reached. This so-called climax community will maintain itself, but minor changes, characteristic of a dynamic biological equilibrium, will continue to occur.

If the first plant community of the series invaded and occupied an area of geologic soil not previously occupied by plants, the succession is said to be primary plant succession. Under these conditions, development of soil from parent material progresses to the degree possible under the climate until a climax vegetation occupies the area.

This is the manner in which our drier upland soils of Iowa have been developed. It is known as the dry series of plant succession, or the *xerosere*. In contrast, poorly drained Webster, Clyde and similar soils have developed from shallow lakes and around the borders of lakes on glacial till in a water series called the *hydrosere*. This sere also occurred, and is still occurring on the flood plains of rivers and creeks in the state. About 84 per cent of the original Iowa soil was developed by the process of plant succession under a climax of prairie vegetation. About 16 per cent of it, in the eastern portion of the state and flood plains and uplands along streams, developed under a forest vegetation climax.

Much of the plant succession which has occurred and is occurring everywhere is secondary plant succession. This is succession on soil which has been occupied previously by plants. It may be initiated by erosion, flooding, and partial or complete clearing, as a result of cutting, burning, plowing or any other disturbance of the succession. The disturbance may occur at any stage of the succession. When it occurs, succession resumes with the stage which naturally occupies the site at that time and proceeds toward the climax. Weedy plants often take over in the stages following disturbance. No bare area or partially bare area will for long remain free of plants. Succession occurs everywhere that plants can grow, and all the time. It starts as soon as erosion or flooding is over or a farmer quits cutting or plowing and continues until a climax vegetation develops or another disturbance occurs. We can depend on its taking place.

Many species of plants occur in the numerous communities which represent the stages of succession of the upland and lowland areas of Iowa. The species in the following lists are some of the native plants which may be said to belong in the developing and developed prairie and forest communities. There are many more. Several of them have sufficient size, numbers and duration to be classified as dominants in their communities. The forest trees and the prairie grasses of any size and permanence are so classified.

However, most of the species are subdominants of different degrees of importance in the life of the community. Many of these attract our attention only at flowering time. Often it is the presence of these less important species that give color, variety and character to the communities. The development of their flowers in different seasons adds to our interest and contributes greatly to the aesthetic value of plant communities.

PRAIRIE PLANTS

SPRING

Porcupine grass
Spiderwort
Wild onion
Yellow-eyed grass
Purple avens
Pasque flower (Fig. 3.4)
Violet wood sorrel
Prairie phlox
Puccoon
Ragwort
Blue-eyed grass

SUMMER AND FALL

Switch-grass
Scribner's panicum
Meadow rue
Lead plant
Wild rose
Partridge pea
Prairie clover
Golden Alexanders
Shooting star (Fig. 3.5)
Gentians (Fig. 3.6)
Butterfly weed
Mountain mint
Horsemint
Ironweed
Hoary vervain
Compass plant
Blazing star
Goldenrod
Wild aster
Coneflower
Sunflowers
Wormwood
Big and little bluestem
Indian grass

Fig. 3.8. A native prairie community in early June.

Fig. 3.9. A basswood-black sugar maple community in central Iowa, in June. Early spring flowers are being replaced by early summer herbs, nettles, Virginia knotweed, sanicle, water leaf and sweet cicely.

Fig. 3.10. An oak-hickory community in June, central Iowa.

FOREST TREES AND SHRUBS

Willows
Poplars
Walnuts
Hickories
Hop hornbeams
Blue beech
River birch
White and red oaks
Elms
Hackberries
Wild crabs
Hawthorn
Dogwoods
Ash
Wahoo

SPRING FLOWERS OF THE WOODLANDS

Dogtooth violet
Trillium (Fig. 3.11)
Buttercup
Early meadow rue
Hepatica
Columbine
May apple
Dutchman's breeches
Violets
Blue phlox (Sweet William)
Virginia waterleaf
Isopyrum
Wild geranium
Ginger
Bluebell

Fig. 3.11. Snow trillium, the earliest and smallest of the trilliums, grows in open woodlands and grassy hillsides.

SUMMER AND FALL WOODLAND FLOWERS

Wood nettle
Black snakeroot
White snakeroot
Sweet cicely
Dogbane
Lopseed
Bedstraws
American bellflower (Fig. 3.12)
Fleabane

Fig. 3.12. American bellflower, lovely blue spire in a moist Iowa woods.

MARSH AND AQUATIC PLANTS

Cattails
Bur-reed
Pond weeds
Arrow-head (Fig. 3.13)
Sedges
Spike rush
Rush
Duckweeds (Fig. 3.13)
Waterlilies (Fig. 3.14)
American lotus

Fig. 3.13. Arrowhead and duckweed in an Iowa marsh.

Fig. 3.14. Water lilies bloom in midsummer in the shallow water of ponds and lakes.

LOESS BLUFFS PLANTS

SPRING

Locoweed
Skeleton weed
Yucca
Porcupine grass
Lead plant
Puccoon

SUMMER AND FALL

Grama grass
Side oats grama
June grass
Lead plant
Dalea
Snow-on-the-mountain
Cactus
Locoweed

IMPACT OF MAN ON VEGETATION

Plants, Soil and Man

Plant life probably originated in the ocean millions of years ago. At an unknown date and in an unknown form plants invaded the land — perhaps four hundred million years ago. Since this event, most of the available soil in the world has become covered with plant growth. The only areas not occupied by plants have been those so cold as to be covered with a permanent layer of ice, or those so dry that nothing could grow on them. There are very few such areas on the earth.

During the many millions of years in which land plants evolved, the various soil types also have gradually developed. The nature of the soil has been affected by the complex interactions between the green plants, the microscopic forms of life in the soil and the climate. Changes very gradual in terms of human existence have taken place as a result of modifications in climate, in the outlines of continents and with the uplifting of mountains. Most of these changes, however, have been so slow that the plant cover and the soil have tended to form balanced relationships lasting many thousands of years.

These balanced relationships between soil and plants are so complex no brief consideration can do them justice. Plants have played, however, an important role in stabilizing soil for their roots hold the particles in place. A detailed study of the roots of a single rye plant revealed some 14,000,000 individual roots with a combined length of 387 miles; furthermore, the roots had a surface area of some 2,500 square feet in addition to 4,300 square feet for the root hairs. All of the roots of the many kinds of plants which cover the earth are in intimate contact with small soil particles. The physical capacities of these roots for keeping the soil in place against the onslaught of rain and wind and in maintaining soil structure cannot be overestimated.

Apparently man or manlike creatures have been on this earth for about 500,000 years. Most of this time they lived more or less in harmony with the established soil-plant equilibrium and had no major effect on the total order of things. But approximately 6,000 years ago man "exploded" and became the dominant biological force on the surface of the earth. We say 6,000 years because this is as far back as we can trace the phenomenon we call civilization. Apparently the major factor setting off this explosion (the beginning of civilizations) was the initiation of agriculture — the cultivation of plants. This started a chain reaction which made possible community living, specialization, and time for a man to sit on a rock and think of better ways of doing things, time to devote to the arts, to the development of a written language and to the invention of tools. The snowballing effects of man's breakthrough are still continuing.

One of these effects has been an upset in the established soil-plant equilibrium. Over much of the earth, man has altered the original plant cover. In some major agricultural areas he has left vast surfaces of the soil free of any plants much of the year. Or, if not this, he has at least destroyed the trees which protected the ground from the drying effects of solar radiation and the pounding of raindrops. Continued overgrazing, decade after decade, in many of the great stock producing areas has reduced the original vegetation to little or nothing. No longer is the soil protected from the elements; no longer is its structure maintained by this growth and decay of the roots of plants; no longer are various physical and chemical characteristics of the soil balanced by stable communities of microorganisms. The consequences, especially the complete loss of much of our best soil, are discussed elsewhere in this book.

Within recent years we have heard much of atom bombs as a threat to civilization. The possible consequences of the use of nuclear energy as a weapon of war are indeed apalling. But other perils have existed for centuries; some of which are perhaps even more dangerous because of their insidious nature. What man has never been able to recognize is that his mighty cities with their gleaming skyscrapers and towers, his beautiful bridges and endless highways, and in fact everything he holds dear in his fumblings for a better life are dependent for their continued existence upon maintenance — beyond the borders of cities and away from the arteries of human activity — of the good soil and the plants that grow thereon.

Feast or Famine

Man seems perpetually perched on the horns of dilemmas. Faced with starvation in parts of the world and with problems of agricultural surpluses in other parts he devises schemes to reduce the surpluses, feed the starving, and support agriculture by purchasing and storing or buying and selling with public funds. With other public funds he supports a program of land reclamation which brings in new lands which will raise additional surpluses for which additional public funds will be needed. With still other public funds he partially restores on land previously drained with public funds the lakes and swamps needed by wild waterfowl for resting places on their flyways. When heavy rainfall occurs and crops are flooded in adjoining fields, he calls the areas disaster areas and uses public funds to reimburse the unfortunate farmers for their losses, in spite of the fact he didn't need their contributions to agricultural surpluses in the first place.

In areas where lakes and sloughs abound, he provides public funds to build drainage ditches and lay tile so crops can be planted, but in areas where no lakes exist, he uses public funds to build them. When periods of drouth occur, he wails because the water table is dropping, the lakes are drying up and the waterfowl are decreasing in number. He then advocates stopping the tiles and damming the ditches so water will accumulate, but before he gets the job done, a wet year makes him change his mind.

He needs power to run factories, farms and homes so with public funds he builds hydroelectric dams and at the same time he realizes some control over floods. On the millions of acres draining into the rivers on which his dams are built, however, he encounters resistance to adoption of soil conserving practices recommended by agencies supported by public funds because the farmers are receiving excellent prices for their crop surpluses from another agency supported by public funds. So the fields erode rapidly, the lakes back of the power dams fill with silt. Then he finds it necessary to use public funds to dredge the artificial lakes to restore the head of water required to operate the power plants. He also finds it necessary to provide incentive payments from public funds to the farmers whose eroded fields have been reduced in productive capacity so they will use fertilizers and soil reclaiming practices to produce more surpluses for purchase by public funds.

In many ways, man is still the savage who eats to excess when hunting is good and starves when it is poor. He is still seeking private gain at the public's expense, still looking for something for nothing. Nevertheless he is progressing slowly. If he can solve the social and economic problems of the world before he overpopulates it and destroys the soil and the plants on it, he has a good chance to feast; otherwise, he'll face famine.

IMPROVEMENT AND MANAGEMENT OF PLANT RESOURCES

The Ecological Basis of Plant Resource Management

Man must base his plans for management of the plant resources of his world on concepts and principles sufficiently broad in scope that all considerations having a bearing on the problem will be included. The plants themselves must be considered on the basis of their heredity, classification, structure and physiology. Such a broad foundation is necessary because, in planning the management of his resources, man is dealing with all native and cultivated plants — including weedy species — which make up every kind of plant community growing in all sorts of environments the world over.

Most of the required information on the foundation subjects listed above and on others, may be acquired from studies in the laboratory and greenhouse. Plants growing in communities out-of-doors, however, are the products of their environment. Management plans for them must be made on the basis of the ways in which they are growing in their environment. The name of the necessarily broad field of knowledge having to do with the relationships existing between plants and their environment is ecology. The concepts and principles of ecology therefore provide a basis for control by man of his plant resources.

In considering the possibility of managing all of our plant resources on an ecological basis, we must not assume more for ecology than is justifiable. Findings of other fields of botany, as suggested above, must be included. Moreover, all advances in plant science must be brought to bear on the problem of managing plant resources as they are affected by and affect their environment. We must also make full use of the results of research in the applied fields of agronomy, horticulture, forestry and range management in which the ecological basis has been used in management studies of specific crops.

In the many activities affecting his welfare man is demonstrating more and more his ability to make adequate plans. However, where natural resources are concerned his record at planning has not been good. He has, more often than not, been an exploiter rather than a builder. He has based his use of material resources on day-to-day expediency rather than on long range planning. As a result, exhaustible natural resources have been and are being used up at a rapid rate. In many localities they are exhausted.

Native Plants Are Adapted to the Environment

As a basis for management of plant resources, man must study plants to determine how they are adapted to their environment. The native plant resources, as man found them, were adapted to their environment. The several plant communities covering the original, undisturbed landscape differed in many ways from one location to another, depending on variations in environment. Remnants of these native communities may be studied to determine how they are adapted to their environments. The capacity of an environment to sustain living communities may be called its biological potential. Although animals as well as plants are members of these communities, it is through the activities of green plants that solar energy is trapped and converted into food. Thus, the living forms depend on green plants for food, and the biological potential becomes less as factors of environment become limiting. Northward from Iowa, solar energy, itself, is reduced and gradually becomes limiting. Westward, across the prairies and plains, soil moisture becomes more and more limiting because of reduced rainfall and an atmosphere which becomes drier and drier. Southward, soil nutrients also generally become limiting.

Variations in the biological potential from place to place are caused by the many differences in environment evident within relatively narrow limits in space. These differences must be studied carefully with the aim of selecting for each area the particular species, varieties, strains and hybrids best suited to the environment of the area and to the economic needs of the people. This applies to all of the plant communities making up the plant resources of an area and not just to the most valuable crop plants.

Use of plants and plant communities to obtain information about what plants will do best in given environments is a very effective method. This is known as the plant-indicator method and is not new. New techniques and applications have brought it up to date. It involves chiefly a simple, quantitative delving into the relationships existing between the plant resources and their below and above ground environment. As new information is obtained, changes can be made in the plants or the controllable elements of the environment to get a better fit of plants with environment.

In making changes in the plants, a method based on the concept of ecological equivalents may be used to good advantage. Plants which respond in about the same manner to given growth conditions may be substituted for each other. This may open up many possibilities for greater control of the composition of our plant resources.

Plant Resources, to Some Extent, May Affect the Environment Favorably

In the dynamic development of natural plant communities, discussed previously, growth conditions in the community improve with time and the community is successively replaced by communities whose plant growth requirements are greater. Man may alternate communities, but generally he keeps the same two or three communities (crops) year after year. In a manner of speaking he has stopped plant succession and, as a result, he is able to remove a higher percentage of the organic matter yield and still keep the plant growth conditions improving. He can do this by careful removal of a portion of the organic matter yield, by incorporating the remaining portion in the soil, by following other cultural practices favorable to plant growth and by adding carefully selected fertilizers in the proper manner and at the rates recommended on the basis of soil tests. Anything less than such treatments results not only in stopping succession, but in gradually reducing the biological potential of his fields.

Farming Practices

Suppose all the people of the United States could come to Iowa and sit at tables for one meal. How many tables would be needed and how long would they be? If each person were allowed two feet of space and there were seats on both sides of the table, each person would need one foot of table length. With 180,000,000 people in the United States we would need about 115 tables, each long enough to reach from the Mississippi to the Missouri River. But each day we would have to add more table room because the U. S. population is increasing. It is expected to increase at the rate of about one and one quarter million persons annually up to 1975. So each day we would need to add another table about two-thirds of a mile in length.

Where would the food come from to feed them? From the land, of course. A few items might come from foreign lands but most would be grown on the 479,000,000 acres of farmable land in the United States. In addition, some of this land would supply other materials not used for food such as cotton, wool and tobacco. This large and continually growing need for food, clothing and other materials has made it necessary to plow native prairies and cut many forests so land could be farmed. One of the biggest achievements in history was the clearing of more than 300,000,000 acres of virgin forest and the plowing of 300,000,000 acres of virgin grassland by American pioneer farmers. Through skillful farming of this land we have been able to obtain in abundance the food and other products we need.

Where Our Food Is Produced

The Corn Belt, our largest food producing area, centers in the middle Mississippi River Valley. On the east it extends into Ohio, on the south it reaches to the Ohio River in Illinois and to the Ozarks in Missouri. Its western boundary is determined by the dry weather of the Great Plains states. Its northern limit is southern Minnesota and Wisconsin. Iowa is near the center of this great agricultural area. The Corn Belt is well named. About three-fourths of the corn harvested for grain in the United States and about 40 per cent of the world's output of corn are grown in the Corn Belt.

In addition to corn there are large acreages of other feed crops — oats, hay, pasture and soybeans. The grains and forage crops are used mainly for producing and fattening livestock. About two-thirds of all the hogs and one-fourth of all the cattle and calves in the United States and between a fourth and a third of the poultry are fed in the Corn Belt. About half of the sheep and lambs "on feed" are fattened in the Corn Belt.

There are about 200,000,000 acres of land in the Corn Belt; about one-third of the total cropland in the U. S. Much of the land is level or gently rolling. The

Fig. 3.15. Why they call it the Corn Belt.

soils tend to be deep and fertile. This combined with favorable climate makes them well adapted to growing feed grain and forage crops. These crops fed to livestock result in meat, poultry, eggs and dairy products.

These same foods in lesser amounts are produced in other parts of the U. S., but many areas are better known for other food products or perhaps for lumber, wood products, cotton, tobacco or wool. For example, most of our wheat is produced in the northern plains states and the winter wheat area centered in Kansas. About 90 per cent of the almonds, lemons, olives, figs, prunes and apricots are grown in California, southwestern Arizona and southern Texas. A large percentage of our oranges, grapefruit and vegetables come from this area and from Florida. Fruits and truck crops also are produced along the Atlantic seaboard, on the shores of the Great Lakes and along the Gulf Coast. States such as Maine, Idaho, Minnesota, Wisconsin and Michigan produce most of our potatoes. The southeastern states from Louisiana east to South Carolina are well known for cotton, peanuts and flue-cured tobacco. The great dairy states are Wisconsin, Minnesota, Michigan, Pennsylvania, New York and the New England states. Washington, Oregon and northern California produce large amounts of vegetables, fruits and grass seeds. The Great Plains states have large areas of range land which produce many cattle and sheep. Most of these are shipped to the Corn Belt for fattening on grain.

Environment and Crop Production

From the foregoing discussion it is evident that different areas of our country are noted for the production of specific crops. This is because man has learned which crop plants are best fitted for the environment of a particular area. In addition he has developed management techniques which enhance the survival and yielding ability of plants. With this knowledge he has been able to replace successfully much of the native vegetation with plants which have greater value. He has established and cultivated plants which have economic advantages, grow well and give high yields under specific soil and climatic conditions. Man is strongly influenced by his environment but he is not entirely subservient to it. Through modern technology he is able to control and direct natural forces in many ways. Great advances in agricultural science have made it possible for farmers to change or modify certain environmental conditions to fit better their needs.

Developments in soil science have led to techniques for improving the physical, chemical and biological properties of soil. Out of these have come a host of soil management practices which include liming, fertilizing, cropping systems, tillage, organic matter maintenance and many others. Man has learned how to drain soils when they are too wet and to irrigate them when they are too dry. He has learned how to conserve soil moisture and to control erosion with practices such as contouring, terracing, strip cropping, grassed waterways, cover crops and others.

Developments in plant science have led to improved methods of planting, growing and harvesting crops. Effective methods have been worked out for the control of weeds, diseases and insects which affect crops. Of great importance has been the development of new or improved varieties and hybrids of all major farm, garden and orchard crops. Varieties and hybrids have been obtained that are better able to withstand conditions of cold and drouth and have resistance to diseases and insect pests. Others have been developed primarily for higher yields, better quality, ease of production or to fit other needs of the grower and consumer.

Soil and climate are not the only factors which determine how farm land is used in any area or region. Economic factors also play a role. Nearness to markets, transportation facilities, public and private investments, patterns of ownership and personal characteristics and skills of farm people are some examples. Crops usually are grown in an area because there is a comparative advantage. It can be physical, economic or perhaps more often a combination of the two.

Although much has been learned about land use, soil management and crop production, there are still many problems to be solved and much yet to be learned. Our land-grant colleges and industries have vigorous research programs designed to provide new knowledge for agriculture. Furthermore, through the Agricultural Extension Service there is a continuing educational program which insures these facts and techniques are given to managers of land resources and the general public. In this way it is possible to achieve an agriculture which will meet our needs for today and the years ahead.

Grasslands

We have been discussing primarily cropland, but pastures and grazing lands are also important. More than a third of the feed for our country's livestock comes from pasture and grazing lands which equal about one-third of our total land area. This includes cropland used only for pasture but does not include some 301,000,000 acres of woodland and forest grazed part of the year.

In general, pastures and grazing lands are not well suited for the production of grain and hay crops. The soils often have low yield potential because of soil type, topographic or climatic conditions. Improvement of pasture and grazing land offers opportunities but also presents many problems. The costs are usually high, and with the general abundance of grazing land available there is little incentive for large scale improvement. As the demand for food increases, more pasture improvement can be expected.

Fig. 3.16. More than a third of the feed for our country's livestock comes from pastures and grazing land. Good pastures also help conserve water and soil.

Iowa Pastures

In Iowa about 3,337,000 acres are classed as permanent pasture. This pasture is mainly on land that is too rough and low yielding to be used as cropland. However, most of it is grazed and is quite productive as pasture, especially when improved by fertilization and seeding.

It is estimated that four acres of an average permanent pasture in Iowa will carry one mature cow for a period of two hundred days. Renovation of such a pasture would increase the carrying capacity about two and one-half times (four acres renovated would carry 2-1/2 mature cows). Renovation is the practice of improving pastures by liming and fertilizing according to soil needs, preparing a seedbed and seeding adapted pasture legumes.

The costs of renovation are high, often as much as thirty to forty dollars per acre. To be profitable, the resulting increased production must be used efficiently by livestock; also, the farmer must decide whether or not this is the best use of his capital.

Nearly 1.6 million acres of woodland are grazed in Iowa. In most cases woodland pasture production is low because of topography and competition from the trees for light, moisture and nutrients. It is generally impractical to try to maintain a good pasture and a productive woodlot together. On land suitable and desirable for pasture, trees and brush should be removed and the pasture improved. On less suitable land or where clearing is impractical, the livestock should be fenced out and a good woodlot developed.

About 2.8 million acres are in cropland pasture in Iowa. Most of this acreage is part of a crop rotation system. For example, the meadow phase in a corn - corn - oats - meadow rotation, may be used for pasture. The cropland pastures are on relatively good land with management designed primarily for grain crops. Consequently yields are much greater than on most permanent pastures.

Forestry Practices

Although Iowa is a prairie state, forests are also important. About 2 million acres of Iowa's land area are classed as forested. Ninety-eight per cent of this area is privately owned and mostly in farm woodlots of less than thirty acres. If Iowa is to use plant life resources, greater attention must be given to protection and management of forests.

Fig. 3.17. About 7 per cent of Iowa's land is classed as forested. Some forest stands, such as this tract on Missouri River bottomland, are very productive. Other tracts need planting and better management to increase productivity.

Forest Protection

The first thing we can do is to take care of the trees. All living things are exposed to enemies and forces which endanger their lives. Trees are no exception. They have many enemies and the greatest enemy is man himself. Millions of acres have been destroyed and are still being destroyed by neglect, misuse and carelessness. Adequate protection is an essential part of the management of a woodland. This is true whether its main value is timber, recreation, wildlife or watershed. Alertness and prompt action must be watchwords in dealing with destructive agents in order to prevent losses. Only when woods are well protected can long-range plans for their use be carried out.

Fire must not be allowed to ruin forested areas. Young trees are killed and large trees are damaged by fire. Fire scars and spoils the value of the finest parts of trees, the large bottom logs. Grazing by domestic animals may severely damage the forest. Wild animals usually are scattered so they normally cause little damage. Man, however, concentrates his cattle and sheep in small areas. They eat the tender shoots of the best young trees and interfere with normal reproduction. Under such treatment, a wooded area soon contains nothing but old scraggly trees of little or no value. Insects and diseases can inflict serious losses in the woodland by killing the trees or damaging them severely. Insects and diseases frequently spoil the quality of lumber even if the trees are not killed. To get the most from his woodlot, one must help the trees fight these natural enemies.

Forest Management

Forest management is a phrase that includes those practices which will give us forests forever. Timber is a crop that can be raised and harvested just like corn, oats and hay. The successful farmer plans where and how much to plant, and when to harvest his grain fields. Timber, too, can be managed according to a plan. Growing trees differs from growing other crops in only two ways. First, it is slower. Second, a tree crop does not have to be cultivated and seldom has to be replanted. Trees will even seed themselves if given a chance. We can, however, help trees to grow. There are three aspects to forest management: (1) Getting information about the woods, (2) Determining the kinds of treatment needed, and (3) Planning the harvest.

Information About the Woods

In order to manage woodlands we must have information about the trees now growing. What is their condition? Where are they located? What kinds are present? How many acres of the various kinds? How many board feet, cubic feet or cords? Such information is obtained by an inventory method known to foresters as a timber cruise.

To cruise a woodland, the forester samples only part of the area according to a plan. This permits a statistical analysis which provides the needed information for the whole woods. Each species of tree is counted and measured to determine the volume of lumber. The trunks of some trees are bored with a special tool so the rings can be counted. From this, the age and the rate of growth of the woodland can be determined.

Kinds of Treatment

The next part of forest management is figuring out the kinds of treatment needed. What practices should be used to grow the greatest amount of good timber? How many trees of what sizes will give the best volume of lumber? These things can be determined from the timber cruise. At this point decisions as to the use of the woodland must be made. Often it is possible to apply treatment while the timber crop is growing. Proper treatment will increase the value of the standing timber and will yield increased cash returns. Most Iowa woodlands need girdling or cutting of the undesirable trees. Many times, low quality but merchantable trees should be removed to make room for others of better quality. One of the treatments that may be needed is tree planting. Sometimes a woodland may be abused so much that nature cannot reseed the trees. Burned areas may need to be planted. In Iowa, many areas which are satisfactory only for growing trees have been cleared for other crops which have not been grown successfully. These areas could grow tree crops again if reforested.

Planning the Harvest

The third part of forest management is planned harvesting. What tree should be cut? In what years? In what manner? What method of cutting will be used? What species of trees will be favored? Planned harvesting permits achievement of the goal of sustained yield or continuous cropping. Crooked, diseased and slower-growing trees should always be the first ones cut. The best trees will then grow at a faster rate. The practice of cutting the poorer trees and leaving healthy, fast-growing ones is called selective cutting. As one plan for gathering the harvest from the woods, it produces a woodland with trees of all ages.

Cutting an entire portion of a woodland at one time is called clear cutting. It is appropriate when most of the trees are mature, for seed from the surrounding trees reforest the clear-cut area. This is even-aged management since it results in a woodland of trees of one age. The forester must decide which method should be followed. Each will produce different results on a given area.

Harvest of the woods also must be planned, just as farmers plan the harvest from their other crops. Corn, for example, is measured into bushels before it is taken to market. Trees, of course, are not counted in bushels; they are measured in board feet. It is simple to record the ripe trees and calculate the board feet of lumber in them. This should be done before cutting and offering the crop for sale. Foresters can help the farmers in these operations.

Timber has one advantage over most other crops. It does not spoil easily. If the price of the product is low, the owner does not have to sell. He may hold the crop for several years until prices rise.

A forest of trees is like a bank account. The owner receives interest on his bank account each year. Trees grow a certain amount each year; this is the interest on the account. This growth, or interest, may be accumulated until the time of harvest.

If properly managed and harvested according to plan, trees plant themselves. This is natural reforestation and maintains the woods bank account. Nature can do this planting much easier and better than man. This is one of the goals of proper management: to maintain an area of woodland in productive condition.

Fig. 3.18. Tree harvest must be planned and properly carried out. Mature trees should be cut and young, healthy trees left unharmed and free to grow.

How to Reach the Goal

Forest management, then, is building up, setting in order, and keeping in order a forest business — a forest business that has been established because of human need. To get into business, a number of measures involving cooperation of private landowners, industries and public forest agencies are necessary:

1. Eliminating cull trees.
2. Increasing growth rate on good trees by making improvement cuttings.
3. Making improvement cuttings (a) to remove merchantable trees that are low in quality or poor risks for the future, and (b) to improve the species composition.
4. Making harvest cuttings when mature crop trees are ready.
5. Keeping livestock out of the farm woods.
6. Obtaining better protection from fire, insects and diseases.
7. Developing new uses and markets for low quality timber.
8. Taking advantage of all aids available to timberland owners.
9. Encouraging more public forests — for aesthetic purposes, for hunting, fishing, picnicking, camping and other forms of recreation.
10. Increasing the means to do a better job in public forests than we now have.
11. Practicing better utilization in the woods and at the mills.
12. Providing more effective channels for reaching the public with the message of woodland conservation and its needs.

Iowa has a greater timber-producing potential than is now being realized. There are large areas available. Conditions are favorable for rapid growth of some of the best species of trees. Unfortunately, existing woodlands are mostly in poor condition. This is because of lack of care, fire and grazing. The farmer is in a key position with regard to timber growing because he owns most of the total wooded area. He has the opportunity through proper management to render forested areas as productive as cropland.

But as a state, we all have a cooperative responsibility to understand and encourage forest conservation and management.

CLASS PROJECTS

Things To Do With the Seed Plants

1. Fruit and Seed Collections.

In the fall it is easy to make seed collections of numerous kinds of weeds. The student should search such places as fields and gardens, roadsides, riverbanks and waste ground. While there are many types of seeds or seedlike units that could be collected, some of the following are especially interesting: quack grass, downy brome, cheat grass, sandbur, crabgrass, stink grass, wild barley, foxtails, buttonweed, hemp, nettle, oxalis, spurges, mustards, pigweed, lambsquarters, smartweeds, four-o'clocks, stickseed, jimpson weed, ground cherry, horse nettle, dogbane, milkweed, sticktights and cockleburs. Seeds or other seedlike units can be mounted easily by placing dabs of plastic cement such as Duco Cement on the mounting material and dusting the seeds lightly over them. They can also be displayed in gelatin capsules and small bottles. (Fall) Similar procedures can be followed with any of the common crop, garden and flowering plants. (Fall, winter, spring)

2. Fruits of Trees and Shrubs.

Ordinarily, people look at shrubs and trees mostly when they are in flower. They have a variety of different types of fruits, however, some of which are distributed by animals, some by the wind and other agencies. Many of these are dry and can be collected and preserved very simply. Some of the fleshy ones might need to be preserved in water with 5 to 10 per cent of formaldehyde added. The student can study the type of dispersal involved in the distribution of each type of fruit. (Fall)

3. Quadrat Study

Stake out a quadrat, that is a square of known size, in a field, a prairie or a roadside. This might be a square meter (3.3 x 3.3 ft.) or a larger plot as desired. Do this early in the spring and follow this particular plot of ground throughout the growing season, making notes as to the time of appearance of the different plants. The student should attempt to identify all of the various plants appearing, not only flowering plants, but also ferns, mosses, liverworts, soil inhabiting algae, fungi and lichens. He could also look for small animals that inhabit the area. He might make notes on overwintering, germination, growth habit and plant type. This is a very good project for demonstrating the complexity and variety of life and the interactions of the different types of organisms. (Spring, fall)

4. A Study of the Vegetation of an Area.

Many a student may be very stimulated by taking a larger area such as a river valley, a woodland, a stretch of prairie, and following the vegetation and the animal life throughout one or several growing seasons. This would be more extensive and less intensive than the quadrat study. Use of quadrats in these different areas is very effective. (Fall, spring)

5. Collections of Trees Throughout the Growing Season.

The student can start by studying the trees of a given locality using keys which will allow him to identify most of the trees from their winter buds and leaf scars. He can make collections of the winter twigs, identifying and labeling them carefully, then collect the same plants in flower in the springtime and later secure specimens from the same trees in full summer leaf and fruit. To finish the collection, samples of the wood can be sanded and finished with several coats of floor seal or shellac. Workbook notes may be made for different seasons. (Fall, winter, spring)

The following references may help in Iowa:

Aikman, John M. Summer and winter keys to trees of the north central states (with workbook appendix). 1962. Iowa State University Book Store, Ames, Iowa.

Muenscher, W. C. Keys to Woody Plants. 1950. Comstock, Ithaca.

Otis, C. H. Michigan Trees. 9th ed. 1950. University of Michigan Press, Ann Arbor.

6. Effects of Different Kinds and Concentrations of Weed Sprays on Crops, Flowers and Weeds.

Secure a wooden flat and fill it with soil. Plant rows of various types of seeds lengthwise in the flat. By means of cardboard or paper shielding, protect all parts of the flat except those which are to be treated. Spray various weed killers in bands across all the different rows of seedlings after they come up. Some of the seedlings will be highly resistant to some weed killers, others will be killed. (Fall, winter, spring)

7. Growing a Crop of Weeds.

Secure a flat wooden box or large flower pot of soil from a garden or a weedy field. Do this in late fall and preferably place out of doors until it is frozen for a period of four to six weeks. Then bring it into the classroom and see what kinds of seedlings will grow from the soil. Attempt to identify the plants as soon as they come to bloom. If a greenhouse is not available, supplemental illumination with fluorescent lights will be needed, especially if south windows are not available. (Fall, winter)

8. Pond Water.

Secure samples of water and some bottom mud from a stream, pond or lake. Place them in classroom aquariums to see what develops over a period of time. Occasionally extensive successions of different types of algae, small crustacea and protozoans will appear. These are usually microscopic forms and will need to be studied with the classroom microscope. (Fall, winter, spring)

9. Forcing Bulbs.

A variety of bulbs is available on the market in the fall. Tulips, hyacinths, squills, grape hyacinths, paper white narcissus, daffodils and others usually are available. If they cannot be secured in local stores, they may be ordered from the seed and nursery catalogs. Many of them will require cold treatment after planting. Specific directions can be obtained from the catalogs or the bulb packages. By holding bulbs in a cool room (40-50° F.) and bringing them into the classroom on successive dates, flowers will be available for a long period. Students will learn much from the various aspects of such a project. The local florist will usually be happy to provide advice and assistance, if requested. (Fall, winter)

10. Forcing Spring Wild Flowers.

In the late fall secure a large piece of sod from a woodland or prairie area where spring wild flowers and ferns are known to occur. Place it in a shallow box and allow to remain out-of-doors in a sheltered location, preferably covered with leaves or straw until about January. Then bring the box in, water it and keep it in a warm place. Wild flowers will grow very rapidly and probably bloom in a month or so, long before they would out-of-doors. Ferns will grow well, also. Discussions can be directed to explaining why these plants are able to bloom so early in the spring, why they probably would not succeed in midsummer in our densely shaded woodlands, what the reserve materials in the resting plants are, and questions about a variety of other physiological processes. Return plants to the area from which obtained. (Fall, winter)

11. Microcosm.

Secure a five-gallon glass carboy. Place several inches of clean sand in the bottom. Do not attempt to use soil, since it ferments and releases hydrogen sulfide. Various aquarium plants can then be planted in the sand, using long sticks through the mouth of the bottle. Floating plants can be added if desired. Fill the bottle about 2/3 with water and allow it to stand for three to five weeks until the plants are well established. A portion of pond water may be added for the various types of small crustacea, etc. which will be found in it. Then introduce a number of small fish, preferably guppies, and some snails. For a five-gallon bottle, a half dozen guppies might be added, being sure that both sexes are represented. Cork the bottle tightly and seal it. It should be set where there is good light all day but probably no direct sunlight. It is essential that there is enough light so the plants grow vigorously. The tank must be protected from low temperatures as well as high temperatures. Under these conditions it is sometimes possible to maintain such a system for several years without breaking the seal. As some of the fish die, they will be replaced by babies. A variety of food cycles and the inter-actions of plants and animals can be demonstrated in this system. It should be understood that this is a difficult project to maintain properly since there is very little leeway for mistakes. The microcosm will not function if there is not a large quantity of air in the bottle to begin with. This is not to be suggested as a practical aquarium, but rather as a demonstration of the various cycles of food production and use, use of oxygen and release of carbon dioxide, use of carbon dioxide in photosynthesis, etc. (Fall, winter, spring)

12. Protection of Soil by Leaves.

Fill a wooden box about one foot square and about four inches deep with fairly heavy soil — not too much sand. Tamp uniformly, place an oak leaf on top of this, pin it down. Remove the four sides of the box and with a sprinkling can, water as in a good cloudburst so that all of the dirt is uniformly covered. Make sure the water reaches the soil uniformly and from a vertical position. This experiment will show how one leaf can cut down erosion. The scalloped indentations of the leaf are even left on the soil immediately below it. (Fall, winter, spring)

13. Effects of Overgrazing.

A flat, 1 foot x 1 foot x 4 inches, can be used to demonstrate overgrazing. Plant two identical flats with oats, wheat, rye or other grasses. After these have grown to a height of 4 to 6 inches, clip one to soil level and the second one to 2 inches. Repeat clipping once a week for a period of three weeks, then wash the soil free from the roots of the plants in both flats and compare the total amount of vegetative material produced. (Fall, winter, spring)

14. Effects on Plants of Different Soils.

Gather soil samples from various types of soil, place in pots or flats and plant each with corn, oats, soybeans, red clover and bromegrass. The samples should include clay, sand and loam soils. The plants should be examined periodically to determine the variations in growth on the different soils. Try to maintain identical moisture, light and temperature conditions, especially after the seedlings have emerged. (Fall and spring)

15. Seeds in Soil.

Gather soil samples from a river bed, the first flood plain, high ground and a pasture. Keep samples separate and sift each to remove all leaves and humus. Place in pots or shallow flats (boxes) and allow seeds present to grow. Examine the vegetation in each soil type and account for the differences. (Fall and spring)

16. Forcing Flowers of Woody Plants.

Stems collected from forsythia, lilac, redbud, apple, peach, pear and plum in winter condition, placed in water, brought slowly to room temperatures and forced into blossom can be used to show emergence of the flowers and leaves from the buds. They demonstrate the way plants grow. (Winter)

17. Rooting of Cuttings.

A shallow box filled with sand sterilized by heating in an oven or by boiling in water for no less than 10 minutes, can be used for rooting various herbaceous and woody stems. After roots form, the stems can be planted in pots or other containers. Students can quickly see which types of plants are adaptable to this treatment. Include willow, geranium, coleus, African violet leaves, yews, juniper, grape and tomato. If desired, one group of cuttings could be treated with a commercial root promoting substance such as Rootone, and compared to an untreated group. Reduce leaf area on cuttings, keep sand moist and cool and provide adequate illumination by placing in a south window or using fluorescent lamps to supplement the daylight. Such lamps need not be turned off at night. (Fall, winter, spring)

18. Seeds, Seedlings and Chemical Treatments.

Plant seeds of corn, oats, soybeans and peas at depths of 1/2, 1, 2 and 4 inches in sand and in soil. Half of the seeds may be placed in one position and half in another, or other variations may be introduced so broader understandings will result. For example: part of the seeds may be soaked in water for 4, 8, 16 and 32 hours before planting, some can be treated at recommended rates with various seed treatment chemicals. Soybeans and clover seeds may be treated with inoculants and the number of nodules counted and compared with those on plants from uninoculated seeds. If facilities are available seeds may be germinated at different temperatures. Be certain to plant at least 25 seeds of each variety or kind in each treatment or variation. (Fall, winter, spring)

19. Inhabitants of Lakes and Streams.

Collect water from lakes and streams some of which are fast-flowing, some stagnant, from stock tanks and rain barrels. Place samples in laboratory jars, keep covered and observe the various types of algae and other organisms that grow in them. Explain the differences. (Fall and spring)

20. Plant Successions.

Observe the succession of plants growing from water line of a lake shore or stream bank to higher ground. Describe the different environments and identify the plants present in each. Compare with similar data from other areas near by and several miles away. Develop explanations for differences and similarities in plant populations and relate to environmental factors. (Fall and spring)

21. Plants in the Spring.

During the spring make weekly field trips to roadsides, prairies, bogs, wooded areas and stream banks. Keep records of the dates when the various wild flowers first appear, bloom and set seed. Keep records, also, of the dates on which the buds first start to swell and the first leaves and flowers appear on trees and shrubs. Record also final dates of flowering, seed-set and seed-ripening. Explain differences between plants of the same and different species. Compare to previous years. (Spring)

22. Tree Bark.

During the winter collect the many types of bark found on trees (without injuring valuable trees), identify and relate to growth habit of tree, environment, cork formation and age of tree. Determine thickness, density, hardness and resistance to water penetration of the cork. (Fall and winter)

23. Frozen Plants and Animals.

During the winter, even though the streams and lakes appear to be devoid of vegetation, samples of ice can be brought into the laboratory and put into small jars. As the water melts observe the various types of plants and animals that develop. Explain presence of the various organisms in terms of survival, life cycles and species distribution. (Winter)

24. Fruits and Vegetables.

Visit a large supermarket and list the various fruits and vegetables being sold fresh and canned. Determine the plant parts being used, for example, the tap root of carrot, the leaves of cabbage, the flowers of broccoli. Are tomatoes fruits or vegetables? What are fruits, botanically? What are seeds and how are they related to fruits? Are baked beans fruits, vegetables or seeds? What are green beans, fruits or vegetables? Why are word definitions important? (Spring, summer and fall)

25. Seed Identification.

Plants can be identified by the use of keys or by comparing unknown plants with known plants. Seeds too can be identified by using keys or by comparison to known seeds.

Select eight kinds of seeds of the legume family, Leguminosae, and prepare a key for their identification. Try to obtain seeds from each of the following groups:

Crops: alfalfa, birdsfoot trefoil, alsike clover, red clover, sweet clover, white clover, cow peas, lespedeza, soybeans, vetch.

Flowers: sweet pea, scarlet runner bean, lupine, kudzu.

Trees: black locust, honey locust, redbud.

Weeds: beggar's ticks, lead plant, hog peanut, partridge pea, prairie clover, prairie mimosa.

Vegetables: garden bean, lima bean, pea, peanut.

26. Seed Testing.

The State of Iowa has laws and regulations which control the movement of agricultural seed from the seller to the farmer. Seed lots cannot be sold in Iowa if they contain any of these eight primary noxious weed seeds: quackgrass, Canada thistle, perennial sow thistle, perennial peppergrass, field bindweed, horsenettle, leafy spurge and Russian knapweed. Sale of seed which has more than $1\frac{1}{2}$ per cent weeds by weight is also prohibited.

Seed analysts evaluate the quality of the seed lots by making tests. These tests include a purity analysis, a noxious weed seed check and a germination test. In the purity analysis the percentages by weight of pure seed, weeds, inert, and other crops are determined.

You may wish to try a purity analysis and germination test. Using a teaspoonful of red clover, alfalfa, or sweet clover, or a cupful of oats or other cereal crops, separate the pure seed, weed seeds, inert matter, and other crop seeds. You may need a pair of tweezers and a hand lens. Count out 100 or 200 seeds from the pure seed portion and plant them on three thicknesses of moist blotters which have been placed in the bottom of a plastic box. Be sure that the lid is securely placed on the box to retain the moisture. Continue the germination test for one or two weeks at room temperature and with ordinary room light, until most of the seeds have sprouted. Count the seedlings which have both a root and a shoot. The seedlings should be vigorous and healthy looking.

27. Seeds and Water.

This is a series of three experiments with seeds and water which may be conducted individually or as a series.

Materials needed: Dried seeds such as peas, beans, squash and brazil nuts; 2 quart jars with screw-on lids; plastic bottle with cork or plastic stopper; a pan; matches; and water, both boiled and fresh.

A. Where does water first enter the seed?

Some seeds have a minute opening called a micropyle through which water enters more readily than through the seed coat. In order to find the micropyle, try this experiment. Boil water, turn heat off, and wait for the water to stop bubbling. Drop in individual seeds and watch the air inside the seed bubble out through the micropyle as the water enters the seed. Be certain that the seed coats are not cracked or the experiment will not work, since the air bubbles will come out along the cracks.

B. The force of germinating seeds.

Fill the plastic bottle with dried peas and then fill the bottle with water. Place the cork or plastic stopper securely in place. In 6 or 8 hours the swelling of the peas will force the cap off the bottle. Notice how large the peas have become, and how they have filled the empty spaces in the bottle.

C. Germinating seeds need oxygen.

This time use the quart jars and either beans or peas. Pre-soak enough seed to fill half a quart and let the seeds sprout before placing them in the jar. Add about an inch of extra water and cap the jar tightly. Take enough dry seed to fill the second jar to the same level as the first jar. After 24 hours insert a lighted kitchen match into the jar with the germinating seed. What happens to the flame? Repeat the same procedure with the check jar, the one with the dry seed. What happens to the flame? Remember that a flame needs oxygen to continue to burn.

28. Seed Dormancy.

Nature has provided a way for seeds to go through the mild weather of October and November without sprouting. Some seeds do sprout during the warm fall days. Other seeds do not sprout because they are dormant. The rigors of winter take a heavy toll of the young plants. However, dormant seeds overwinter as seeds then sprout in the spring when the weather is favorable for sustained growth.

Plant a few apple, peach or plum seeds in moist cotton in each of two jars. Add enough moist cotton to fill the jars. Cap the jars and then place one jar in the refrigerator and the other on an inside window sill. In approximately two months the refrigerated jar will contain seedlings while the jar on the window sill will contain unsprouted seeds. The cold habitat in the refrigerator has broken the dormancy. Keep the cotton moist but not saturated. (Fall)

29. The Germinating Seed.

Materials needed: Corn, beans and peas; blotters; 2 plastic boxes with lids; and water.

A. Germination.

Place 5 seeds each of corn, beans and peas on 3 thicknesses of wet blotters which have been placed in the bottom of a plastic box. Secure the lid of the box to retain the moisture. Provide the seeds with light during the day. The seeds may be germinated at ordinary room temperature. Check the seeds several times a day during the test period. Which part of the new plant appears first? Why is it important that the root comes out of the seed first? As the roots grow what happens to the main portion of the seed of the corn, bean and pea? Which seed is lifted off the blotters and which still rest on the blotters?

B. Light and germination.

Plant the seeds as in A but this time place one plastic box in complete darkness and the other plastic box in a room where light is available. Which seeds have green shoots at the end of a week? Be certain that the seeds in the dark have complete darkness. (Fall, winter, spring)

Things To Do With Fungi

1. Make Spore Prints of Mushrooms.

Collect various kinds of fresh mushrooms in good condition. If they have stems, remove them carefully. On the under side of the cap are thin platelike strips called gills. Place the cap, gill side down, on a piece of paper, cover it with a bowl or pan and leave for several hours. The gills may be different in color in different kinds of mushrooms. This color is usually caused by the spores which are formed on the gills. If the gills appear white, the spores will probably be white, so the best results would be obtained by putting this cap on dark paper. When the cap is removed, a pattern will be visible. It has been formed by the masses of spores that have fallen from the gills. (Spring, summer and fall)

2. Collect Bracket (Shelf) Fungi and Puffballs.

The bracket fungi that occur on dead and living trees can be collected and examined. Notice that the undersides of some are smooth, some have jagged toothlike projections and some have porelike surfaces. Cut across one of the larger woody ones and notice the layers.

Find puffballs in various stages of development. When young they are white, becoming brown often with a definite hole in the top as they age. When dry, squeeze them and watch the cloud of spores "puff" out. (Spring, summer and fall)

3. Collect Larger Discomycetes and Observe "Puffing" (Spore Discharge).

In the spring, often by late February, large (1" - 2" in diameter) cup fungi can be found in the woods. One early one is a brilliant red and others are quite showy. Try to find different kinds and identify them. If the cups are placed in a moist chamber (a covered container lined with moist paper) for several hours, then the cover removed and less humid air allowed into the container, many of the spore-containing structures that line the inner side of the cup will release their spores at the same time. The spores are visible as a group looking like a puff of smoke. (Spring and summer)

4. Collect Rust Fungi.

One common group of parasitic fungi are the rust fungi. They are often showy and obvious. Cedar-apple rust, cedar-hawthorne rust, and grass rust usually are abundant. The "spore horns" of the cedar rusts on cedar are interesting. (Spring for cedar-apple rust galls on cedar, summer for grass rusts)

5. Grow a Slime Mold Plasmodium.

Collect some leaf mold from a woods or some dead wood that is in the "punky" stage. In the laboratory, place in a moist chamber and leave for several days or weeks. If slime molds are present, the plasmodiums (shapeless masses of protoplasm) will move about and will be visible. They are commonly white, yellow or some shade of red. A plasmodium can sometimes be maintained by moving it with a piece of the material on which it is growing to another moist chamber and feeding uncooked flakes of old-fashioned oatmeal. (Any season of the year)

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4. Animal Life

MAN'S DEPENDENCE UPON ANIMAL LIFE

Food Chains

The influence of wild animals upon man often is indirect but still of great importance. Food relationships demonstrate how forms which directly affect man are dependent upon less conspicuous organisms.

Animals are entirely dependent upon plants for food, some eating plants directly (herbivores), some eating herbivores or smaller meat eaters (carnivores), while some utilize both plant and animal food (omnivores). There is usually a chain-like relationship between food-producing organisms and various consumers. The herbivores are the first consumers, converting plants to animal tissue. Predators which eat herbivores make up a secondary food level, and large predators feeding on smaller carnivores form the tertiary food level. A good example of a *food chain* found in a fresh-water lake is shown in Fig. 4.1.

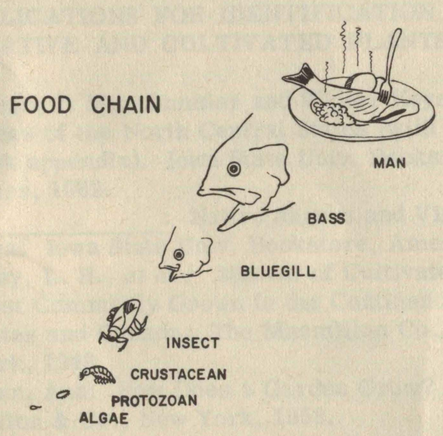

Fig. 4.1. Food chain — bigger forms prey on littler forms.

Few organisms restrict themselves to one food item, however, and several animals may have similar diets involving several food chains. Such a relationship of various animals is termed a *food web*. An example might be taken from a terrestrial (land) community (Fig. 4.2).

At each transfer of food, there is a loss in energy. Therefore, the shorter food chain is more efficient, and each consumer level usually is smaller in energy, biomass (total weight of plants and animals) and numbers of individuals than the previous level. This energy-abundance relationship forms the concept known as the *pyramid of numbers* and may be diagrammed as in Figure 4.3. This scheme of life functions as a relatively balanced system but it often is upset by man.

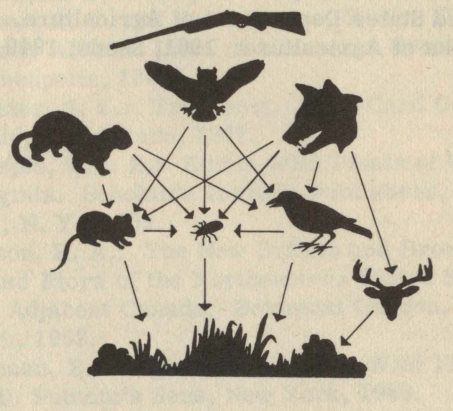

Fig. 4.2. Food web — Nature interweaves food chains.

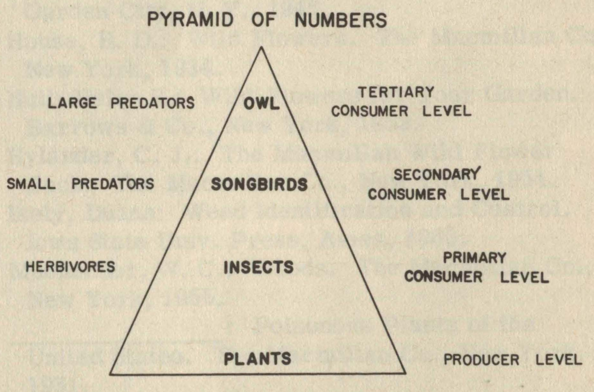

Fig. 4.3. Pyramid of numbers.

Beneficial Effects of Animals in the Soil

The soil as a source of nutrients for both producer and consumer organisms is vital to all life. Soil texture, aeration, and fertility may be influenced by earthworms, ants and other insects which break the soil into fine particles, create pores and mix organic material with the soil. Moles, gophers, and burrowing mice and ground squirrels create sizeable burrow systems serving in water storage and movement.

Human Food and Clothing

In primitive areas, wildlife still plays a major role in providing food and items of trade. The Eskimo is dependent primarily upon caribou, fish and seals; the Oriental relies on carp and netted waterfowl; and the tropical native takes fowl by snare, blowgun, or arrow. Even in America, hunting of the familiar cottontail provides many meals annually. The average American consumes about 12 pounds of fish a year. In some other countries fish is a major source of protein.

Furs and feathers for warmth and fashion represent a multimillion-dollar industry. The quest for furs was especially important in opening the American West to settlers. Trapping is still important to the economy of some sparsely populated areas.

Recreational Values

When seeking game for food, man was forced to match skill and cunning with the wild animals he hunted. Now, the pursuit of game is mainly for sport. Economics and leisure have both made this feasible, and hunting and fishing now serve as a recreation for one out of every five persons in the United States. These recreationists spend over 3 billion dollars annually in pursuit of game.

A still larger number of individuals enjoy watching, photographing or studying animals as a hobby. The recreational and esthetic value of wild animals cannot be assessed financially.

CHANGES IN IOWA ANIMAL LIFE (WHITE MAN BROUGHT CHANGES)

History of Wildlife in Iowa

The first white travelers to Iowa found many small herds of bison (Fig. 4.4), great flocks of prairie chickens on the prairies and large flocks of passenger pigeons in the timber. There were elk and wolves on the prairie, and deer, black bears, panthers, bobcats, cottontails and bobwhite quail along the edges of the woods. Deep in the timber were wild turkeys, ruffed grouse, gray squirrels and a few fox squirrels. The prairie marshes and river sloughs produced large numbers of muskrats and ducks, and in the fall and spring sheltered innumerable geese and ducks during their annual migration. The streams held large numbers of beaver, muskrats and otters. Lakes and streams supported a wide variety of fishes, clams and other aquatic life.

The explorers, like the Indians, killed only enough of this great supply of fish and game for food. The real harvest of wildlife began with the trappers of beaver and otter, and with the hunters hired to supply army forts with buffalo and deer. The earliest settlers who moved into southeastern Iowa about 1820 established farms along streams and at the edges of the timber. Here they hunted deer, turkey and prairie chicken, but took only what they needed for food and clothing.

The admission of Iowa as a state in 1846 marked the beginning of drastic changes in some wildlife populations. Bison and elk already were reduced in numbers; bear, panther, timber wolf, beaver and otter were scarce. Deer and rabbits, however, were responding to habitat changes brought about by primitive agriculture and were increasing in numbers. Turkey, prairie chicken and ducks were still plentiful. During the last half of the 1800's intensive land use and persistent hunting wrought havoc on most game species except the cottontail, and in some areas the bobwhite quail.

Since the mid-1930's, deer and beaver have been re-established to harvestable populations. The pheasant, introduced in 1900 or 1901, has increased until it is now the Number One choice of Iowa sportsmen. The cottontail and the fox squirrel are numerous and, over most of the state, could support even heavier hunting than they presently do. The ruffed grouse also has increased in recent years in northeastern Iowa, but there is no open season on this species. Ducks

Fig. 4.4. Bison once roamed the prairie areas of Iowa. Plains Indians were dependent on them for food.
Photo by St. Joseph Museum.

nest only in limited numbers in the state but good numbers are normally present for the hunting season during the fall migrations.

Habitat Changes Affect Fish and Game

When the white man came to Iowa, about 19 per cent of the land was in forest, about 16 per cent in marsh vegetation, and the rest in prairie grasses. Timber occurred largely along the stream valleys that extended like dozens of fingers out into the prairies. Harvest of timber over the years has reduced the acreage to 7 per cent (2.5 million acres) of the total land area of the state.

Reduction of Timberland

The reduction in quality of timber has been even more important to wildlife than the reduction in acreage. The ruffed grouse, the turkey and the gray squirrel are creatures of the truly "wild" and mature timber, away from farmsteads, logging operations and other interference by man. When the larger trees were cut and the wooded lands were grazed by cattle, many wild creatures were eliminated. Habitat no longer suited to the gray squirrel was taken over by the fox squirrel. Deer benefited by the increased amount of browse resulting from timber cutting, as new growth of stump sprouts and seedlings provided increased amounts of browse that the deer could reach and eat.

Plowing of the Prairies

Although the slaughter of bison, elk and prairie chicken was tremendous, these creatures were doomed in the end by the plowing of the prairie (Fig. 4.5) and the building of roads and fences. The prairie chicken needed large areas of permanent tall grass for its nesting and yearly shifts in range, and so it decreased in numbers as the tall prairie grasses disappeared. Even though protected in Iowa from hunting since 1917, prairie chickens have become fewer and fewer until in 1959 they apparently were all gone from the state.

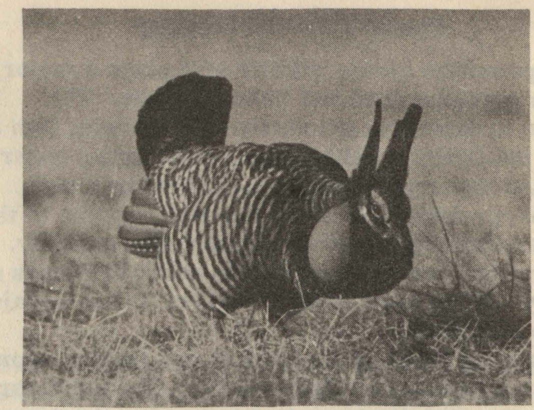

Fig. 4.5. Land use change from native prairie to cultivated crops spelled doom to the prairie chicken which required permanent grassland. *Photo by Wilford L. Miller.*

Drainage

Drainage of Iowa prairie marshes and potholes over the years has eliminated at least 96 per cent of the habitat for muskrats, mink and waterfowl (Figs. 4.6 and 4.7). By 1938 only about 50,000 acres of such habitat remained. Since then extensive additional drainage has occurred. With this loss went most of Iowa's important waterfowl-nesting habitat. Northern pike and other fish which spawn on marshes also have decreased in numbers. Recent trends toward building artificial lakes, restoration of some drained marshes and construction of roughly 50,000 farm ponds have benefited migratory waterfowl to some slight extent.

Stream Flooding and Pollution

While Iowa streams have always been subject to periodic flooding and to heavy silt loads, the breaking of prairie sod, grazing, and cutting of timber have

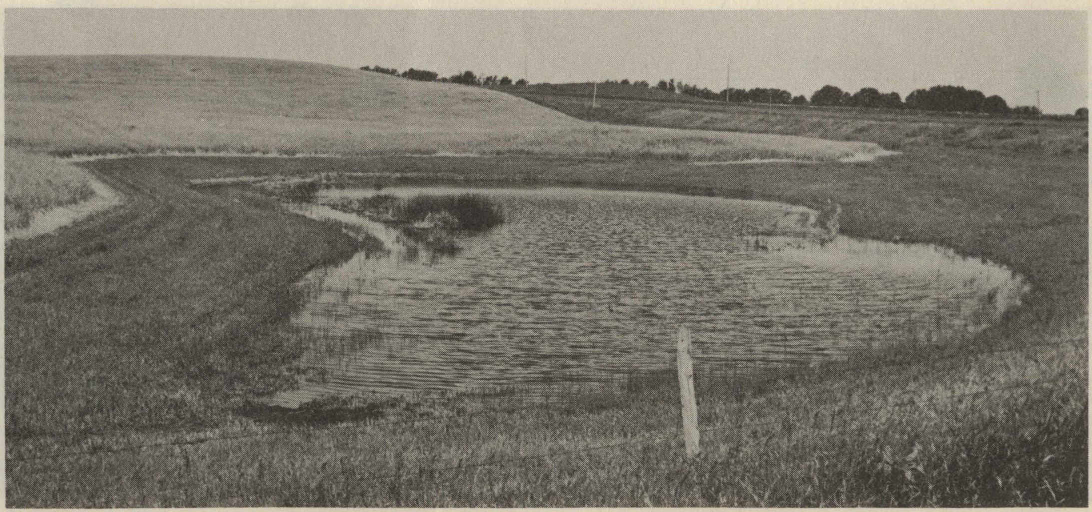

Fig. 4.6. Innumerable potholes such as this once dotted the prairies of Iowa. *Fish and Wildlife Service photo.*

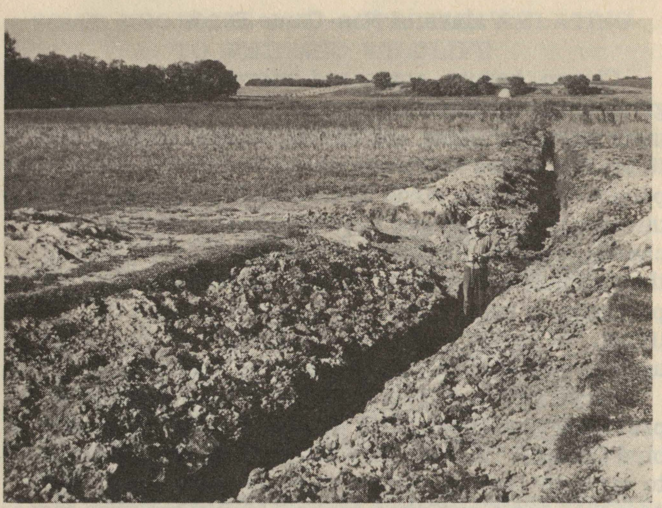

Fig. 4.7. Drainage of potholes has seriously depleted habitat for waterfowl in Iowa. Areas such as this once provided important duck-nesting habitat. *Fish and Wildlife Service photo.*

resulted in greater water level fluctuation, greater silting of holes in streams where fish seek cover, and other deterioration of stream and lake habitat. Soil conservation practices such as contouring, terracing and grassed waterways favor quail, pheasant and rabbits by providing nesting cover and travel lanes as well as reducing the silting of streams, lakes and marshes. Conservation programs also have resulted in planting of unused areas to shrubs, trees and other vegetation useful for wildlife.

Pollution has been and still continues to be a major problem to aquatic life. Chemical wastes, sewage, and silting are involved. Up to now, laws apparently have been inadequate to fully censure and curb violators. Removal of water for cooling in factories, for irrigation and countless other uses seriously endangers aquatic life in periods of normally low water flow.

Agricultural Chemicals and Wildlife

A host of new chemical herbicides and insecticides has appeared in recent years. These chemicals are in universal use and can do a thorough job when properly applied. Unfortunately, they may kill many desirable forms of plant and animal life when carelessly or improperly used.

Weed killers such as 2,4-D and closely related chemicals are not in themselves poisonous to wildlife, including fish. A few herbicides such as Dalapon and sodium arsenite will kill birds and small animals, if sprayed directly on them, but these chemicals are used for spot treatments rather than for entire fields or contiguous areas. The greatest hazard for wildlife in the use of weed killers comes about in the reduction of food and cover plants. Much cover in fence lines and along country roads, especially, has been lost as a result of use of herbicides.

In any program for control of insect or plant pests it is necessary that the danger to wildlife be considered. The proper chemical to do the job must be chosen and its application kept at a minimum level and under conditions of the least possible damage to our fish and wildlife.

MANAGING, USING AND PROTECTING ANIMAL LIFE

Wildlife Management

The wildlife manager has the job of increasing production of wildlife, often on lands devoted to producing other products required by people for everyday life. He attempts to maintain populations of fish, birds and animals for better fishing, hunting, and other outdoor recreation. Research and experience have taught him that one of the best ways to produce more wildlife is to provide and/or improve habitats that contain the right food and cover combinations. He knows that each species of fish, bird and mammal has its own habitat needs, and that plants producing choice food for one kind of wild animal may be most useful for cover to another. He recognizes that even in the best of habitat, wildlife populations change from year to year. The wildlife manager has at his command several "tools of his trade" that he must use to produce required results.

For proper management the wildlife biologist must also know the "life history" of each kind of bird, fish or mammal he wishes to manage. He must know their requirements for reproduction, the rate of survival of the young, their enemies, and the effects of diseases and parasites. Such basic information about birds, fish and mammals is supplied by research biologists who constantly seek new facts.

In nature, several kinds of wildlife live in the same place and, although they may use slightly different foods or nesting places, competition for space occurs, especially when exotic species are introduced. At times the manager is called upon to reduce numbers of less desirable species for the benefit of a desired form. For example, carp, an exotic species, compete with more desirable fishes by changing the habitat, by roiling the water, and by upsetting the normal "food chains" needed by bass, bluegills, pike and other game or pan fish (sunfishes, croppies, yellow and white bass and bullheads). Since more people want to catch bass or pike rather than carp, it becomes necessary to remove carp artificially to make more living space for bass and pike. In some cases, undesirable fish are removed by poisoning, or by draining farm ponds or artificial lakes to allow a fresh start. In lakes, ponds and rivers, hatchery-reared fish may be used for restocking.

Orderly Harvest of the Crop

Where conditions are favorable, game and fish species produce an annual increase or harvestable surplus. On the basis of observations of field conditions and populations surveys, the manager makes recommendations for seasons and bag limits. These recommendations are conveyed to conservation administrators who then consider facts from all sources in establishing seasons and bag limits that will permit orderly harvest of the surplus crop of fish and game. Where regulations are based on research fact, overhunting and/or overfishing are practically impossible.

Law enforcement officers are needed. They are insurance for an orderly harvest of game and fish and a fair share of enjoyment in the harvest by every sportsman. Conservation officers are needed to discourage poaching, to enforce bag limits and to carry on various other conservation and educational activities in the field. Their duties are designed to help provide the most recreational hunting and fishing to the greatest number of people. Their job also includes enforcement of regulations protecting songbirds.

Administrators, biologists, managers, conservation officers and farmers must work as a well-coordinated team to carry out effectively a sound conservation program. If their job is to be effective, they must also have the understanding and wholehearted cooperation of the public.

Conservation employees know their work is basically a public service and for this reason they must "sell" their program to the public through a coordinated and continuous educational program (Fig. 4.8). It takes such an educational program to make the public realize that research and management based on facts provide a sound approach to maintaining wildlife populations of desirable numbers and species. The proper understanding between the *public and the conservation professionals* makes it possible to improve hunting and fishing and other outdoor recreational possibilities.

Fig. 4.8. Proper understanding between the public and conservation professionals helps improve hunting, fishing and other outdoor recreation.

Values of Non-Game Birds

Charm, beauty, songs and interesting habits have given birds an universal appeal. Through the years their presence about our homes, farms, forests and fields has added much enjoyment to life for observant people. Watching birds as they make their way through the garden and field crops, flit through orchards, explore ornamental shrubbery, and trees of the woodlot, and search for food provides a real opportunity to relax from the stresses of modern living. In recent years bird watching has even been used in psychiatric therapy in some hospitals.

Birds can be attracted to homes and gardens by providing shrubbery, food plants, nesting boxes and/or bird feeders. A farm may be made more attractive to birds by leaving some shrubs in fence rows, odd corners, and along ditch banks. Multiflora rose fences provide good nesting sites, a place of refuge, and emergency food for many species. Information on how to attract birds can be secured from the Superintendent of Documents, Washington 25, D. C.

Most biologists of today question that birds exert any significant control over insect populations but it is well known that many destructive as well as some useful insects are included in the diet of birds. There is no need to seek economic justification for preserving any species; their continued presence is part of nature's scheme of things. Because of man's controlling position, it is our responsibility to help preserve all species in our universe. Thus far, our record in this matter has been unenviable. To mention a few, we have lost the passenger pigeon, the Carolina paraquet and the ivory-billed woodpecker. At present a number of species teeter on the verge of extinction. They include the whooping crane, Everglade kite and the California condor. Others like the bald eagle and the prairie chicken are declining rapidly. To our credit is the fact that we have been successful in preserving the trumpeter swan. We can preserve other species too, if we have the interest and willingness to work toward that end.

Both the economic and esthetic usefulness of wild birds was recognized in migratory bird treaty acts with Canada in 1918 and with Mexico in 1936. These acts provide for continent-wide protection and orderly harvest of migratory game birds and complete protection for migratory insectivorous birds, and certain other migratory non-game birds. No federal protection is accorded crows, hawks, owls, eagles, ravens, magpies and cormorants. Birds of prey, although generally well deserving of federal protection, were not mentioned in the migratory bird acts. The bald eagle, our national symbol, was given total protection in the U. S. by congressional action in 1940. Most states give some degree of protection to hawks and owls and a few others recently have enacted laws offering complete protection for these unique species. Consult your local conservation office for information on this subject in Iowa.

SOME PROJECTS AND ACTIVITIES RELATING TO FISH AND WILDLIFE

For Fall

Wildlife Habitat Studies

1. Locate and make a model of the home of an underground animal, such as a mole, or a ground squirrel.
2. Locate, examine and identify some birds' nests; construct one from natural materials.
3. Model the home of a beaver or muskrat.
4. Start a terrarium for desert life.
5. Study and map plants and animals in your locality.
6. Study changes in local animals during seasons. For example, weasels change color in winter.
7. Observe and record influence of weather conditions on various animals: for example, burrowers (fosserial), surface dwellers (terrestrial), tree dwellers (arboreal) and fliers.
8. Catch a pair of ground squirrels in fall of the year and keep them in captivity. Study how they react to a cold school room over the weekend (hibernation). Be sure they have ample covering so they will not freeze. Observe their food habits — besides eating corn, they are persistent eaters of adult and larval insects.
9. Observe squirrels while hunting or hiking through the woods. Nests: Are they used to store food in or to live in? Have you seen corn cobs in a tree? Find out why the squirrel put them there. Make note of any other observation about squirrels and their habitat.

Feeding Stations for Birds

1. Build a feeding station that will attract many kinds of birds.
2. Observe feeding habits of a specific bird. Is there any relationship of the type of beak they have to the type of food taken?

Bird Migration

1. Keep a record of the birds migrating through your area during fall.
2. Record the dates when birds depart from your area. In what part of the country do they nest? Where do they winter?
3. Learn to identify birds by their calls.
4. Bird banding — Information on leg bands of birds is needed to help in studies on migration and the length of life of wild birds. All information on leg bands or color markings should be sent to the U. S. Fish and Wildlife Service, Bird Banding Office, Patuxent Research Refuge, Laurel, Maryland.

Gun Safety

1. Arrange an assembly and have your local conservation officer discuss and demonstrate gun safety.
2. Secure the cooperation of a local organization such as Rod and Gun Club, Izaak Walton, or Sportsmen's Club in arranging for supervised target practice, etc.

For Winter

Bird Studies

1. Birds around school and at home. Construct a bird feeder and supply it with the type of feed used by the species of bird you wish to attract. Keep a record of the kind and number of birds you see. Compare your record with others (in a valley, on a hill, in town near a park, etc.). It may also be interesting to record what time they feed during the day, and during which part of the winter certain kinds may occur.
2. Birds in woods, fields, along roadsides and streams. Take a winter bird hike to study the numbers and kinds of birds present. Observe the kinds of seeds and other items they feed on. Take several trips to different kinds of places and during different kinds of weather to observe the effect of weather and habitat. Assist in the Annual Audubon Christmas Bird Count, an excellent group activity for high school students and adults. For information contact the National Audubon Society, 1130 Fifth Avenue, New York 28, New York.
3. Reports and library projects. After a list has been compiled (by both direct observations and reference books), assemble a report on what kinds of resident birds are present in your community in winter (insect or seed eaters, flesh eaters) and make a notebook (including charts) on their life habits to stress their conservation values.

Mammal Projects

1. Projects related to commercial fur trapping. A conservation officer or a high school boy can explain fur trapping. The class (or other group) can prepare a project report on topics such as the following — with emphasis on the conservation viewpoint: (a) the kinds and values of fur; (b) the importance of local and nationwide fur bearers in American history; (c) the fur itself — what makes the color pattern, the different kinds of hair in a pelt as observed under the microscope, why it is "prime" in winter, and poor in summer; (d) compare the fur of water and land mammals; (e) life habits of fur bearers and their relationship to other living things.

   Elementary grades will be interested in stories of how the Indians used furs and how they trapped fur-bearing mammals.

   Junior and senior high school students may be interested in the history and economic significance of the Hudson's Bay Company and the American Fur Company of John Jacob Astor, of local significance along the Mississippi and the Missouri River valleys.
2. Observe tracks and trails. A number of books have mammal tracks and trails illustrated; e.g., Murie's *A Field Guide to Animal Tracks*, Seton's

Lives of Game Animals, and Hillcourt's *Field Book of Nature Activities*. With these for reference, a good outdoor project would be to identify mammals from their trails and to study their activities from their tracks.

3. Observe squirrel nests. Note their construction materials and how they are used. They are easy to see during winter when the leaves are gone.

Fish and Other Aquatic Life Studies

1. Take a field trip to a local spring, stream, pond or lake. Observe both the plant life and animal life (fish, aquatic worms, insect larvae, snails, etc.).

2. Establish an aquarium, stocking it with plant and animal life from a local stream. This provides an opportunity to observe in the school room the immature stages of many types of insects (mayflies, dragonflies, etc.). This experiment should promote discussion on food requirements and relations, water conditions and the web of life. Discuss the effect of oxygen supply, food supply, and numbers of fish; food chains; microcosm (balanced aquarium on small scale for minute plants and animals).

For Spring

Nature Awakens

1. Conduct nature hikes, keeping a dated cumulative record of species and numbers seen, details of habitat and behavior, etc. For helpful suggestions refer to "Bird Study for School," a mimeographed paper by State Conservation Commission, East 7th and Court, Des Moines 8, Iowa.

2. Take a natural history census of an area. Show the locations of trees and other types of wildlife cover on a map. Information on birds should be shown in a table, presenting habitat where seen, dates, numbers and other details. Organize a bird migration calendar of your own design. See Turtox Service Leaflets Nos. 19 and 29.

3. Encourage hobbies such as photography of wildlife and recording of bird songs.

4. Prepare a collection of mounted insects, tree leaves and twigs. For details of insect collecting see Turtox Service Leaflets Nos. 10 and 23, for herbarium collection #24. *Methods and Materials for Teaching Biological Science* by Miller and Blaydes also has valuable material on this.

Riker mounts are ideal for permanent study and display collections and may be made according to Miller and Blaydes (p. 249) or as described in "Inexpensive Teaching Materials and Project Ideas" by Robert A. Hodge, "The American Biology Teacher," November 1958. Here two glass plates are glued to a frame of balsa wood and have the added advantage that they allow viewing from all angles which is not true of most Riker mounts. A bit of glue is used to fasten the specimen securely within the mount.

5. Label trees and shrubs of school grounds, town, etc. with common name, scientific name, commercial value and values for wildlife.

6. Collect eggs of frogs and toads from a pond, and place and hatch them in pond water in an aquarium. Record the stages of development, length of time involved, etc.

7. Construct nest boxes for birds; observe construction of a nest by a wild bird; study the habits of a species while nesting, and the food fed to young, etc. Be careful not to disturb the birds.

Nuisance Animals and Plants

1. Make a survey of nuisance animals and plants in your community, secure information about their control and (through local paper, PTA, etc.) make this knowledge available to interested persons. Study effects of pest control programs on birds, etc.

2. Study safety precautions and first aid for snake poisoning, poison ivy, etc.

For Summer

Insect Collection

1. Make a collection of useful, and/or harmful insects.

2. Select specimens from one or more orders, and mount and label them. One method of mounting for display consists of cutting frames from heavy cardboard. These may be made of any desired size. Thickness is obtained by laying two or more frames on top of each other. Sheet cellophane is glued over one side of the frame. The insect is placed inside the frame and stuck fast to the cellophane with glue or cement (cellophane cement can be purchased) and the other side of the frame closed with another sheet of cellophane. When mounted in this manner the specimen may be viewed from either side. Very small forms may be placed in thin frames and examined under the microscope. The materials are inexpensive and the mounts will last a long time.

3. Collect the stages of an insect from egg to adult so metamorphosis may be studied.

Recreational Aspects of Conservation

Many of the following activities might well be under the auspices of service clubs, summer recreation programs and the community in general. Courtesy, responsibility and safety should be major objectives.

1. Promote swimming safety. Help promote the Red Cross lifesaving program by calling attention to the need for expansion of opportunities for local children to receive swimming and water safety instruction. Promote the "buddy" system for swimming and boating whereby no one ever swims or boats alone. These and other safety hints may be encouraged through posters, eye catching articles or ads in local papers, etc.

2. Fishing. Solicit the help of sportsmen's

groups in teaching casting and other fishing techniques. Include information on outdoors manners. Teach people to prevent damage to river banks, littering of fishing sites, etc. Under auspices of your local Conservation Officer and sportsmen's groups, sponsor a Huck Finn Day or Fishing Derby during which youngsters learn fishing laws and techniques.

3. Group camping (school, scout and family camping). Take a camping trip to some suitable area. Report on your experiences, including what you learned, the mistakes you made, wildlife seen, etc.

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5. Rocks and Minerals

THE ROLE OF ROCKS AND MINERALS IN IOWA'S EARLY HISTORY

It might well be said that Iowa's wealth today is mainly a concentration of many minerals that make up the rich topsoil that produces food to feed a hungry world. However, minerals have played an important role in the development and commerce of Iowa. Exploration of the minerals of this region began in the year 1700, when the French explorer Le Sueur explored the Mississippi region in search of mineral deposits. Descriptions of rich lead deposits in the upper Mississippi region were described in 1752.

In the year 1788, Julien Dubuque opened and operated lead mines and founded one of the first settlements in the city that bears his name. In the year 1880, zinc deposits in this same region were exploited. Iowa's other mineral industries were well under way at this time with the mining of coal, clay, shales for brick and tile, building stones of sandstone, limestone and dolomite. Currently industry is mining limestone and dolomite for the production of lime and cement, crushed rock and agricultural lime, gypsum for the manufacture of plaster coupled with vast deposits of sand and gravel. These rocks and minerals comprise the commercial deposits of our state.

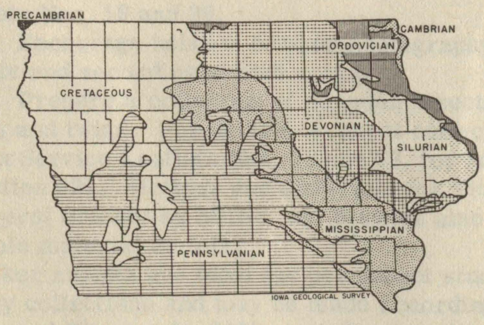

Fig. 5.1. Generalized sketch map of the consolidated rocks of Iowa.

ROCK LAYERS A CLUE TO IOWA'S PAST

Early Man

The various layers, one upon the other through the ages, forming Iowa's soils and rock layers, contain a host of rocks, minerals and fossils, telling the history of the various periods of geological times. Our topsoils often bear the remains and artifacts of the early Red Man and Mound Builders covering a period of many hundreds of years. Their mounds, graves, pottery, tools and weapons are an interesting portion of Iowa's early history.

Deposits Left by Glaciers, Wind and Sediments

Underlying the topsoils are encountered a variety of materials deposited by glacier, wind and water. Often exposed on the surface as large boulders are the remains of the Ice Age or the Pleistocene period. (See Figure 5.2) Many types of igneous rocks worn to pebbles and boulders, composed of granite, quartz and other hard substances that resist abrasion, are found. A great many forms of rocks and minerals can be found in glacial gravels. Of interest to rock and mineral collectors are the Lake Superior agates, chalcedony and jaspers brought in from the Lake Superior region. Copper nuggets are occasionally found. Patient panning often will reveal small particles of gold. Pleistocene gravels also contain the remains of mastodons, mammoth, bison and other large mammals who roamed thousands of years ago in this area.

Loess formations often contain an abundance of animal life, small snails or gastropods and many lime concretions. Excellent studies of these formations can be carried out at road cuts, gravel pits and other places where the deposits are exposed.

Cretaceous deposits in the northwest quarter of Iowa, made up of limestone, sandstone and shales often bear crystals of gypsum. Some of the limestone formations bear remains of clams, plants and fish. Occasionally limonite occurs in these formations and composes Iowa's only source of iron ore, with limited supplies in the vicinity of Waukon.

In the vicinity of Fort Dodge are large deposits of gypsum. As these deposits contain no fossils, the age of these rocks is in doubt, but are believed to be deposited during the Permian period. (See Figure 5.2)

THE "COAL AGE"

Remains of Plant and Animal Life

Deposits of the Carboniferous period cover the greater part of the south half of Iowa and carry many

ERA AND AGE	PERIOD OR EPOCH	CHARACTERISTIC LIFE	CHIEF EVENTS
CENOZIC (Age of Mammals)	Recent (last 11,000 years)	Development of man and domestic animals	Origin of Great Lakes
	Pleistocene (Great Ice Age) one million years	Primitive man, bison, mammoth, mastodon	4 Glacial periods Grand Canyon
	Pliocene 11 million years	Modern horse, camels	Volcanic action
	Miocene 16 million years	Grasses, grazing animals, sequoia trees, tropical trees Apes in Europe	North America and Asia joined Columbia River lava plateau
	Oligocene 12 million years	Diatoms and flowering plants Mammals continue to develop	Volcanoes in W. United States, Alps and Himalayas
	Eocene 20 million years (Age of Horses)	Small horses Monkeys	Coal forming in west
MESOZOIC 125 million years (Age of Reptiles)	Cretaceous 70 million years (Chalk Age)	Flowering plants Deciduous trees Primitive mammals and birds	Rocky Mountain uplift. Western coal swamps
	Juriassic 25 million years (Age of Dinosaurs)	Dinosaurs dominant Conifer and cycads	
	Triassic 30 million years	Reptiles First primitive mammals	Volcanic action in New England, Petrified Forest in Arizona found
PALEOZOIC (Age of abundant life)	Permian 25 million years	Corals abundant. Insects, fish, amphibians Trilobites disappear	Salt deserts in West
	Pennsylvanian 25 million years (Coal Age)	First reptiles. Insects large and abundant. Ferns, horsetails	Great coal-forming swamps
	Mississippian 30 million years (Crinoids)	Ferns and cone-bearing trees dominate. Crinoids, amphibians	
	Devonian 60 million years (Age of Fish)	Invertebrates common. Fish, corals, brachiopods First forests on land	
	Silurian 35 million years	Scorpions, spiders, trilobites, corals, crayfish, sponges	Salt and gypsum Deserts in East
	Ordovician 80 million years	First fish, corals, Gastropods. Mollusks: clams snails cephalopods	Most of North America under water
	Cambrian 80 million years	Seas filled with snails, sponges, seaweeds Brachiopods Trilobites	
PROTEROZOIC	1200 million years	Invertebrates without shells Worms, sponges No record of life on land	Lava flows, iron, copper, nickel ore
ARCHEOZOIC	$2\frac{1}{2}$ billion years	No life on land Some sea life may have existed	Much volcanic action
AZOIC	Lifeless Period	Birth of the Earth	Rocks unknown

Fig. 5.2. The Geologic Time Table.

layers of coal, shale and limestone, bearing abundant invertebrate animal life. Prominent in these deposits are many types of brachiopods, crinoid stems and a variety of gastropods and pelecypods with the remains of vertebrates, such as spines and teeth of a variety of fishes. Sandstone deposits, common during this period, overlay many of the coal layers. Particularly common in some of the deposits are small fossils appearing like grains of rice, called fusulina.

In coal deposits, made up of the remains from a number of species of plants, often the impression of stems, leaves and roots of these plants are to be found. Many fossils of the Coal period are preserved as pyrite or marcasite replacements. Nodules of marcasite and hematite as well as crystals of marcasite and pyrite are common in these formations. Gypsum in the form of selenite may be found as crystals, rosettes or "fish tail" twins in these deposits.

Crinoids and Geodes

Lower Carboniferous formations are composed of many layers of limestone and shale and carry a large and varied fauna. Some limestones are made up almost entirely of crushed and broken remains of fossil crinoids.

Formations of this age often contain beautifully preserved specimens of crinoids and other echinoderms. Particularly noteworthy for their fossils are the beds at Le Grand, Keokuk, Burlington and Gilmore City. Some layers contain large numbers of the grinding teeth of large fishes. Bands of chert variously colored and mottled are found in these formations.

Shale layers in southeastern Iowa in the areas of Van Buren, Lee and Henry counties contain geode beds. Here are found some of Iowa's most beautiful mineral specimens, with geodes varying in size from a pea to twenty or more inches in diameter. These hollow formations contain beautiful crystals of quartz and accessory minerals, such as calcite, pyrite, millerite and many others. Geode formations in the vicinity of Neota, Illinois, directly across the river from Fort Madison, often are found to be filled with a heavy black petroleum.

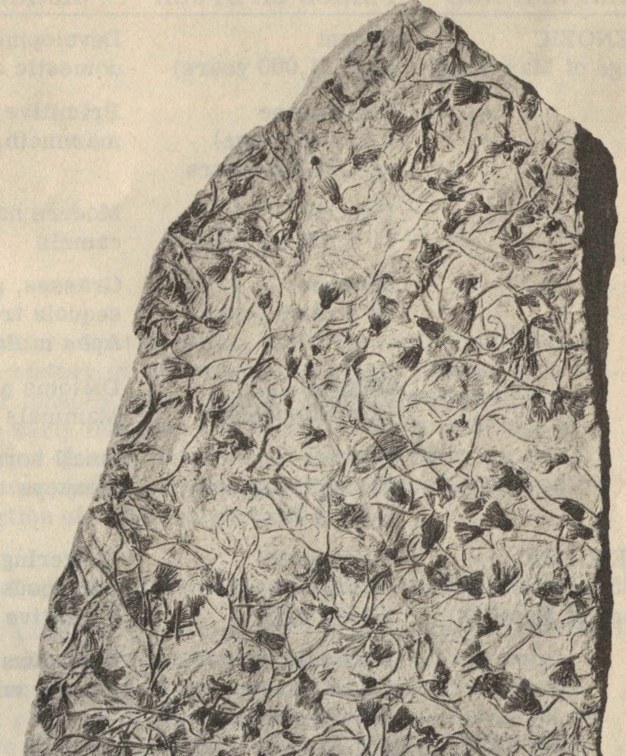

Fig. 5.3. Fossil crinoids from the Mississippian period. (From the collection of B. H. Beane, Le Grand, Iowa)

FOSSILS OF EARLY GEOLOGIC DEPOSITS

Corals and Other Sea Life

Devonian deposits of east central Iowa, composed mainly of limestones and shales, contain abundant fossils of large corals, brachiopods and in many places large numbers of fish teeth. Particularly noteworthy is the area around Rockford, where many species of fossils are beautifully preserved. This is an area visited by collectors from many parts of the world. Some Devonian deposits contain large coral reefs, and beautifully preserved specimens are to be found near Iowa City, Coralville and Fayette. Silurian deposits of limestone in eastern Iowa often contain extremely large and varied corals. While many of these formations are barren, some areas, particularly around Monticello, have silica replacements of many types of corals. Large brachiopods, also occur in Silurian deposits. The area of Backbone State Park has many places where the limestone is filled with the casts of large brachiopods.

Trilobites

The northeast corner of Iowa has exposed Ordovician deposits composed of limestones, shales and sandstones. Found in these formations are the remains of trilobites, brachiopods and cephalopods. Some shale deposits are extremely rich in beautifully preserved specimens. Areas of study are in the vicinity of Claremont and Elgin, where parts of trilobites, occasionally complete specimens, are to be found. Limestones near the town of Graf contain layers made almost entirely of cephalopods. Other layers contain graptolites.

In extreme northeastern Iowa, in the vicinity of Lansing, the rock layers contain some of the oldest fossils to be found in this state. These Cambrian

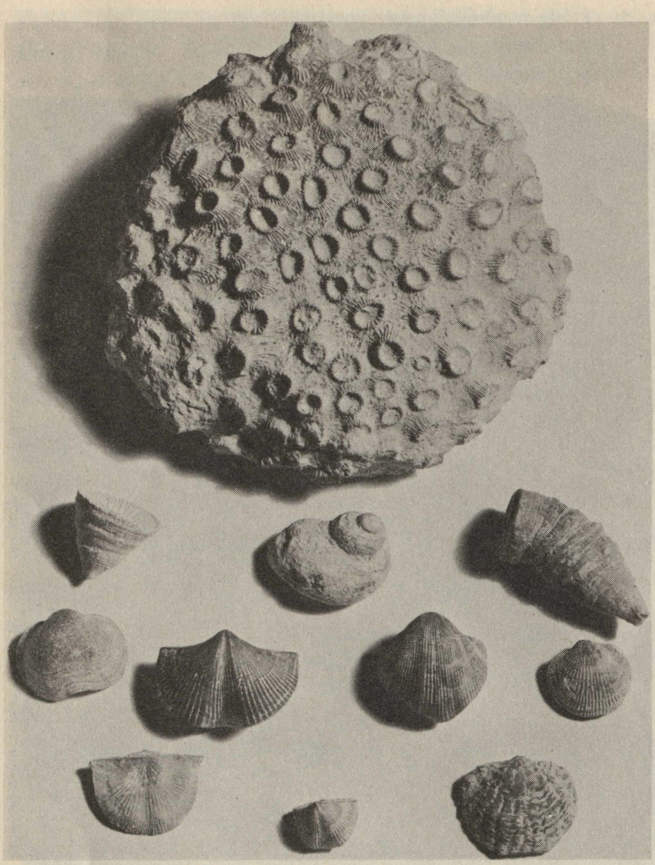

Fig. 5.4. Devonian fossils. (From Rockford, Iowa)

deposits bear the remains of early trilobites and other invertebrates. For the most part these fossils are badly broken and only small fragments tell us of the varied forms of life that existed during that period.

Oldest Exposed Metamorphic Rock in Iowa

In the extreme northwest corner of Iowa are exposed the oldest rocks found in this area. This is the Sioux quartzite of pre-Cambrian Age, made up of small particles of quartz, firmly cemented together and bearing no traces of fossils.

The Earth - A Book

The various layers of rocks, formed through many geological periods over hundreds of millions of years, lay one upon the other like the pages of a gigantic book. Each layer, like the page of a book, is illustrated with the forms of life that have existed. These are the pages of nature's own book of the history of the earth. It is an old book somewhat crumpled by the ages. Many of its pages are no longer legible and a few of its chapters are missing, but it will prove to be a most interesting volume for anyone who takes the time to delve into its many chapters.

COLLECTING ROCKS, MINERALS AND FOSSILS

Basic Information for Beginning Collectors

An interesting way to become quickly acquainted with the geologic resources of Iowa is to begin a collection of some of the rocks, minerals and fossils which lie on or near the surface of the earth. This need not be an extensive collection, but the very fact of having *started* to examine some specimens may provide new avenues of adventure and satisfaction and may lead to an engrossing life-long interest or hobby.

The beginning collector will need assistance in identification of the various specimens and for this he will find help in some of the references which are listed at the close of this chapter. He will also find help in the following paragraphs which attempt to answer such questions as: What are rocks? What are minerals? How do they differ from each other? What is a fossil? How may we learn to recognize some of the common rocks and minerals?

ROCKS - MIXTURES OF MINERALS

Rocks are the materials composing the crust of the earth. They may be exposed at the surface, or if not, underly the covering of soil, vegetation or water. They may be consolidated or unconsolidated. Unconsolidated materials, such as clay, silt, sand, gravel and boulders, are just as truly rocks as their consolidated forms called shale, siltstone, sandstone and conglomerate. Most rocks are an aggregate of one or more minerals. For example, limestone consists chiefly of calcium carbonate ($CaCO_3$ — calcium, carbon and oxygen). Granite consists largely of quartz and feldspar with mica, hornblende or pyroxene and other accessory minerals.

Three Groups of Rocks

Rocks have been classified into three groups according to their mode of origin and their relation to one another. In a simple classification these three groups of rocks are as follows:

1. Igneous rocks — made by the solidification of molten masses that come from deep within the earth.
2. Sedimentary or stratified rocks — formed by the transportation and deposition of sediments by water, wind or ice, or by chemical precipitation.
3. Metamorphic rocks — formed by alteration of igneous or sedimentary rocks, usually by pressure or heat.

<u>Igneous Rocks</u>

Igneous rocks lie beneath the sedimentary rocks and glacial deposits in Iowa and are encountered only in drilled wells that extend to great depths. The igneous boulders and pebbles scattered at the surface are not native to our state, but were brought in by the glaciers which covered this region during the great

Ice Age. Most of the igneous rocks that we find here come from the country north of Iowa. Large boulders of granite, gabbro and basalt are very common on our farms or in the beds of creeks and rivers.

Some igneous rocks found in Iowa:

1. Granite — consists mostly of glassy or milky quartz and white or pink feldspar, includes biotite mica and other minerals.
2. Gabbro — darker and heavier than granite because it contains a large proportion of iron-bearing minerals.
3. Basalt — originally a molten lava which flowed out of volcanoes or cracks in the earth; a very fine-grained dark gray or black rock.

Sedimentary Rocks

Examples of sedimentary rocks are limestone, sandstone and shale. These are the most widespread and common types of rock in Iowa. In most places the consolidated sedimentary rocks (commonly referred to as bedrock) are covered by a thick layer of unconsolidated glacial drift. Natural exposures of bedrock formations occur at the surface in cliffs or in stream beds of many river and creek valleys. Man-made quarries and road cuts are good places to study these rocks. The total thickness of the sedimentary layers varies in different parts of the state. They are thickest (5,000+ feet) in southwestern Iowa and thin toward the north and northeast. They are underlain by igneous and metamorphic rocks. Some sedimentary rocks found in Iowa:

1. Conglomerate — consists of pebbles cemented together generally in a matrix of sand or silt.
2. Sandstone — cemented sand grains.
3. Siltstone — cemented silt that is more fine grained than sandstone, but coarser than shale (clay).
4. Shale — a consolidated clay or mud; often splits into thin sheets like slate.
5. Limestone — consolidated lime mud or cemented fossil shells made of calcium carbonate.
6. Oolitic limestone — an unusual variety of limestone resembling fish roe.
7. Chalk — a soft variety of limestone.
8. Dolomite — similar to limestone but with less calcium and more magnesium.
9. Coal — plant material that accumulated in marshy areas and later was buried under thick clays and sands and finally compressed to coal.

Metamorphic Rocks

1. Quartzite — a metamorphic rock native to Iowa is the Sioux quartzite found at the extreme northwestern corner of the state in Lyon County. Quartzite is one of the hardest types of rock. It was formerly a sand or sandstone. The sand was cemented by silica or was recrystallized so that the rock is practically a solid quartz mass. Other quartzites may be found in abundance in the glacial drifts. This quartzite was brought from Canada.

Fig. 5.5. A limestone quarry near Council Bluffs, Iowa. Note the loess deposited over the bedrock. The rock layers were formed during the Pennsylvanian period.
Des Moines Register photo.

2. Slate — may be found as "capstone" in some of the coal mines. Slate is an altered or changed shale, silt or mud. The Iowa slate is usually not of good quality.
3. Marble — a changed limestone. There are no marble quarries in Iowa, but collectors have no trouble securing it, since it is used in buildings and may be secured from a stone cutter.
4. Gneiss — a foliated rock in which the layers are of different mineral composition; generally the mineral particles are coarse enough to be seen with the naked eye. Usually a changed granite.
5. Schist — differs from gneiss in having closely spaced foliation planes; it splits readily into thin flaky slabs or plates. Mica schist and hornblende schist are common as glacial contributions.

Unconsolidated Material, or Unsorted Rock

When the glaciers covering Iowa melted, they dropped huge loads of clay, sand, gravel and boulders which had been trapped in the ice. Much sand and gravel was spread across the state by streams that flowed beneath or out from the glacial borders. This unconsolidated glacial debris is known as drift. In some places, particularly in the western part of the state, the glacial drift may be several hundred feet thick, but generally it is less than 200 feet thick on the average. In other places, as in northwestern Iowa, it may be entirely absent where erosion has removed it.

MINERALS

Minerals exist chiefly as compounds of elements. Some minerals may contain but a single element, such as sulfur, gold or copper. Minerals may be found free, in crystal form, but many of them are known as "rock-making minerals." When certain minerals combine in a mixture, that mixture is known as a "rock."

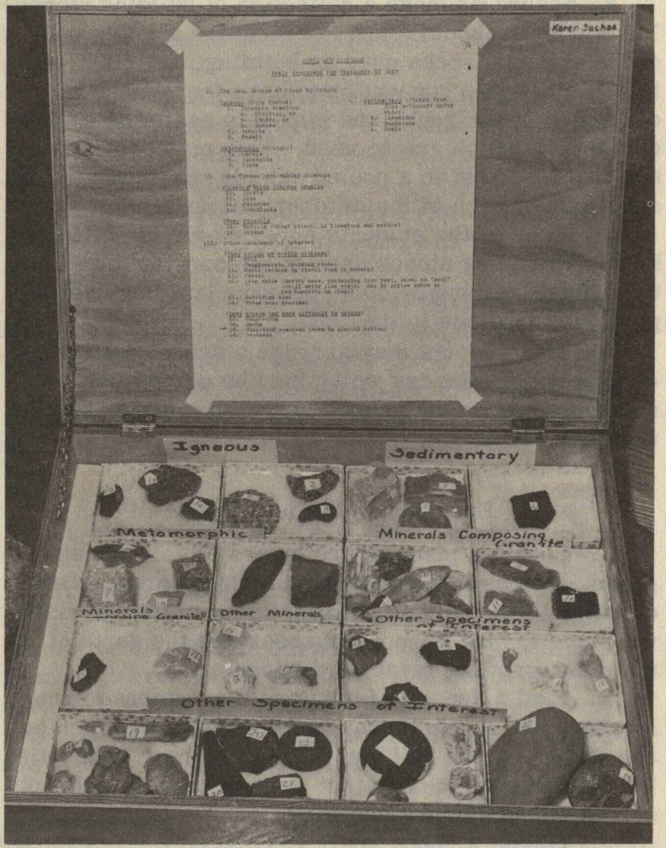

Fig. 5.6. A labeled collection of local rocks and minerals is a good student project. *Des Moines Register photo.*

The Rock-Making Minerals

1. Calcite — a very common mineral, composed of calcium, carbon and oxygen (calcium carbonate, $CaCO_3$). Limestone and marble consist of tiny calcite crystals. A calcite crystal may be Iceland spar, Dogtooth spar or Rhomb spar.

2. Quartz — this most common mineral has the composition of silicon dioxide (SiO_2), and assumes many forms, e.g., sand, sandstone, chert, flint, agate and amethyst. A quartz crystal has six sides and a pyramidal top. Quartz is one of the chief minerals in many granites. Flint is a variety of quartz in which the crystal structure cannot be seen — used by Indians for arrowheads and tools.

The following three minerals may or may not be found "free," or in separate, individual crystal form. They may be easily identified in coarse-grained granites. Feldspar and mica may often weather free of the granite. These of course were brought to Iowa by the glaciers.

3. Feldspar — one of the chief minerals in granite. Makes a squarish, smooth-faced crystal. When broken, it breaks with rather smooth, *flat, shiny* surfaces. There are many feldspars. Colors vary from pure white to gray, to rose, brown and reddish. Easily weathered. When finally broken down, *clay* is the residue. The fine-grained, white varieties yield kaolin or kaolinite; a very soft, fine clay from which high-grade china is made. Moonstone, a jewel stone, is a form of partly weathered feldspar.

4. Mica — a thin, elastic, transparent mineral. Easily scratched with a knife or fingernail. Forms in large tabular sheets which may be easily separated. Resists weathering; will not burn; does not react to acid. It is found scattered through shales and sandstones as fine sparkling flecks. Three chief varieties are:

a. Biotite (black)
b. Muscovite (a clear whitish color)
c. Phlogopite (brownish; dull color; may or may not be in granite). Many *mica schists* (metamorphic or changed mica).

5. Hornblende (see pyroxene) — Pyroxene and hornblende are two very similar minerals usually identified as having long shiny needle-like crystals of dark gray (nearly black), dark greenish or light green upon weathering. Found in granites or alone. There are many hornblende schists which are metamorphic or *changed* hornblendes.

6. Gypsum — rather abundant in southern and central Iowa. Found in massive and crystal forms. It is a hydrous calcium sulfate mineral ($CaSO_4$ + $2H_2O$). There are several varieties of gypsum and it has many uses.

a. *Alabaster* — a very fine-textured form of gypsum. Prized in Italy for statuary and vases.
b. Massive forms — grayish; white and pinkish fine grains, somewhat resembling sugar cubes in shape.
c. Satin spar — rosy colored or pure white. Long fiber-like crystals resembling satin in texture and sheen. Reminds one of taffy candy in the pulling process. Easily split lengthwise with fiber.
d. Selenite — a clear, transparent, tabular crystal somewhat resembling mica in that it may be split into sheets, but it is not elastic.

The "Ore" Minerals or Metals

1. Limonite — a hydrous iron oxide mineral found near Waukon and at many other places in Iowa.

2. Pyrite — an iron sulfide mineral very common in the rocks of Iowa; commonly called "fool's gold."

3. Galena — a lead sulfide mineral and the chief source of lead; found in the vicinity of Dubuque.

4. Sphalerite — a zinc sulfide mineral associated with Galena in the Dubuque vicinity.

FOSSILS

Animal and plant remains, known as fossils, are found in the sedimentary rocks. The fossils generally consist of parts or impressions of shells, skeletons, or leaves and wood that were buried in the lime or mud at the time of deposition of the sediments.

In many cases the fossils later turned into stone as the sediments hardened or were cemented into layers of rock. Well-preserved bones, teeth, and tusks of mastodons and mammoths, animals that roamed this region in recent geological time, occasionally are uncovered in stream beds or sand and gravel pits. Fossils provide a record of the life of the past. Some fossils found in Iowa:

Animal life:

1. Invertebrates — corals, brachiopods, bryozoans, gastropods, cephalopods, trilobites, crinoids, graptolites, sponges and conodonts.
2. Vertebrates — fish teeth, mastodon and mammoth teeth and tusks, bison skulls and horns.

Plant life:

Many impressions of leaves, stems and trunks of ancient fernlike plants which grew during the Coal Age. Some of these are horsetails (joint grass), lepidodendrons and others.

SPECIMENS OF UNUSUAL FORMATIONS

1. Concretions — many and various peculiarly shaped pieces of clay and shale, or lime, sometimes containing iron, often resembling some fancied creature. Often formed around a central nucleus which may be a pebble or a fossil.
2. Geodes — rounded specimens (nodules) with cavities usually filled with quartz or calcite. Rough, unattractive on the outside, but when broken open reveal beautiful crystals. They vary in size. Some are completely filled and do not show crystals.
3. Glaciated rocks — may be granite, basalt, or quartzite or any hard material. Show plane surfaces, often with striations, scratches or flutings made by the glacier carrying rocks grinding against each other. A typical glacial boulder shows two or three smoothed or planed-off surfaces. They all do not have the "scratches" still preserved.
4. Gravel or waterworn specimens — pebbles of varying composition, chiefly of quartz or other weather-resisting types. These have been carried in streams and have dashed against other rocks until they have become circular in shape and have no sharp edges, but are smoothed and often polished.
5. Septaria — peculiar forms of claystone, mud or shale; when dried the cracks become filled with calcite carried by water in solution, and the result is a queer-shaped rock presenting four, five, or three-sided, cell-like cracks, outlined with the veins of calcite. These are sometimes commonly called "Turtle Backs" or "Waffle Cakes."

SUGGESTED ACTIVITIES

Collections

1. Students may wish to make or add to a permanent collection of minerals and rocks for the school or camp, which may be left in the building. Each individual may wish to make his own collection. For help in this project, the student or camper may consult the appended information for beginning collectors at the close of this chapter.
2. Secure or make a collection of building stones. The students should learn to recognize at sight some of the common rocks used as building materials. It is helpful in this connection to have them make a collection of the rocks and minerals available in the community which are so used. This may be a group activity resulting in a pooled exhibit consisting of one specimen of each of the different materials.
3. Some of the students may find out the different kinds of building stones used in the construction of the school building or some near-by building and report their findings to the class.
4. The students may arrange a school collection of mineral substances which may be placed in a suitable place in the school where others may profit from the collection.

Excursions or Field Trips

1. Locate a place where layers of soil are exposed, such as in a cut above a highway or in an excavation for a building. If possible, arrange to visit the place for the purpose of observing the depth of the plant-growing layer or the topsoil.
2. Find a deposit of clay and if it is conveniently located, plan a trip there to observe the depth, color and texture of the soil and the plant growth it sustains. The deposit may be one that is being used by a brick or tile manufacturing company.
3. Locate a place where the glacial till is exposed, and if possible, have the class or small interested groups visit the exposure for the purpose of observing the unsorted soil. Gravel, sand and rocks of irregular shape and of differing sizes may be found mixed with the clay.
4. Locate a place where large boulders of granite or quartzite may be found imbedded in the soil or exposed in the bed of a stream. These boulders are "foreigners" and were transported to Iowa by a glacier.
5. Visit a river or a creek that has cut a channel through soil or rock. Notice the layers of soil or strata of rock. Many of the students will have been to the Ledges State Park and will recall that the stream has cut through the sandstone there. Visit buildings made of sandstone or limestone for the purpose of observing evidences of weathering.

Investigations, Demonstrations or Experiments

1. Find a piece of coarse-grained granite which has been exposed to weathering for a very long time (such as may be found at the surface of the Kansan Glacial Drift). Break this apart. Try to find a piece which may be easily broken up by one's hands. Note the resulting "sand." See the mica, feldspar and other materials. This should illustrate how rocks break up and yield gravel, sand and finally become mineral soil.

2. Examine some scale in the bottom of a teakettle and discuss its source. Test it with some hydrochloric acid to determine its composition.

3. If a student has visited a cavern or cave, have him report his experience to the others. If none has had this experience, some of the students may make an investigation of some of the caves which may be found.

4. Make a strong solution of salt or alum and observe the crystal growth. For detailed directions in making crystals, see the references listed at the close of this chapter.

5. If any of the students have visited quarries or mines, have them give descriptions of the visit to the class.

6. Visit the geology exhibit at the State Historical Museum in Des Moines or examine a private collection of some member of a rock and mineral club.

7. Investigate the possibilities of securing polishing equipment and of cutting and polishing your own specimens.

A WORD TO THE TEACHER OR LEADER

The experiences involved in this phase of the study of geology relate in a very real and tangible way to the *immediate* environment, perhaps to a greater degree in the minds of pupils than do the materials of the other areas of subject matter. The soil and the rocks are everywhere present and pupils are already somewhat familiar with this part of their environment. Because of this they may, with but little direction, be led to an increased understanding and appreciation of the value of the common materials of the earth.

As the work of the collecting progresses, the pupils should show growth in the following understandings:

All soil comes from the disintegration of rocks and minerals by the action of natural forces.

Apart from being the original source of our soils, the rocks and fossils of the earth furnish almost the sole record of the earth's history previous to the records of man.

The development and use of the rocks and minerals of the earth have played an important part in the progress of the race.

Iowa's greatest natural resource is the soil, and the boys and girls of Iowa should appreciate why Iowa soils are especially rich in plant food.

No one would dispute the significance of the last statement given, and one of the best ways to lead children to an understanding of the importance of soils is through an appreciation of the study of rocks and minerals. When it comes to the question — which comes first, the soil or rocks — it will be seen that it is impossible to present the work on soils without treating the relationship between rocks and soil. It may be that a short study of rocks and minerals could profitably be made the center of interest, and the important understandings concerning soils be developed as outgrowths of the central interest. Children and young people are much interested in rocks and minerals because of the ease with which they may be handled and examined, because of the outdoor activity connected with the study and because of the joys of collecting.

Therefore, the teacher or leader should not neglect the opportunity to open the field of rocks and minerals as a hobby interest for boys and girls. If properly presented, the study of soil need not be "as dry as a pinch of dust" but may be a living and vital experience.

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6. Natural Areas

OUR HERITAGE OF WILD NATURE

Any comprehensive approach to conservation of resources should include wilderness — a very fragile resource. The preservation of nature's sanctuaries — wilderness areas, national parks and related lands — is as important to our nation's spirit as the conservation of physical resources is to our nation's economy.

There is much to be learned about nature's sanctuaries, their resources and what they have meant and can mean to human beings. These areas have been given many names — wilderness, primitive areas, primeval areas, nature reserves, sanctuaries, biological treasure houses, biological or geological monuments, wildlife refuges, green belts, open space, parks, natural areas, virgin areas and natural control areas. Within our national forests, primitive areas and wilderness areas have been officially designated. Most of the areas in our national parks are managed to preserve the natural scene.

Gifts of Nature Help Advance Civilization

Historically, human beings have advanced civilization and many cultures by using the gifts of nature. Man's ingenuity has enabled him to take the raw materials of nature and fashion them into devices and products.

Generally, the native *(indigenous)* resources are the primary basis of settlement. However, through trade and travel many resources, as well as diseases and parasites, are brought into a settlement from the outside. Introduced wild plants and animals are called *exotics;* such exotics are most frequently introduced accidentally. The vicinity of railroad yards, for example, usually are rich in exotic plants.

Throughout all of the activities of human beings, the *use idea* has become deeply seated and permeates our everyday thinking about natural resources. Resources and goods acquired "market-place values" and the use of money in trade became widespread.

Not Always a Dollar Value

If a natural resource or an object of nature was of little or no value in the market place, it was apt to be ignored or considered useless. Today we find ourselves plagued — and sometimes divided — because we can't give a market-place value to certain resources. We are inclined to write off as "idle" or "useless" those resources to which we cannot attach a dollar sign. This is a narrow point of view which should not characterize the attitude of modern man who aspires to travel through space and who lives in a nation with so high a standard of living.

Despite the difficulty of evaluating in dollars our various natural areas, the protection and study of undisturbed land and water areas is very much a part of modern life and conservation efforts. In its larger aspects, nature protection and natural history are the root foundation of many kinds of conservation activities that deal with the land, water and plant and animal life.

In view of human population increases, wild lands of all kinds are acquiring a "scarcity value." This in itself has greatly intensified recent interest in wild lands and their preservation.

Wild Land Protection and Study Is an Organized Movement

Many organizations and individuals seek out, preserve, study and are learning the art of managing nature reserves and wilderness areas.

Private Organizations

Some important private organizations in the United States devoted to preservation of wild lands are: the Wilderness Society, the Nature Conservancy, the Save-the-Redwoods League, the National Audubon Society, the National Parks Association, the Izaak Walton League of America, the National Wildlife Federation, Trustees for Conservation, the Grassland Research Foundation, the American Nature Study Society, and the Sierra Club.

In 1959, the *National Wildlands News,* published monthly, was started to report objectively what is happening relative to nature sanctuary lands throughout the United States.

Federal Agencies

Federal government agencies concerned with preservation, use and study of wild lands include the National Park Service, Fish and Wildlife Service, Indian Service, Bureau of Land Management, and the Forest Service.

On state, county and municipality levels there are many agencies concerned in part with wild lands. They include conservation commissions or departments, state park and forest commissions, county conservation boards and other planning and development groups. Many nongovernmental organizations giving support to these matters are listed in the Appendix.

International Organizations

Internationally, there are such organizations as: the International Union for Conservation and Protection of Nature (IUCN), the Committee for International Wildlife Protection, the International Council for Bird Preservation, the International Whaling Commission, the (North American) Migratory Bird Conservation Commission, the Quantico-Superior Committee (Canada and the United States), and the International Association of Fish, Game and Conservation Commissioners.

In Great Britain the British Nature Conservancy is a lawful arm of the government. Similar agencies exist in other countries, many of which work under the auspices of IUCN to report progress, hold meetings and field trips, organize research and acquire undisturbed land and water areas for protection.

Educational Institutions

Many educational institutions (private and public) in the United States, from the lower grades through universities, have acquired lands, some undisturbed, which serve as outdoor laboratories. Early in 1960, for example, the State University of Iowa acquired a 50-year lease from the U. S. Corps of Engineers on a 600-acre wooded area in a bend of the Iowa River a few miles north of Iowa City in the Coralville Reservoir area.

People involved in nature protection are raising many thoughtful questions about man's role in changing the face of the earth. Through comparative studies of undeveloped and developed lands and application of principles learned, man may come ever closer to the goal of Harmony with Nature.

NATURE SANCTUARIES

What Are They?

Nature sanctuaries have been called "Nature's Biological Treasure House." This is a good description for wild lands wherein the soil-water-plant-animal complex remains relatively unmodified by actions of modern man.

Wild lands are fragile — once destroyed, they can never be replaced. They are storehouses of scientific treasures ranking greater than any man-made monument, library or museum. Man lacks the power to restore *completely* all the elements of interactions that make up a natural area. In the 1950's estimates showed that less than one per cent of the total area of the United States was included in wilderness and national park lands. In 1959, the statement was made, "What we save in the next few years is all that ever will be saved."

Restoring Natural Areas

If disturbances have not gone too far, we do have some techniques whereby nature can be assisted in *partial* restoration.

Ecologists have learned, for example, how to use native prairie plants to restore certain physical, biological and chemical aspects of Great Plains soils which had been drastically disturbed after years of growing wheat.

In Iowa, botanists at Ames were able to reestablish certain native grasses. A good example of this sort of restoration can be seen at The Ledges State Park in Boone County, Iowa.

In inhabited parts of the world it is easy to see examples of man's activities. We see how man has farmed, grazed lands with his stock, mined, cut timber, burned, polluted water and the air, dammed and flooded, irrigated, overfished, drained and covered vast areas with structures and roads. We see also the dumps, auto graveyards, urban blighted areas and litter. Man changes the landscape in a haphazard and piecemeal fashion. Natural conditions are bound to be altered.

We emphasize this upsetting of nature because it is one of the reasons for preserving samples of undisturbed landscape. When a landscape gets "sick," we should have something "normal" for comparison and diagnosis of the illness.

In diagnosing disturbed lands in the Great Plains States, grassland ecologists have used virgin tracts of grasslands. Their findings have been applied to the restoration of range and plow lands that were a part of the Dust Bowls of the 1930's and the 1950's.

These investigators received much inspiration and guidance from Iowa prairie studies made by Dr. Bohumil Shimek and reported in a series of papers published from 1911 to 1948, and from Dr. Ada Hayden who reported in 1946 before the Iowa Academy of Science on the progress being made in preservation of prairies in Iowa.

In 1947, the Society of American Foresters established a "Natural Areas Committee" to list such areas and to recommend action for preserving examples of undisturbed forest stands in 156 recognized forest types of the United States. The search for natural areas was greatly intensified in 1959.

Value of Natural Areas

From natural areas and wilderness, which are "untapped reservoirs of life," may come many of the miracle drugs of tomorrow, new crops for food, raw materials for industry and genetic strains of trees for reforestation. Studies of natural areas will lead to a greater knowledge of how living communities of life function in *cooperative wholeness*.

Fig. 6.1. Students in a natural area. This is an oak-hickory community in central Iowa, in early October.

Cooperative wholeness may be a term that can be used in place of *competition.* This latter term has created in our minds a cruel "tooth and fang" concept of nature, whereas in undisturbed nature many interdependencies have evolved which seem to function to the benefit of the whole system. From understandings of natural laws made possible by natural areas will come sociological and psychological relations of value to human communities.

Why We Seek the Out-of-Doors

What are the effects on human beings of living in an environment richly endowed with natural areas as contrasted with one wherein natural areas or a richness of natural things have been eradicated? Is the current desire by masses of Americans to seek outdoor recreation related, in part, to a wish to be exposed to features in the less disturbed, more natural environments? The implications of man's reactions to nature are worthy of more intensive analysis and study.

Nature's sanctuaries have other significant values. They are sources of wonder and excitement to all of us as they unfold the story of nature. From wilderness we learn some of the natural forces that helped produce our civilization. Many people, by visits to wilderness and natural areas, recapture and relive much of the "march of civilization and history." Some 60 million people visit the national parks of our nation — millions of them find their spirits refreshed by this contact with nature. Here is high-quality recreation we can ill afford to lose.

The development of a system of migratory bird refuges in North America (primarily designed for waterfowl) and the international migratory bird treaties, involving Canada, the United States, Great Britain and Mexico, is a fascinating story of nature protection. Many wildlife refuges, although not entirely natural because of farming and water-control manipulations which tend to amplify certain special food and cover qualities, are excellent places in which to see the natural history of bird migration. (See Chapter 7 for the location of federal and state refuges in Iowa.)

More recent are efforts to save underwater habitats from damage by aqua-lung and skin-divers. Preservation of salt water estuary and tide marsh areas is vital to the survival and growth of many salt water animals, including marine sport fishes. Speleological organizations (cave-exploring groups) have recognized the necessity for protecting wild caves from thoughtless damage.

Man does not live alone on this planet. The great humanitarian, Dr. Albert Schweitzer, with his Reverence for Life philosophy, and the American writers, Joseph Wood Krutch, Henry Thoreau, Olaus J. Murie and Devereux Butcher, are outstanding exponents of this "right-to-live" philosophy. Wilderness — both land and water — areas are living examples of the "right to live."

CONSERVATION INVOLVES MANY POINTS OF VIEW

Conservation, regardless of our approach, involves many points of view. There are many different approaches. An understanding of these differences will help us understand the total conservation problem.

Teachers can help encourage students to take the "long look" and to "walk all around" (think all around) many problems of resource use and management. The young minds of students are not hurt by exposing them sequentially to questions and discussions involving "wholeness" and "beauty" and "preservation" in conservation efforts, as contrasted to more strictly "economic" approaches. The legacy of beauty and reverence for life which has been developing in human minds should be recognized and strengthened.

Theodore Roosevelt, who did much to promote conservation efforts in the United States, said, in talking about conservation efforts: "There is nothing more practical in the end than the preservation of beauty, than the preservation of anything that appeals to the higher emotions of mankind." His actions as President of the United States, in getting some outstanding natural areas of great beauty preserved, proved he understood and believed in what he said.

The careful and observing teacher will soon discover many areas of controversy among the various users of land and other natural resources. "Hot" questions will be raised involving wilderness, national parks, drainage and damming — just to name a few. These questions, when they arise, are worthy of exploration to uncover the facts of both approaches. Working from the concept of preserving nature may help.

NATURAL AREAS IN IOWA

Few states have utilized for agricultural purposes as large a proportion of their area as Iowa has. This is true chiefly because of the favorable topography and climate and the high fertility of the soils. Nevertheless, Iowa has had an ambitious program of preservation and use of natural areas.

Early interest and activity in the program was stimulated by three great Iowa conservationists: Doctors T. H. McBride, L. H. Pammel and Bohumil Shimek. There activities in the establishment of state parks and preserves were carried on in connection with the Iowa Park and Forestry Association (1901-1917), the Iowa Conservation Association (1918-1921) and the State Board of Conservation, after its establishment by the general assembly in 1921. These men and others worked also through the Conservation Committee of the Iowa Academy of Science. In 1920 this committee, made up of W. H. Davis, Bohumil Shimek, H. E. Jaques, G. B. McDonald and G. A. Chaney, in their report recommended immediate action be taken by the Academy for the preservation of streams and lakes, endorsed the policy of plant and game preserves in rough lands along streams, advocated changes in the law regulating hunting and fishing seasons and recommended passage of a law for the preservation of Indian mounds.

Interest in conservation grew with the help provided by the Academy committee and other public-spirited citizens. Probably the most profound positive influence among the citizens generally was the cartoons drawn by J. N. (Ding) Darling, editorial cartoonist for the Des Moines Register from 1906 to 1949. Syndicated by the New York Herald Tribune from 1917 until 1949, the cartoons, appearing in 150 newspapers, frequently and pointedly told the story of destruction of wildlife and other natural resources by indifferent, careless and wasteful farming and forestry practices and greedy exploiters. Darling was a member of the Iowa State Fish and Game Commission in 1933 when the "Report on the Twenty-five Year Conservation Plan" was published. A year later he was named Chief of the United States Biological Survey, a post he held for only twenty months. This was long enough to get the national program moving, however, and it has maintained much of the vision and momentum he gave it.

The "Twenty-five Year Plan" was the first undertaking of this kind in the nation. As a clear statement of conservation needs, sound planning for the future and as a program for building a network of state parks and preserves the plan still stands as an important milestone. It served to coordinate and integrate the efforts of private citizens interested in conservation with the efforts of such leaders as Dr. T. H. McBride, Dr. L. H. Pammel, Dr. Bohumil Shimek and members of the Board of Conservation, the State Fish and Game Commission, the Isaak Walton and Will Dilg leagues, the ornithologists, the garden clubs, the Academy of Science, the American Legion, women's clubs, the Extension Service, the legislature and numerous county engineers, farm agents and state officials. Conservation in Iowa today owes its existence and motivation to these early efforts and to the programs developed since by the Iowa State Conservation Commission which evolved from the old Fish and Game Commission and the Board of Conservation.

The first state park acquired was Ledges State Park near Boone, in 1919. Iowa now has jurisdiction over 90 state parks and preserves totaling more than 28,000 acres. There are also 7 state forests and one forest nursery totaling more than 13,000 acres. There are more than 150 state-owned public hunting areas and over 200 areas which provide access to fishing waters.

In the parks the recreational facilities have been increased and improved to a degree that the needs of young and old in all parts of the state are provided for within easy driving distance. Although our state parks are being used increasingly for recreation, more than 50 of them have natural areas of varying size which are disturbed very little. Many park areas and the 7 state forests are, for the most part, natural areas without special recreational facilities. The state-owned public hunting areas also contain many thousands of acres which can well be classified as natural areas. In fact, excessive disturbance by man is easier to control in these areas than in the natural areas within the state parks because use is less. Because of a well-planned long-range management program, even the balance of game species will not be greatly altered even by increased use.

Setting aside these areas for hunting has provided almost every county in the state with at least one natural area that will be protected from excessive disturbance and will be allowed to develop naturally in the future. The limitations imposed on these areas by their use for hunting will not materially interfere with their use by nature-lovers. Those who enjoy observing and studying natural biological communities

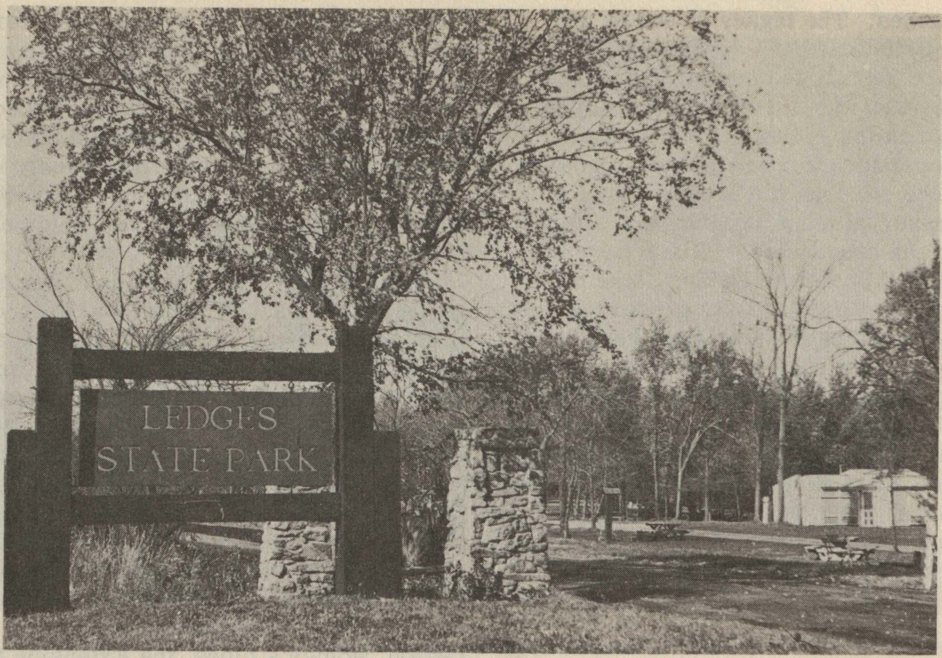

Fig. 6.2. State parks are excellent study places as well as recreational sites. The Ledges State Park in Boone County is a favorite study area because of its interesting rock formations, remarkable plant specimens and many varieties of birds.

will have an opportunity to do so under this program for it is designed to make full use of all natural areas without causing any unfavorable effects on their growth and development.

Acquisition of additional natural areas is planned as opportunities and needs arise and available funds permit. Precedents have been established for use of funds from both the Lands and Waters Division and the Fish and Game Division of the State Conservation Commission for purchase of natural areas. Gifts of natural areas to the Conservation Commission by individuals and groups are increasing. This source can be an important one in the long-range program.

Many tracts of varying size throughout the state which are being maintained by private owners as natural areas are available for use by considerate, cooperative nature-lovers. More individuals should take advantage of them. In the interest of good owner-visitor relations permission should be requested in advance. Conservation-minded organizations of various sorts, especially at the county level, can do much through education and possible purchase and management, to promote on a permanent basis the preservation and use of natural areas.

NATURAL AREAS AS PLACES OF STUDY

Natural areas, wilderness, and other wild lands are ideal places in which to study nature at first hand. From such study will come great enjoyment. Greater understanding of management of farm and grasslands, forests and human communities can come from this study. There is no limit to the educational assets of studying nature in the outdoors. It is an excellent example of education "extending."

Many conservation and land-use practices today have become possible because people are becoming more skilled in *identification, life histories* and *ecology*. How do these three great overlapping areas of study aid us in all kinds of conservation efforts?

1. *Identification* (taxonomy). Resource management is based upon knowing what you are working with — this involves *identification.* Identification of plants, birds, mammals, fish, rocks, soils and the many other things that make up nature is best begun when one is young.

2. *Life histories.* All plants and animals, and even rock and soil formations, have life histories — all have certain patterns of development.

Life history facts are of great help to conservationists and to users of natural resources. A forester collecting seeds must know when to collect them. Production of seeds by a tree is part of its life history.

Much life history information is lacking today because some plant and animal communities have not yet been studied and observed thoroughly and long enough. Many aspects are difficult to study and require ingenious ways to get at the facts.

Life histories are a challenging field of study. Plant growth studies have been made, for example, through the use of time-lapse filming. Secretive animals are brought into a laboratory and studied behind one-way glass. Soils can be tested for their chemical, physical and biological properties. By using certain radio-active tracers (e.g., tritium), we are learning more about the "life history" of water, for instance, as it percolates into the ground and is pumped to the surface.

3. *Ecology* is the study of the interrelationships of plants and animals and their environments. Ecology

is difficult because it involves many sciences and arts. It is a synthesizing discipline. Ecology has aided us greatly in conservation work and is the foundation upon which better management of many natural resources is based. Management of a resource involving plants and animals (wild or tame) and soil and water has many inter-connections that must be understood or appreciated somewhat by the person or group doing the managing. Some plants require the activities of certain insects in order to be pollinated; birds eat insects; insecticides can kill insects and birds.

Thus go on and on interdependencies that exist in nature and the activities of man. Some of these interdependencies are familiar to us — the hydrologic (water) cycle, carbon cycle, nitrogen cycle, food chains and energy circuits.

The bread you ate for breakfast may have come from wheat grown in Nebraska and been transported in box cars built out of wood from the state of Washington and on iron rails made of ore mined in northern Minnesota and smelted and fashioned in Gary, Indiana. All of these are examples of how we make up diagrammatic pictures of the inter-connections that exist in nature. Many interesting charts, models, and diagrams can be constructed by students to show these interdependencies and connections. A discussion of how man breaks these circuits and taps off "energy" in the form of crops, animals, fiber and wood products can be quite revealing. How does man restore some of the energy or nutrients he has taken from the land?

Applied Ecology — Conservation

Much conservation and resources use — especially in relationship to many of the things we do on land and water — is applied ecology.

Can we visualize that man is only a "cog in an ecological mechanism"?

We know that man has made and continues to make many errors in his management of land, water, plants and animals. Correction of these errors and establishment of better housekeeping, in large part, is going to depend upon how well he learns and adjusts to the facts of interdependencies. Such adjustment makes up a large part of so-called conservation efforts today.

Education in the out-of-doors is where we have opportunities of viewing, studying and comparing areas disturbed with those relatively undisturbed by man. Many people seem to be agreed that such education affords one of the wiser ways of obtaining a well-rounded perspective of the meaning of conservation and some fundamental laws of nature.

Henry David Thoreau wrote:

> "All things invite this earth's inhabitants
> To rear their lives to an unheard of height,
> And meet the expectation of the land."

What are our expectations for our state? For our home community? Our school grounds? The children and future children of our state? The wild plant and animal communities?

Development of curiosity, courage and perception is strongly interwoven into any good educational program. Acquisitions of new knowledge and skills are another part. The study of nature contains strongly all of these elements of education.

Many of today's scientists acknowledge a debt to training received in nature study during formative years. Many adults pursue wholesome and intelligent hobbies and studies derived from nature study undertaken during childhood. Aldo Leopold reminds us that "recreational development is a job not of building roads into lovely country, but of building receptivity into the still unlovely human mind."

There are indications that more school systems will be participating in school camping, not only during the school year, but in summer months. Now is the time to acquire more adequate school-ground and off-campus areas which can be developed or used for outdoor instruction. In all of these endeavors, nature protection and nature study should be the backbone of the program.

To "meet the expectation of the land" is not going to be easy. The best in all of us will always be challenged by the land and by users of the land.

WHAT CAN WE DO TO PRESERVE NATURAL AREAS?

First, we can visit some established natural areas. In this way we become acquainted firsthand with some of the aspects of natural areas. In making such visits, the individual or teacher would do well to be accompanied by persons who have made studies of natural areas. Many Iowa teachers have had an opportunity to visit and study several natural areas as a part of courses at the Iowa Teachers' Conservation Camp held at Springbrook State Park each summer.

Second, we can seek out areas that are considered natural or relatively undisturbed, and compile a list of them. Any listings should be submitted to the Nature Conservancy headquarters in Washington, D. C., which is a clearing house for such information, and to the Iowa Conservation Education Council.

A list of what to look for and the sort of things to consider in the search for local natural areas can be developed by the teacher and students. Here is a suggested generalized list. (See Chapter 7 for the location of natural areas in Iowa.)

Lakes, marshes, swamps and bogs
Springs, streams and waterfalls
Sand dunes, salt springs or licks
Soil sample areas
Caves and sink holes
Forests, brush and prairie areas
Cliffs, bluffs and ledges
Buttes, ridges and badlands
Natural bridges
Glacial moraines, kettles and eskers

Loess hills with native vegetation
Petrified trees, coal beds and other fossil deposits
Places of significant use to certain animals, e.g., prairie chicken booming grounds

Third, we can appraise the areas. We can state why we think they are relatively undisturbed; we can list the plants, animals and types of land and water communities we find. We can list all known facts to build up a "case history" of each area: location, size, drainage, geology, soils, distance to nearby schools and towns, present owner and address, past and present use and average price of land locally. Maps, aerial photos and photographs should be assembled or catalogued.

In appraisal work, seek out the aid of local amateur and professional naturalists; trained soil, water, biology and forestry technicians; planners and certain organizations. Valuable assistance can be obtained on occasion through colleges, universities, agencies and organizations employing specialists in natural history and conservation fields.

The aid of newspaper editors and reporters, political leaders, county supervisors, county conservation board commissioners, garden club and women's club leaders and soil conservation district commissioners should be enlisted early.

Fourth, we can aid in taking action to insure that natural areas will remain protected as "natural areas." Out of the many areas listed and appraised, a few will emerge for consideration of immediate action for preservation. Purchase may be necessary, and in some cases political action may be required in getting areas set aside and purchased. If an area has been purchased, some responsible agency or organization must see to it that protection is provided and proper use is made of the area. Constant vigilance is necessary to preserve natural areas from many kinds of encroachment. We should not allow natural areas to be turned into playgrounds or parks; other lands less precious can be found for such purposes.

Fifth, we should learn how to use natural areas in our school programs, for research and by the general public. Here is a pioneering educational program for all of us who are concerned with education and nature protection. This program, as it progresses, should be carefully documented and given carefully prepared publicity among teachers, scientific groups, political leaders and the general public. All the media of selective and mass communication can be utilized.

One way to protect an area from encroachment is to use it and let school associates and the public know fully and repeatedly about this use.

Rules of use need to be posted so areas are not needlessly damaged. Some natural areas are in delicate balance and should be given only limited use.

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7. Places to Go

TO THE TEACHER

Teachers in the area of conservation education in both public and private schools often have need for advice, information, facilities and assistance of various kinds in order to do a fully adequate job of teaching the many concepts related to this broad field. The kind of help needed may vary from personal assistance with an outdoor class-study period to reference materials, visual aids and other things.

Today there are many agencies and organizations which have functions and responsibilities wholly or in part related to the development, use and conservation of natural resources. Many of these are public supported. All have deep-seated interest in resource conservation and welcome the opportunity to work with teachers and schools.

Up to this time there has been no single source of information available to teachers which lists these various groups and organizations, describes their functions and indicates the type of service and assistance they are equipped to furnish in the area of conservation education. This is the purpose of this chapter.

For addresses and phone numbers of these organizations and/or individual representatives at the county and local community level, the teacher should consult local telephone directories, local chambers of commerce or the office of the county extension director where fairly complete information of this kind usually is maintained.

Teachers are urged to seek assistance when they have need for it. In most instances the kind of assistance needed is or can be made available if the proper contacts are made far enough in advance.

HELP AVAILABLE

Resource People

Resource people in the area of conservation education usually are identified with public service agencies and organizations. Examples would be the State Conservation Commission, Extension Service, Soil Conservation Service and local soil conservation districts. All of these organizations have offices or persons in each county in Iowa — usually in county seat towns.

Agencies and Organizations

Agencies and organizations vary in the type of facilities they have for assisting in conservation education. This is true because each was created to do a special kind of work — something which no other agency or group was adequately equipped to do. Following is a listing of the better known public agencies and organizations and the functions which they are best equipped to perform:

Agency or Organization	Function
County extension staff	Agricultural education (informal).
County extension council	County program planning in agricultural extension education work.
Soil Conservation Service	Technical assistance in planning and applying soil and water conservation programs.
Soil Conservation District Commissioners	Coordinating various agency functions and administering the soil conservation program at the local level.
State Conservation Commission through local conservation officers	Information and education programs related to fish-wildlife and recreational areas and other related items.
Agricultural Stabilization and Conservation Service through the Agricultural Conservation Program (ACP)	Stimulate acceptance of soil and water conservation practices through cost-sharing benefits to cooperating farmers.
Izaak Walton League of America	Conservation and enjoyment of outdoor America through individuals, community chapters and state divisions.
County conservation boards	Development of recreational facilities through use of local county tax funds.

Agency or Organization	Function
Farm organizations	Promote programs in the long-time economic and social interest of farm people.

Other Service Organizations

Figure 7.4 lists service organizations usually available in all counties in the state with checked indications of the type of service normally available from each. Since the type of assistance available will vary somewhat from county to county and city to city, the checked areas cannot always be assumed to be accurate. Those organizations which deal with the natural resources in general or in a broad way such as Izaak Walton League, Boy Scouts and Girl Scouts, county conservation boards, League of Women Voters, etc., are shown as having only general services available. Only those organizations having trained specialists in specific natural resource areas are checked under the categories — Soil, Water, Forests and Wildlife.

Figure 7.5 gives similar information to that found in Figure 7.4 but for those service agencies and organizations at the state level and with statewide responsibilities. These organizations are often good sources for reference materials and visual aids as well as other services checked in the table.

STUDY AREAS

State-Owned Recreation Areas

Iowa has a large number of state-owned recreation areas well distributed over the state. These areas offer excellent opportunities for outdoor study in the broad area of conservation. There are also seven state forest areas having certain facilities which would lend themselves to the teaching of conservation concepts. Both the recreation and forest areas are shown and identified in Figures 7.6 and 7.7.

State-owned hunting and fishing areas where available to the teacher and her class may likewise be usable in studying various phases of animal and water life. These areas are listed in Figure 7.8. Federal Wildlife Refuges offer excellent opportunities to study native and migratory wildlife. These refuges are shown in Figure 7.9.

Watershed Development Areas

Watershed development areas make excellent subjects for outdoor study in the conservation of natural resources. Many such small watersheds are in various stages of development in Iowa. Several are completed such as Mule Creek in Mills County, Honey Creek in Lucas County, Harmony in Harrison County and more than 30 small watersheds in the Little Sioux River drainage area of northwest Iowa. These latter watersheds can be found in Monona, Woodbury, Ida, Cherokee, O'Brien and Buena Vista counties. See Figure 7.10.

Experimental Farms

The Iowa State University Experiment Station in addition to facilities for experimental work at Ames and Ankeny, operates several outlying experimental farms on various soil association areas of the state. These should, in the localities where available, afford an excellent opportunity for outdoor study in soils,

Fig. 7.1. Experimental farms operated by the Iowa State University Experiment Station are excellent for outdoor study in soils, crops, soil and water conservation and livestock.

soil and water conservation, crops, trees, fruits and other things depending upon location. These experimental farms are identified in Figure 7.7.

Other Study Areas

Many points of conservation interest in or near any community or metropolitan area may be the subject of a trip that can last for a few hours or even a day or more. In a theme built around soil, water, minerals, forests or wildlife, the potential is great and the field of study extremely broad. Following is a partial list of areas that should be considered for outdoor or out-of-classroom study in various areas related to conservation:

Well managed farms (Soil Conservation District cooperators)
Areas of excessive erosion (poorly managed farms)
Watershed development areas (See Extension or Soil Conservation Service representative)
State and local parks (See Fig. 7.6)
State forests (See Fig. 7.7)
Natural areas such as protected native prairies (See Fig. 7.6)
Flood prevention projects (Contact local Soil Conservation Service representative)
Wildlife management areas (Contact local conservation officer)
Biological stations (See Fig. 7.7)
City water systems
Filtering and treatment plants
City water reservoir
Industries that use large quantities of water
Industrial treatment plants
Sewage disposal systems
Lakes
Rivers
Polluted streams
Food processing plants
Saw mills
Paper mills
Gypsum mills
Pulp mills
Strip mines
Gravel pits and quarries
Geological formations
Flood and erosion damage after severe rains
Weather station
Nurseries
Greenhouses
Museums
Special events such as sports shows, wildlife painting displays and Soil Conservation Society of America photograph displays

TIPS FOR A SUCCESSFUL TOUR

A tour or field trip, well planned, and conducted in a business-like manner is one of the more dynamic teaching aids available to educational groups.

Your planning should include:

1. What the class will see.
2. Where and when it will be seen.
3. Definite transportation arrangements. Use bus transportation if possible.
4. A definite route. Use all-weather roads whenever possible. Avoid routes that present traffic hazards. Help from the Highway Patrol and

Fig. 7.2. Conservation specialists are available to help with field trips, tours and classroom discussion. This group is examining soil and learning about its properties and characteristics.

local law enforcement officers can be arranged in advance if needed.
5. Meal and rest stops. (Have clean-up committee.)
6. Information to agency or organization personnel who may be helping with the field trip. Be sure that each one knows where and when he will be needed and what is expected of him.
7. Making a pre-tour visit to all stops if possible.
8. Taking all necessary safety precautions, including care and disposal of waste materials.
9. Following up the field study trip with a discussion, an examination or evaluation period on what was learned.
10. Effectively correlating what was learned into other activities and subject matter areas. Use exhibits, displays, demonstrations, essays, scrap books and other methods.

EXHIBITS

Exhibits are an important facility in teaching. What is seen is often remembered and makes a lasting impression on the learner.

Exhibits take many forms. They can be outdoors, such as a well managed watershed; or indoors, merely depicting a concept in miniature form. The outdoor or "real" variety is very impressive. Equally as good are those which the children or learners develop with their own hands and skills.

Following are listed only a few places and facilities containing exhibits (natural or man-made) which are worthy of serious consideration. These are divided into two categories: state and local.

State Level

1. Conservation Commission Wildlife Exhibits
2. Conservation Commission Fur Exhibits
3. State Fish Hatcheries (See Fig. 7.8)
4. State Game Farms
5. State, City, College and University Museums
6. Iowa State University Experimental Farms. There are 13 outlying experimental farms well distributed over the state. (See Fig. 7.5)
7. Watershed development areas (See Fig. 7.7) Little Sioux Flood Prevention Program in northwest Iowa. Public Law 566 watershed development programs throughout the state. Contact the Soil Conservation Service locally.
8. State forest, hunting, fishing and recreation areas. (See Figs. 7.4 and 7.5)
9. Federal Wildlife Refuges (See Fig. 7.6)

Local or School Level

1. Catalogued material
2. Conservation projects in schools or on school grounds
3. School forests
4. Conservation farm models
5. Watershed models
6. Planting demonstrations
7. Collections (plants, insects, minerals and others)
8. Soil profiles
9. Water retention structure models
10. Terraria
11. Aquaria
12. Transparencies

Fig. 7.3.

13. Films and slides
14. Conservation and nature trails
15. Schoolyard weather station (correlate weather influences on soil, water, plant and animal life)
16. Science fairs
17. School camping

Fig. 7.4. Service Organizations in Counties and Their Facilities.

Services Available*	General				Specialists Available: Soil				Water				Forests				Wildlife			
At the County or Community Level	Speakers	Field trips	Projects	Exhibits	Speakers	Field trips	Projects	Exhibits	Speakers	Field trips	Projects	Exhibits	Speakers	Field trips	Projects	Exhibits	Speakers	Field trips	Projects	Exhibits
County Extension Staff	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
County Extension Council	X	X																		
Soil Conservation Service	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Soil Conservation District Commissioners	X	X		X																
State Conservation Commission through local Conservation Officers	X	X	X	X									X	X	X	X	X	X	X	X
Community Development Commission	X	X		X																
Agricultural Stabilization and Conservation Services	X																			
Local Schools and Colleges	X	X	X	X																
Izaak Walton League of America	X	X	X	X																
Local Organizations with conservation interests	X	X	X	X																
Public Utilities				X																
Industry	X	X		X	X			X	X			X	X	X	X	X				
Farm Bureau, Grange, NFO and Farmer's Union	X	X	X																	
Boy and Girl Scouts	X	X	X	X																
Camp Fire Girls	X	X	X	X																
Plant Iowa Committee	X		X	X									X		X	X				
County Conservation Boards	X	X	X	X																
League of Women Voters	X		X	X																
Ministerial Associations — soil stewardship	X																			

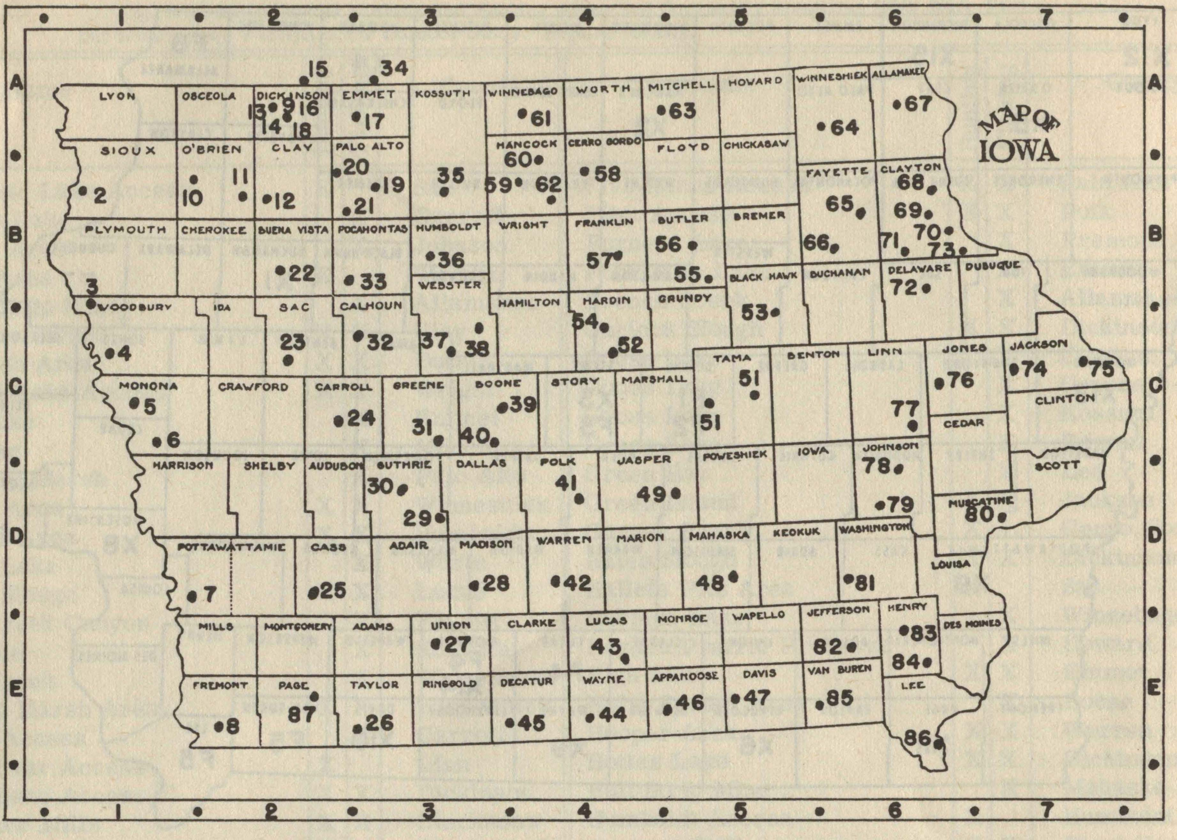
*Services are available for special purposes and/or in certain communities such as: Izaak Walton boys and girls conservation camps and special conservation field trips (contact Izaak Walton State Hdqts.); Teachers' Conservation Camp (contact State College of Iowa); 4-H Conservation Camp (contact local county ext. director); and projects under county conservation boards (contact local board chairman).

Fig. 7.5. Service Organizations at State Level and Their Facilities.

Services Available*	General					Specialists Available: Soil				Water				Forests				Wildlife			
At the State Level	Speakers	Field trips	Projects	Exhibits	Teacher train.	Speakers	Field trips	Projects	Exhibits	Speakers	Field trips	Projects	Exhibits	Speakers	Field trips	Projects	Exhibits	Speakers	Field trips	Projects	Exhibits
Iowa State University	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
State College of Iowa	X	X	X	X	X																
State University of Iowa	X	X	X	X	X																
All other colleges which participate in conservation education	X	X	X	X	X																
State Conservation Commission	X	X	X	X	X									X	X	X	X	X	X	X	X
State Soil Conservation Committee	X			X		X			X	X			X								
Iowa Natural Resources Council	X									X											
State Department of Agriculture	X																				
Soil Conservation Service (state office)	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Newspapers, Radio, T.V.	X		X		X																
State Sup't. of Public Instruction	X	X	X	X	X			X	X			X	X			X	X			X	X
State Geological Survey	X	X		X	X					X											
Soil Conservation Society of America (Iowa Chapter)	X		X	X																	
Izaak Walton League of America	X	X	X	X																	

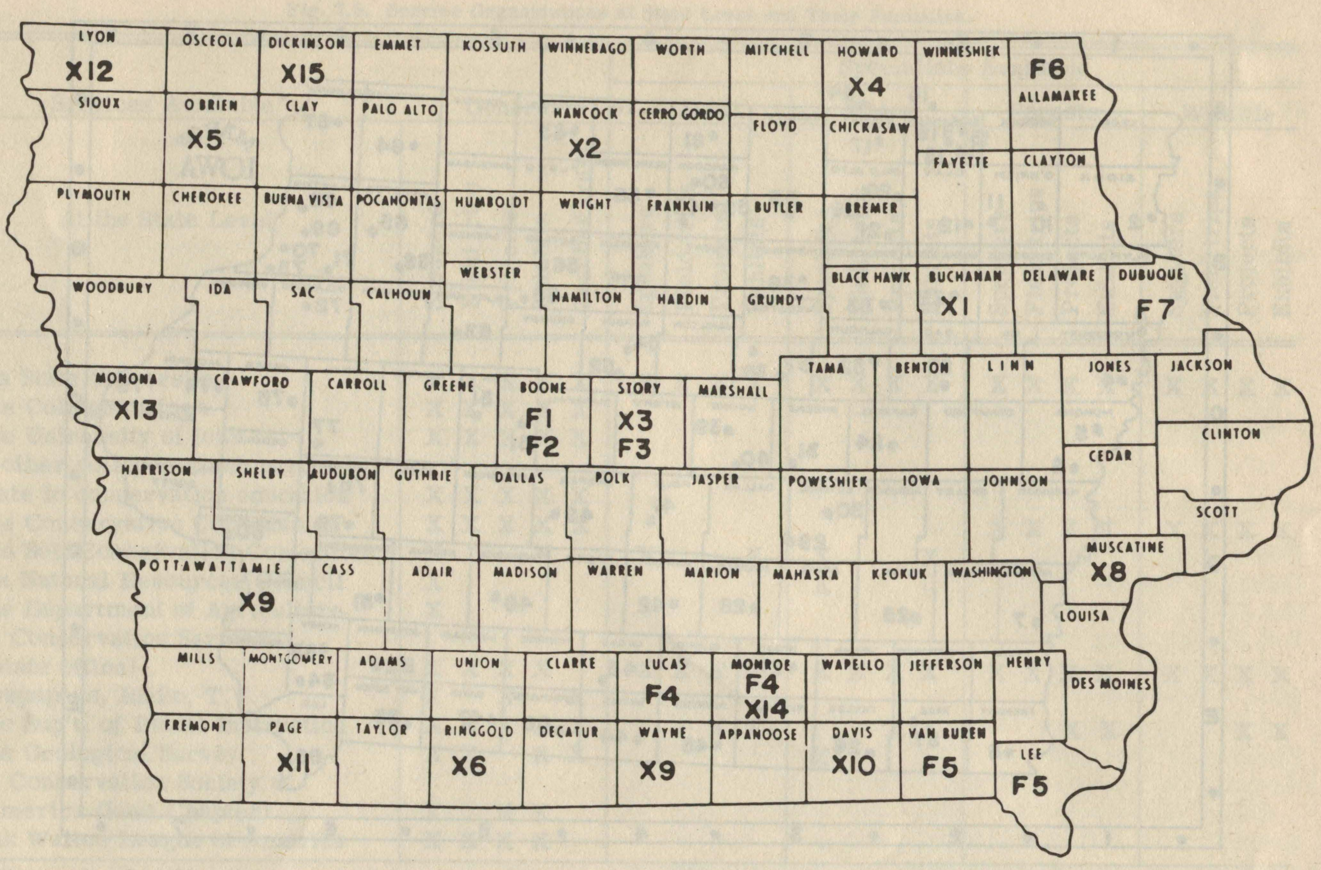
*For services or information in special fields not listed above such as rock formations, minerals, geology, prairies and wildflowers, contact Iowa State University, State University of Iowa, State College of Iowa, the Iowa State Geological Survey, the State Conservation Commission or the State Historical Museum (Des Moines).

Fig. 7.5. Service Organizations At State Level And Their Facilities.



Name	No. on Map	Location on Map	Name	No. on Map	Location on Map	Name	No. on Map	Location on Map
Ahquabi, Lake	42	D-4	Gull Point	13	A-2	Pine Lake	52	B-4
Allerton	44	E-4	Henry Woods	56	B-5	Pioneer	63	A-5
Ambrose, A. Call	35	A-3	Indian Village	11	B-2	Plum Grove	79	D-6
Backbone	72	B-6	Inn Area	16	A-2	Point Ann	69	A-6
Barkley	39	C-4	Kalsow Prairie	33	B-3	Preparation Canyon	6	C-1
Beaver Meadows	55	B-5	Kearny	19	A-2	Red Haw Lake	43	D-4
Beeds Lake	57	B-4	Keomah, Lake	48	D-5	Rice Lake	61	A-4
Bellevue	75	C-7	Lacey-Keosauqua	85	E-5	Rock Creek	49	C-4
Bixby	71	B-6	Ledges	40	C-3	Rush Lake	21	B-2
Black Hawk	23	B-2	Lennon Mill	29	C-3	Sharon Bluffs	46	E-5
Brown's Lake	4	B-1	Lewis and Clark	5	C-1	Springbrook	30	C-3
Brush Creek Canyon	66	B-6	Lost Island	20	A-3	Spring Lake	31	C-3
Clark, T. F.	51	C-5	Macbride, Lake	78	C-6	Steamboat Rock	54	B-4
Clear Lake	62	A-4	Manawa, Lake	7	D-1	Stone	3	B-1
Cold Springs	25	D-2	Maquoketa Caves	74	C-6	Storm Lake	22	B-2
Darling, Lake	81	D-6	Margo Frankel Woods	41	C-4	Swan Lake	24	C-2
Dolliver Memorial	37	B-3	McGregor Heights	68	A-6	Three Fires, Lake of	26	E-3
Eagle Lake	59	A-4	McIntosh Woods	58	A-4	Trappers Bay	9	A-2
Echo Valley	65	A-6	Mill Creek	10	B-2	Turkey River Mounds	73	B-6
Fish Farm Mounds	67	A-6	Mini-Wakan	15	A-2	Twin Lakes	32	B-3
Fort Atkinson	64	A-5	Nine Eagles	45	E-4	Union Grove	50	C-5
Fort Defiance	17	A-3	Oak Grove	2	A-1	Viking Lake	87	D-2
Galland School	86	E-6	Oakland Mills	83	D-6	Wanata	12	B-2
Gardner Sharp Cabin	18	A-2	Okamanpedan	34	A-3	Wapello, Lake	47	E-5
Geode	84	E-6	Palisades-Kepler	77	C-6	Wapsipinicon	76	C-6
Geo. Wyth Memorial	53	B-5	Pammel	28	D-3	Waubonsie	8	E-1
Gitchie Manitou	1	A-1	Pikes Peak	70	A-6	Wild Cat Den	80	D-7
Gotch, Frank A.	36	B-3	Pikes Point	14	A-2	Woodman Hollow	38	B-3
Green Valley	27	D-3	Pilot Knob	60	A-4	Woodthrush	82	D-6

Fig. 7.6. Recreational Areas.



State Experimental Farms

Key	County	Soil Association
X1	Buchanan	Carrington-Clyde
X2	Hancock	Clarion-Webster
X3	Story	Clarion-Webster
X4	Howard	Cresco-Kasson-Clyde
X5	O'Brien	Galva-Primghar
X6	Ringgold	Grundy-Shelby
X7	West Pottawattamie	Horticulture
X8	Muscatine	Sand (Muscatine Island)
X9	Wayne	Seymour-Shelby
X10	Davis	Edina (southern Iowa)
X11	Page	Marshall (Soil Conservation)
X12	Lyon	Moody
X13	Monona	Ida-Monona (western Iowa)
X14	Monroe	Southern Iowa Pasture
X15	Dickinson	Lakeside Biological Station

State Forest Areas

Key	County	Name	Facilities Available
F1	Boone	Pilot Mound Forest	Hunting, hiking
F2	Boone	Holst Forest	Hunting, hiking
F3	Story	State Forest Nursery	No recreation areas
F4	Lucas and Monroe	Stephens Forest	Hunting, hiking
F5	Lee and Van Buren	Shimek Forest	Hunting, hiking, picnicking
F6	Allamakee	Yellow River Forest	Fishing, hunting, hiking
F7	Dubuque	White Pine Hollow Forest	Hiking

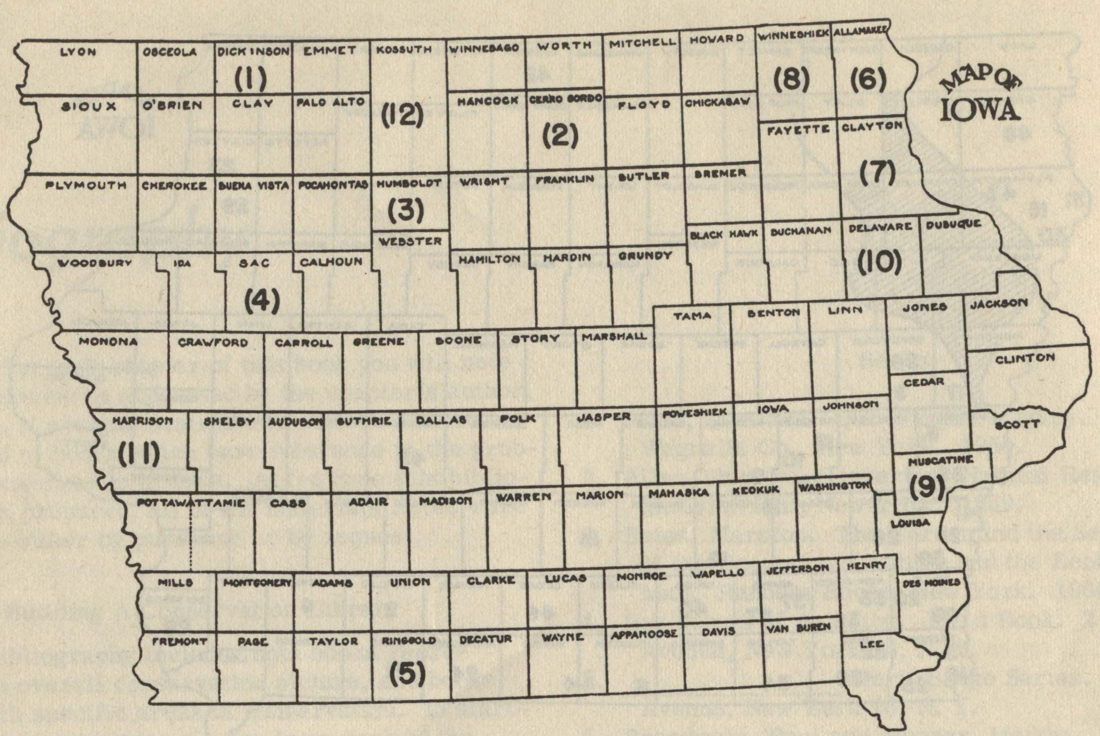
Fig. 7.7. Locations of State Experimental Farms and Forest Areas.

Fig. 7.8. State-Owned Fishing and Hunting Areas not Ordinarily Identified With State Parks but Which Have Facilities for Outdoor Study. Inquire locally.

Name	Hunting	Fishing	County	Name	Hunting	Fishing	County
Arrowhead Lake Access	X		Sac	Five Island Access	X	X	Palo Alto
Artesian Lake		X	Carroll	Flint Access	X	X	Polk
Babcock Area		X	Johnson	Forneys Lake		X	Fremont
Banner Area	X		Warren	Four Mile Lake		X	Emmet
Banner Strip Mine		X	Allamakee	French Creek		X	Allamakee
Barringer Slough	X	X	Clay	Garlock Slough	X	X	Dickinson
Big Marsh Area	X	X	Butler	Goose Lake		X	Clayton
Big Wall Lake Access	X	X	Wright	Goose Lake		X	Greene
Birge Lake		X	Emmet	Goose Lake		X	Kossuth
Blue Lake		X	Monona	Grass Lake		X	Emmet
Blue Wing Marsh		X	Palo Alto	Green Bay		X	Lee
Bluffton Area	X	X	Winneshiek	Green Island	X	X	Jackson
Bradgate Area	X	X	Humboldt	Garner Beach	X		Cerro Gordo
Brights Lake		X	Worth	Hales Slough	X	X	Dickinson
Browns Slough	X	X	Lucas	Hallets Pits Area	X		Sac
Brush Creek Canyon		X	Fayette	Harmon Lake		X	Winnebago
Burt Lake		X	Kossuth	Hayden Prairie Preserve		X	Howard
Canoe Creek		X	Winneshiek	High Lake	X	X	Emmet
Cardinal Marsh Area	X	X	Winneshiek	Holst Forest Area		X	Boone
Carroll Access		X	Carroll	Hooper Area	X	X	Warren
Cedar River Access	X		Linn	Hottes Lake	X	X	Dickinson
Center Lake Access	X	X	Dickinson	Hull Strip Mine		X	Mahaska
Chickasaw Mills	X	X	Chickasaw	Humboldt Access	X		Humboldt
Childs Access	X		Black Hawk	Husman Riffle	X	X	Black Hawk
Christopherson Slough		X	Dickinson	Ingham Lake	X	X	Emmet
Coldwater Springs		X	Winneshiek	Iowa Lake	X	X	Emmet
Colyn Access Area	X	X	Lucas	Iowa Lake	X	X	Osceola
Coon River Access	X		Carroll	Jemmerson Slough	X	X	Dickinson
Cottonwood Pit Area	X	X	Monroe	Kains Lake		X	Allamakee
Crandalls Beach	X	X	Dickinson	Kellogg Game Area		X	Jasper
Crystal Lake Area	X	X	Hancock	Keokuk Lake		X	Muscatine
Cunningham Slough	X		Emmet	Klum Lake		X	Louisa
Cutshaw Bridge	X	X	Buchanan	LaHart Area	X	X	Monroe
Dakota City Access	X		Humboldt	Lake Cornelia	X		Wright
Dalton Lake Area	X	X	Jackson	Lake Manawa	X	X	Pottawattamie
Dan Green Slough	X	X	Clay	Lake Odessa		X	Louisa
Dead Man Lake	X		Hancock	Lakin Slough	X	X	Guthrie
Decatur Bend Access		X	Monona	Lansing Big Lake		X	Allamakee
Deception Hollow Access	X	X	Webster	Lewis Lake	X		Linn
Del Rio Access	X	X	Polk	Little Clear Lake	X	X	Pocahontas
Deweys Pasture		X	Clay	Little Spirit Lake	X	X	Dickinson
Diamond Lake Access	X	X	Dickinson	Little Storm Lake	X	X	Buena Vista
Dudgeon Lake	X	X	Benton	Little Wall Lake	X	X	Hamilton
Dunbar Slough		X	Greene	Lizard Creek Area	X	X	Webster
Eagle Lake		X	Emmet	Lizard Lake	X	X	Pocahontas
Eagle Lake		X	Hancock	Lower Gar Lake	X		Dickinson
Earlham Access	X	X	Dallas	Mac Coon Area	X	X	Jefferson
East Okoboji Access	X	X	Dickinson	Malanaphy Springs	X	X	Winneshiek
East Swan Lake		X	Emmet	Marble Lake	X	X	Dickinson
East Twin Lake		X	Hancock	Matsell Bridge Access	X	X	Linn
Edgewater & Tama Beach	X		Des Moines	McCord Pond	X	X	Guthrie
Eldon Game Area	X	X	Davis	McIntosh Woods	X		Cerro Gordo
Elk Lake		X	Clay	Minne Estema	X	X	Benton
Elm Lake Access	X	X	Wright	Minnewashta Lake	X		Dickinson
Emerson Bay Access	X		Black Hawk	Morse Lake	X	X	Wright

Fig. 7.8. State-Owned Fishing and Hunting Areas not Ordinarily Identified With State Parks but Which Have Facilities for Outdoor Study. Inquire locally.

Name	Hunting	Fishing	County	Name	Hunting	Fishing	County
Mt. Ayr Game Area	X	X	Ringgold	Silver Lake	X		Delaware
Mud Hen Lake		X	Allamakee	Silver Lake	X	X	Palo Alto
Mud Lake		X	Clay	Silver Lake		X	Worth
Muscatine Slough	X	X	Louisa	Skunk River Access	X	X	Des Moines
Muskrat Slough		X	Jones	Smiths Slough	X	X	Clay
Myre Slough		X	Winnebago	Soper Mills	X	X	Story
New Albin Big Lake		X	Allamakee	South Twin Lake	X	X	Calhoun
Nobles Lake	X	X	Harrison	Spirit Lake		X	Dickinson
North Bear Creek		X	Winneshiek	State Fishing Dock	X		Cerro Gordo
North Road Grade	X		Dickinson	Stephens Forest	X	X	Lucas
North Twin Lake		X	Calhoun	Stripping Station	X		Dickinson
No. 9 Highway Grade Access	X		Dickinson	Sunken Grove		X	Pocahontas
Ocheydan Game Area	X	X	Clay	Sunken Lake	X		Dickinson
Onawa Materials Yard		X	Monona	Sweet Marsh	X	X	Bremer
Opedahl Area		X	Palo Alto	Swiss Valley Access		X	Dubuque
Orleans Access	X		Dickinson	Thayer Lake	X		Union
Otterville Bridge	X	X	Buchanan	Toolesboro	X		Louisa
Pella Strip Mine		X	Marion	Towhead Lake		X	Calhoun
Pickerel Lake	X	X	Buena Vista	Trumbull Lake	X	X	Clay
Picture Rock Area	X	X	Jones	Tuttle Lake	X	X	Emmet
Pillsbury Point Access	X		Dickinson	Twelve Mile Lake		X	Emmet
Pleasant Lake	X	X	Dickinson	Upper Gar Lake	X		Dickinson
Port Louisa	X		Louisa	Ventura Marsh	X	X	Cerro Gordo
Prairie Lake	X	X	Dickinson	Viking Lake	X		Montgomery
Rainbow Bend	X	X	Calhoun	Virgin Lake	X	X	Palo Alto
Randolph Access	X	X	Iowa	Walnut Woods Access	X		Polk
Rippey Area	X	X	Greene	Washto Access	X	X	Ida
Riverton Area	X	X	Fremont	Weise Slough	X	X	Muscatine
Round Lake	X	X	Harrison	Welch Lake	X	X	Dickinson
Round Lake	X		Clay	West Blue Lake	X		Monona
Ryan Lake		X	Emmet	West Okoboji		X	Dickinson
Sac City Access	X	X	Sac	West Swan Lake	X	X	Emmet
Sand Run	X		Louisa	West Twin Lake	X	X	Hancock
Shaeffer Point	X		Louisa	White Pine Hollow		X	Dubuque
Shimek Forest		X	Lee	Williamson Pond	X	X	Lucas
Silver Lake	X	X	Dickinson	Yellow River Forest	X	X	Allamakee



STATE FISH HATCHERIES

(1) Orleans
(2) Clear Lake
(3) Humboldt
(4) Lake View
(5) Mt Ayr
(6) Lansing
(7) Strawberry Point
(8) Decorah

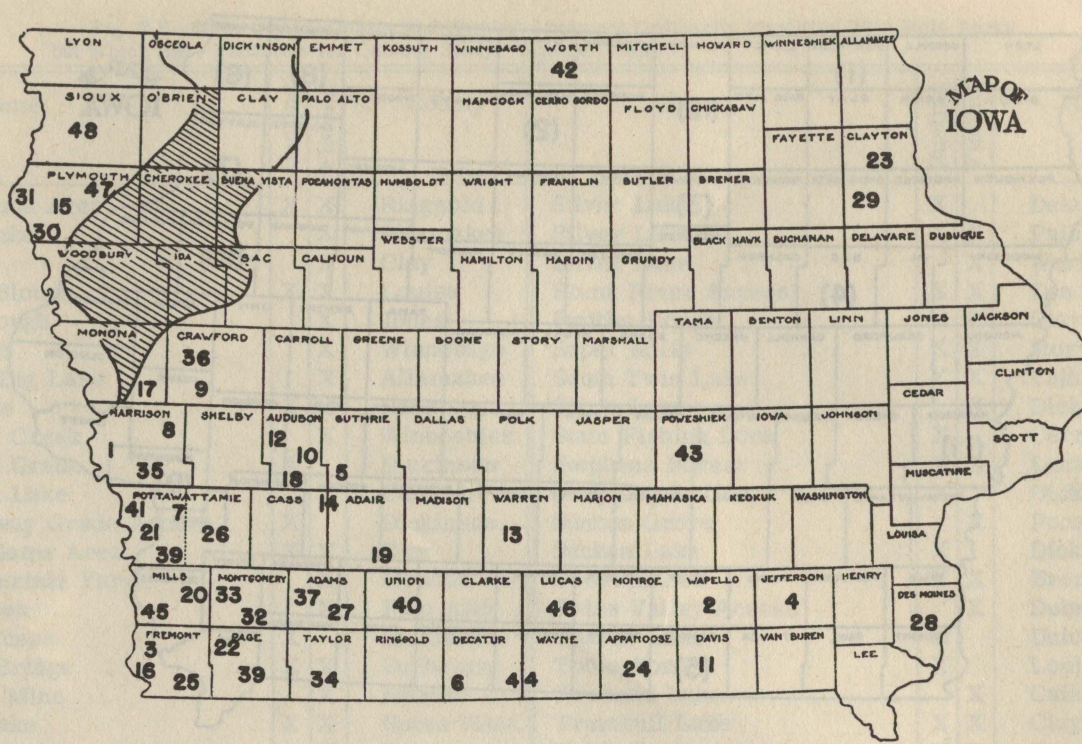
U. S. FISH HATCHERIES

(9) Fairport
(10) Manchester

FEDERAL WILDLIFE REFUGE AREAS

(11) Desoto Bend
(12) Union Slough

Fig. 7.9. State Fish Hatcheries; U. S. Fish Hatcheries; Federal Wildlife Refuge Areas.



PUBLIC LAW 566 WATERSHEDS	County
1. Harmony	Harrison
2. Chippewa	Wapello
3. Simpson Creek	Fremont
4. Rocky Branch Creek	Jefferson
5. Upper Crooked Creek	Aud., Guthrie, Cass
6. Big Creek	Decatur
7. Indian Creek	West Pott.
8. Mill-Picayune	Harr., Shelby, Craw.
9. Big Park	Crawford
10. Davids Creek	Audubon, Guthrie
11. Big Wyacondah	Davis
12. Blue Grass	Audubon
13. Badger Creek	Madison, Dallas, Warr.
14. Turkey Creek	Cass, Aud., Guthrie, Adr.
15. Held	Plymouth
16. Hamburg	Fremont
17. Davis Battle Creek	Monona
18. Troublesome Creek	Guthrie, Cass, Aud.
19. Three Mile Creek	Adair, Union
20. Pony Creek	Mills, W. Pott.
21. Ryan Henschel	West Pott.
22. Pierce Creek No. 1	Page
23. Clayton	Clayton
24. Moulton	Appanoose
25. Hound Dog Creek	Fremont

Name	County
26. Bee-Jay	East Pott.
27. Walters Creek	Adams
28. Yellow Spring Creek	Des Moines
29. Cox Creek	Clayton
30. South Hungerford	Plymouth
31. Gant Creek	Plymouth
32. Red Oak Creek	Montgomery
33. Stennet Creek	Montgomery
34. Blockton	Taylor
35. Mosquito of Harrison	Harrison
36. Dane Ridge	Crawford
37. West Douglas	Adams
38. West Tarkio	Page, Montgomery
39. Twin Ponies	W. Pott., Mills
40. Twelve Mile	Union, Adair
41. North Pigeon	West Pott.
42. Deer Creek	Worth
43. Diamond Lake	Poweshiek
44. Caleb Creek	Wayne

PILOT WATERSHEDS	
45. Mule Creek	Mills
46. Honey Creek	Lucas
47. Upper Plymouth	Plymouth
48. Nassau	Sioux

Fig. 7.10. Organized watersheds in various stages of development, as of December, 1961. Included are Little Sioux Flood Prevention Authorized Area (cross-hatched area on map), Pilot Watersheds, and those Public Law 566 Watersheds approved for assistance.

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Following each chapter of this book you will note a list of references suggested by the chapter's author. In addition, it seemed desirable to include a more extensive list of books which have relevance to the problems of conservation in Iowa. At the time this bibliography was prepared, all of the materials listed were available — either by purchase or by request.

Building A Conservation Library

This bibliography includes both books representing the overall conservation picture, and books dealing with specific areas of conservation. In starting a library, select some titles from each of the areas. If some conservation subjects are already adequately covered in your library, select books from other areas so as to round out the subject-matter coverage. This is a selective, rather than a complete, listing, so that all titles will be useful in a small conservation library.

Some of the more useful information appears in the form of booklets or pamphlets that are available for a time, and then go out of print. Sometimes nothing of equal interest or value takes their place. Therefore, a library should have some means, such as a series of file boxes, for collecting and filing such materials. The pamphlet headings used in this bibliography may serve as a guide to indexing your own collection.

Films

A film bibliography has not been included. Films can be obtained most readily through the local representatives of state or federal agencies, or from the film library catalogs of Iowa State University and the State University of Iowa. The local representatives to be contacted include: county conservation offices, for materials from the Iowa State Conservation Commission; county work unit conservationists for Soil Conservation Service materials; and county agricultural extension directors for materials from Iowa State University. These representatives may also be able to supply some publications on conservation.

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