IT'S YOUR SOIL TOO!

IOWA STATE UNIVERSITY of Science and Technology
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Have you stood on the bank of a stream after a heavy rain and noticed how the water is colored? It's dark because soil is mixed with the water. Since white men began cultivating Iowa soils, about 100 years ago, billions of tons of soil have been carried away by water.

Explorers Found Forests and Prairies

The early explorers who came to Iowa found hardwood forests growing along the larger streams. These hardwoods included such trees as the oak, maple and walnut. Between the larger streams on the vast prairies, grew grasses that were taller than man. It was in this grassland and along the streams that all Iowa's plants and animals lived and died. There was little waste. Plants took from the soil what they needed for growth. The remaining portions of dying plants became organic matter in the soil. Also animals ate the plants; when the animals died, their bodies became a part of the soil.

Some of the soil washed away in that age, but it washed away slowly under the trees and the tall grass. The slow action molded the hills, cut the valleys and widened the stream beds. But in the main, nature rebuilt the soil as fast as it wore away. During this time most of the soil stayed where nature placed it.

Fig. 1. Early explorers who came to Iowa found hardwood forests growing along the major streams.

How Is Soil Wasted?

Today the picture has changed. Wind and running water are eroding soil on sloping land which is not adequately protected. Soil is being wasted by poor land use and failure to use the right management practices. This wasting of soil causes the muddy creeks and streams that you have watched so often. Streams carry away thousands of tons of soil each year.

Plant food materials are also lost when farmers sell grain off the farm. In the grain are plant food materials taken from the soil. Even the animals that are sold from the farm represent a loss of soil materials, since they fed on plants that grew on the soil. We must put these soil materials back in the soil if we want to keep it productive.

We Depend on the Soil

Iowa is mostly a farming state. Nearly three-fourths of the total area of Iowa is cultivated cropland. Much of Iowa's prosperity depends on producing good crops. This in turn depends upon the productivity of the soil. So soil conservation is important to all of us. When essential soil materials are lost by erosion, overgrazing or the sale of grain and animals, townspeople as well as farmers are the losers.

Fig. 2. Much of Iowa was covered with vast prairies of tall native grasses. Many species of grasses and legumes grew on the prairies.

You have learned in your study of science how the chlorophyl of the green leaf combines the elements in air, water and soil to form plants. This is done in an action (photosynthesis) that seems like magic. You also know that these plants in turn make food for animals. You can see why no animal can live without plants.

Minerals (such as calcium and phosphorus) which animals need in order to live are in the plants they eat. If the soil doesn't have enough of these minerals, the plants won't grow well. Neither will the plants have enough minerals in them for man and

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Prepared by F. W. Schaller, extension agronomist; T. L. Willrich, extension agricultural engineer; C. R. Ballantyne, extension soil conservationist.
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animals—enough minerals to make them grow well and keep healthy and strong. Some animals live by eating other animals, but the animals that are eaten use plants for food. Neither man nor animals can live without plant life; and most plant life depends upon the soil.

Iowa is well supplied with good soil. It has a warm growing season and usually enough water to grow bountiful crops. Iowa leads all states in the production of corn and oats. It ranks second in the production of soybeans and third in hay. It leads all states in cash receipts from the sale of livestock and livestock products.

It is not just because Iowa has good farmers that it ranks so high in output of farm products. It is because Iowa also has good soil—soil that furnishes what is needed for plant growth. We must remember that we are not getting these wonderful crops for nothing. We pay a high price for them with our soil. As crops grow, they use up the plant food in the soil. If we care for the soil in the right way, it will last a long time and continue to grow good crops. The right way is to select crops best suited to each kind of soil, and use management practices that prevent serious erosion and maintain productivity.

HOW ARE SOILS MADE?

What are soils made of? Soils are formed from mineral and organic matter. The *mineral matter* originally came from rock. *Organic matter* is the remains of plants and animals. Before soils can form, the mineral matter and organic matter must

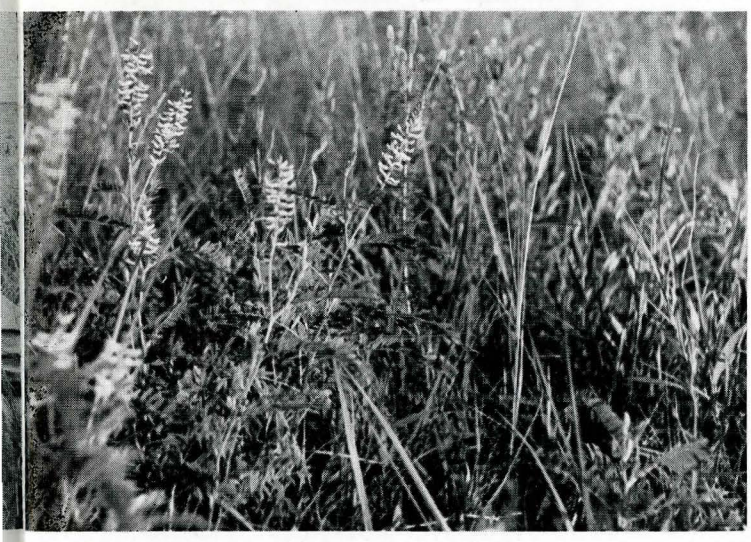

Fig. 3. Close-up of prairie vegetation.

be broken into small pieces. The breakdown of mineral matter is called *weathering*. The breakdown or rotting away of organic matter is usually called *decomposition.*

Weather Breaks the Rocks

In physical weathering the original material changes in size and often in shape. Glaciers grind up rocks, crush and shatter them. They carry huge blocks of ice and boulders which grind and dig their way across rock surfaces as the ice moves slowly along. Moving water carries rock particles of all sizes which bump and roll along, wearing off pieces as they go. River gravel is round on the edges because the corners have been knocked off and worn smooth as the river rolled the gravel along.

Wind picks up silt and sand and hurls it against rocks. The silt and the sand wear the rocks away. A single sandstorm on the sea coast will sometimes cut or wear the glass of a lighthouse so that it will have to be replaced.

Rocks are broken by freezing and thawing. When water freezes it expands. Water expanding in the cracks of rocks makes the cracks larger. The heating and cooling of rocks sometimes causes them to break apart, just as pouring hot water on a cold glass may break the glass.

The roots of trees growing in cracks in rocks will often split the rocks. Perhaps you have seen rocks that have been broken by roots. Even animals do their part to break up the rocks. They dig in loose rock, roll rocks around, start landslides and build dams.

Chemistry Helps, Too

In chemical weathering the material is broken down into parts which no longer have the same form as the original. Chemical weathering of rock is not so easy to see as physical weathering. But we can see its results everywhere about us: caves formed in limestone, rust on old pieces of iron, rust on rocks with iron in them—these are all results of chemical weathering. The sea is full of salt that was once part of rocks before chemical weathering set it free.

Chemical weathering works hand in hand with physical weathering to break rocks into material that can be made into soil.

Plants Turn Into Soil

Most of the decomposition or breakdown of organic matter is caused by tiny plants, so small you can see them only with a microscope. We call the tiny plants *micro-organisms*. The most important of

these are the *bacteria* and *fungi*. These small plants decompose organic matter; in doing so they set free the minerals taken from the soil. This makes it possible for other forms of life to use the minerals over again. This is nature's way of saving soil minerals. Without decomposition (rotting), all minerals would be tied up in the remains of plants and animals. Then no new plants could grow. Soil organic matter is also called *humus*.

Trees, Grass, Rocks Make Soil

The glaciers, which came into Iowa four different times, ground rocks into grit and dust. Then came the running water and wind; they scattered grit and dust all over Iowa in deep layers. This was the first step in the building of Iowa soils. Native timber and grass added the organic matter. After awhile soil layers began to develop. Under the trees and grass, a deep, dark, rich surface-soil formed. When the white man first came to Iowa, all the state was covered with this rich topsoil. This rich soil has made Iowa farmers prosperous. It has made Iowa one of the greatest food-growing areas in the world.

Can you guess how long it took the soil to form? It took hundreds of years to build one inch of this good topsoil. But it can be lost very quickly. One heavy rain can carry away more than one inch of this soil if the land has been carelessly farmed. To be able to stop it, we must learn as much as we can about the soil.

Soil Is in Layers

After being left on the surface of the earth awhile, parent material begins to develop layers. Soil is made up of three layers. The top layer is called topsoil, and it may vary in thickness from a few inches to about 16 inches. Beneath the topsoil is the subsoil, which may be a few inches to about 2 feet thick. Beneath the subsoil is the soil parent material, and it often is many feet thick. To show you how these layers differ we will tell you something about each one.

In the top or surface layer, roots and organic matter are most plentiful. This organic matter (plant and animal material) gives the topsoil a dark color. In most Iowa soil, water filtering through the topsoil carries clay particles into the lower layers. The top layer usually is the richest or most productive part of the soil. It is loose and porous like a sponge, and soaks up water and stores it for plants to use later on.

The subsoil, next below the topsoil, is not so loose. It is heavier and more compact because it contains more clay, part of which filtered down from the topsoil. Since the subsoil contains less organic matter, its color is lighter than the topsoil.

The third layer is soil parent material which has been changed little or none by soil-forming processes.

Later we shall learn other reasons why the topsoil is the most productive. Now we'll take a look at soils and the way they nourish plants.

HOW DO WE MAKE SOIL PRODUCTIVE?

The productivity of a soil is its ability to grow crops. One aim of soil conservation is to keep the soil productive. Often soil becomes more productive when we use the right soil management and conservation practices. Soil productivity depends upon two important factors: (1) the right amount of water and air around the roots and (2) enough of the right plant nutrients (plant food).

Air and Water for Roots

First, let's see why it is important to have the right amount of water and air around the roots. Roots need air to breathe, just as animals do. Plants can drown. A few plants have become adapted to living in water, just as a few animals, like fish, live in water. But most of our common crops must have air around their roots in order to live.

To have good circulation of air, the soil must have enough large pores (openings) in it to let excess water pass through. It must also have enough underground drainage to carry excess water away. In some places where the soil does not have enough underground drainage, we must build drains to carry some of the water away. That's what tile lines and ditches are for—to carry away excess water.

The Soil Particles

Soil particles may be made up of single pieces of rock or organic matter; or they may be made up of clumps or clusters of little pieces of rock or organic matter. The rock material is divided by size into three groups—sand, silt and clay. You can see and feel sand, the largest of the three. If you take some soil in your hand, wet it and rub it between your fingers, you can feel the sand.

Silt particles are much smaller than sand. Most of the single particles can be seen only through a microscope. Even if you try hard, you can't feel the separate particles of silt in soil. When you rub it between your fingers, it feels smooth like talcum powder.

But the smallest of the soil particles are clay. Clay particles are so small they can't be seen through an ordinary microscope. They form sticky masses when wet and hard lumps when dry.

If you would place a pumpkin, an egg and a wheat seed side by side, the pumpkin could represent a sand particle, the egg a silt particle and the wheat seed a clay particle. This gives you an idea how much smaller the silt and clay particles are. It is hard for us to imagine how small the clay particles really are.

Pore Spaces

Pore spaces are the openings in the soil; they contain only air and water. The size of the pore spaces depends much on the soil particles. The pore spaces in a sandy soil are so large that the soil can't hold water except for a short time. The water either drains away or evaporates into the air. Because of this, few plants can grow in extremely sandy soil unless rains come often or unless we add water by irrigation.

Silt, because its particles are smaller, has smaller but many more pore spaces between the particles. It therefore can hold more water and hold it longer than sand.

Clay, because its particles are the smallest of the three, can hold the most water and hold it longest. Clay can hold even more water, however, if we add organic matter to it. Organic matter will absorb and hold more water than any other soil material. Clay is a good water-holder. But too much clay in a soil will clog the pores; then it will keep water from draining away unless the soil has *good structure.*

What Is Soil Structure?

What do we mean by *good soil structure?* A soil has good structure when the particles are grouped tightly together into clusters called granules. We say that such a soil has a *granular* structure. Farmers know that granular structure is good. You can see granular structure if you take a handful of topsoil from beneath an old grass sod. The granules look like bread or cake crumbs. In fact, farmers often call the granules "crumbs."

When the clay particles in a soil are held with silt and sand particles in granules or crumbs, there are plenty of open pore spaces between the granules. Air and water can pass readily through these pore spaces. Thus, good granular structure allows surplus water to drain out and air to get into the soil, even if the soil has quite a bit of clay in it. If the clay particles were not held in granules, they would sift down into the pore spaces and clog them.

A soil with good granular structure will not be carried away easily. Rain will soak into it instead of running off (flowing away over the ground surface). Another reason why soil with granular structure is not easily carried away is that the clay particles are stuck together in crumbs. If soils have good granular structure, plant roots can grow in them quite easily.

You can see that soil structure is very important. We can't have productive soils without good structure. Soils with poor structure are usually slow to drain and may suffer from too much water and not enough air. Soils with poor structure are hard when dry and sticky when wet. Such soils are easily carried away by wind and water. They are also hard to work.

Have you ever made mud pies? You were really puddling the soil by mixing or working it when it was very wet. What you did was to break down the granules and cause the fine clay and silt particles to run together, forming a dense, compact mass. So good soil structure can be injured by plowing or cultivating soil when it is too wet.

We Can Improve Structure

Getting organic matter into soil helps its structure. Soils which have a large amount of organic matter are usually granular. We know that soil structure is improved by freezing and thawing, wetting and drying. Have you ever noticed how soil becomes looser in the spring after it has been fall-plowed and left exposed to the frost all winter?

We also know that good granular structure will form where grass roots are growing. In fact, growing grass is a good way to improve the structure of a soil. Topsoils usually have better structure than subsoils. One reason for this is that there is more organic matter and root growth in the topsoil.

Because the topsoil has good granular structure, we must not allow it to wash away. Once it is gone, the subsoils, which often have much clay and little organic matter, will become puddled easily.

Atoms and Elements

You have heard a great deal about the *atom.* No doubt you have found it rather mysterious and hard to understand. All matter is made up of small packages or units of material. It took scientists a long time to find this out. These units are called atoms. Groups of atoms which act alike are called elements. There are about 100 different kinds of elements.

Now you are wondering, "What is an element?" An element is a substance which has only one kind of atom in it. For example, lead is an element made up of only lead atoms. Silver is an element containing only silver atoms. Everything exists as a pure element, such as gold, lead, zinc and tin, or as a combination of elements, such as iron oxide, which contains iron and oxygen. You know this combination of elements as iron rust.

In order for a plant to live, it must have 16 important elements. Mother Nature takes 13 elements from the soil and moves them up through the roots and stems to the leaves. She takes the three other elements from the air and water. The sun combines the 13 soil elements and the three air and water ele-

ments into plant food. Every one of the 16 elements is needed for plant growth. If one element is missing, the plant will not live. These elements that plants need are called essential *plant nutrients*.

Many of the elements found in rocks can't be used by plants because they are not in the proper form. When this is the case, we say the elements are not available or are unavailable. When elements are in forms that can be taken from the soil by the plant, we say the elements are available. As rocks change to soil, some of the unavailable plant nutrients in them change to available forms. Plant nutrients are usually more readily available in a *developed soil* than in the soil *parent material.* Also, nutrients are usually more available in surface soils than in subsoils. When the soil doesn't have enough of any one necessary nutrient in available form, we may add it by using fertilizers.

How Do Soils Lose Productivity?

There are four ways by which soils lose productivity:

1. Organic matter decomposes and the amount in the soil decreases. Decomposition occurs when soil organisms such as bacteria and fungi break down the organic matter. Plowing and cultivating speed up decomposition and the loss of organic matter from soil.

2. Nutrients are lost by *leaching*. Leaching is the washing of minerals from the soil as water drains through it. Leaching is important in Iowa, but only over long periods of time or in sandy soils. Unless excess water drains away, most crops will not grow well. As the water drains down through the soil, it carries away some soil minerals, among them some of the plant nutrients.

3. Nutrients are lost through the growing of crops and animals. The nutrients that are used by plants are lost from the soil if the crops are taken off the farm. Soil nutrients are also carried away in the bodies of animals and in milk, wool and hides sold from the farm. When an animal eats a plant, it eats nutrients that have been taken from the soil by the plant. On the average only one-fourth of these nutrients stays in the animal; the other three-fourths go into the manure. So if a farmer saves the manure and spreads it on the land, he will usually save part of the soil nutrients removed by the crops.

4. Nutrients are lost through soil erosion. This is an important cause of soil nutrient losses in Iowa. We shall discuss it at some length here.

SOILS WEAR AWAY—THAT'S EROSION

By erosion we mean wearing away. Many kinds of erosion are going on about us. We are most interested in water erosion, because it is the kind that does the most damage in Iowa.

It's the force of running water that does the eroding. Deep, fast-running water has more force than shallow, slow-running water.

If you take a pail full of water and throw it out fast—dash it out—along the top of the ground, it will wash. But if you pour out the same amount of water slowly, it won't wash away the loose pieces of soil and other things on top of the ground. That's why water that flows fast will wash or erode land more than water that flows slowly. If the water runs fast, it will carry more soil with it.

The rate of erosion (or amount of soil that will be washed away in a given time) will depend also on how easily the soil will erode. For example, water may be flowing over two different kinds of soil at the same rate, at the same depth and for the same

Fig. 4. Soil is being wasted by poor land use and failure to use the right management practices.

length of time. Yet one soil will wash away much faster than the other. This is because the two soils differ in their ability to resist erosion.

Let's see what it is that makes water run fast and deep and what it is that makes some soils resist erosion. Maybe we can then decide what farmers have to do to stop erosion on their farms.

Flowing Water Erodes Soil

We know that the steeper the slope of a stream, the faster the water will move in it. If you have ever taken a trip to the mountains, you will remember how much more swiftly the streams flowed there than they do in Iowa. Every farmer knows that water runs faster on a steep slope, but he can't do much to decrease the slope of his land. It would cost him too much.

There are some things, however, that farmers can do to slow down water running over the surface of the land. They can plant grass where erosion is worst. They can use a mulch or crop litter made up of such things as leaves, straw and cornstalks spread over the soil. Plant rows can be run across instead of up and down the slopes; this will make them act as little dams to check the flow of water. Farmers can do all these things (and others discussed later) to reduce the power of water to pick up soil particles and carry them along.

Now let's see if we can answer the question "What can the farmer do about depth of flow?" The depth of flow depends on the amount of water that runs off the land. This depends largely on how hard and how long it rains; it depends on how fast ice and snow melt and how long the melting lasts. Since the farmer can't do much about the weather, he can't control these factors. As someone has said, "Everybody talks about the weather but nobody does anything about it." There is nothing we can do to change the weather. But we can do a great deal about what the rain and snow do to our land.

The amount of water that runs off the land doesn't depend entirely on the amount that falls on it. It depends also on how well the soil absorbs water. The more water the soil will soak up, the less there will be to run off. The amount of water that a soil will absorb from a rain depends on how long the water is on the land and how porous the soil is. So anything farmers can do to slow down the flow of water over their land and to make their soils more porous will help prevent erosion.

Farmers can do several things to hold water on their land and give it a chance to soak into the soil. We will describe these things briefly in the next section.

How Can We Help Soils Resist Erosion?

The main things that help soils resist erosion are good soil structure and a good covering of plants. We can do much to improve soil structure. You will recall that soil structure is usually best where the soil has much organic matter. Anything farmers can do to add organic matter to their soil will (1) improve the structure, (2) give the soil ability to hold more water and (3) make the soil less likely to erode. There are many ways we can add organic matter to the soil. Farmers do this mainly by plowing under manure and plant vegetation such as straw, cornstalks and remains of hay crops.

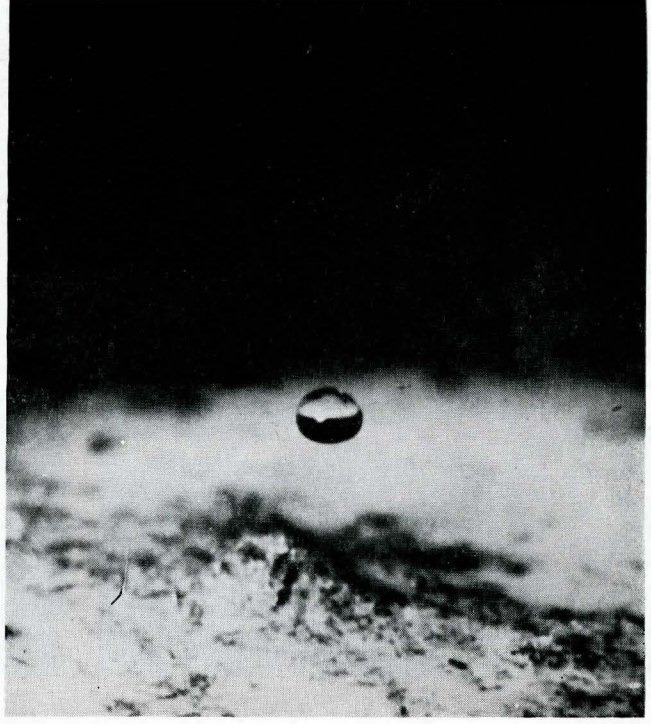

Fig. 5. A raindrop falls . . .

Plant cover prevents erosion, since it helps to stop and hold the individual raindrops where they fall. Stopping a raindrop is like trying to catch a miniature bomb. The result of a drop of water falling on bare soil somewhat resembles the action of an exploding bomb. Each raindrop digs a small hole in the ground surface. The loosened soil can then be easily washed away if the water is not held where it falls.

We can protect the soil from raindrop bombardment and splash erosion by growing a good covering of crops. A growing crop serves as the best umbrella over the soil surface to break the force of the raindrop. It lets the water flow and drip more gently

Fig. 6. . . . and explodes as it strikes unprotected soil.

Fig. 7. Furrows and wheel tracks on the contour will hold and store rainfall.

Fig. 8. Contour listing or ridge planting provides larger furrows for storing rainfall.

to the ground surface. Also, the many roots of the growing plants bind the soil particles together. The soil is more difficult to loosen and carry away.

We can also protect the soil from raindrop impact and splash erosion by leaving *crop residues* on the soil surface. Crop residues are the plant stems and leaves that are left after a crop is harvested.

Small Dams Hold the Water

Frequently rain "falls by the bucketful" and cannot soak into the soil as rapidly as it falls. If the raindrop is to be held where it falls, it must be "dammed up" and stored on the soil surface. Various kinds of small dams are used for just this purpose.

Sometime in the past you undoubtedly have seen a large dam made of earth or concrete with water stored behind it. The water surface was level because water, as a liquid, takes the shape of its container until it has a level or horizontal surface. So we make the top of every dam level, no matter how large or small the dam is, so that the water will be stored behind it.

Contour Farming Stores Water and Saves Soil

To store water on the soil surface, we can make a series of small dams with level tops by farming on the *contour*. To plant a row of corn on the contour is to plant it around the sides of the hill. The row then stays on the same level all the way around, like the shore of a lake. Each farm-implement furrow and wheel track on the contour will hold and store rainfall. In contrast, each implement furrow or track going down the hill, instead of around the hill, serves as a small ditch to collect the rainfall, and to increase the depth and speed of its downhill flow. The result is less water for the crops, and more soil is lost with the larger amount of fast-moving water.

Soil loss from erosion means a loss in crop production. If the soil is eroded away from the plant roots, they may die. Sometimes the whole plant will be completely washed away with the soil. Other plants may be covered by soil which has been eroded from other places in the field. The covered plants will be smothered and die. None of these damaged plants will ever produce a crop for harvest. Destroyed plants, loss of water needed for plant growth and loss of soil containing plant nutrients all decrease crop production. Therefore, we use contour farming to make small dams which store water and decrease erosion.

Aids to Contour Farming

Sometimes contour farming alone does not provide enough water storage. Larger dams are needed. We can make bigger dams by *listing* or *ridge planting* on the contour around the hills.

Maybe you've helped your mother plant a flower or vegetable garden and noticed that she smoothed the soil with a rake before she planted the seed. Most farmers also prepare a smooth seedbed for their crops. But some farmers plant their crops on top of ridges of soil or in furrows between ridges. Planting in the furrows is called listing. Planting on top of the ridges is called ridge planting. By either method, alternate ridges and furrows are formed. The ridges vary in height from 4 to 8 inches. It is these ridges, on the contour, which serve as larger dams to hold more water than would be held by contour planting on a smoother surface.

Another aid to contour farming is strip cropping. Strip cropping is the planting of crops in strips or bands. Strips of cultivated crops, such as corn, are planted on the contour between strips of hay or meadow crops. This combines the use of two erosion prevention principles—contour farming and a con-

Fig. 9. Strip cropping is the planting of crops in strips or bands.

tinuous covering of plants in the strips of hay or meadow. Erosion may be high in the corn strips but very low in the hay strips. Soil eroded from the corn strips will be caught and held in the hay strips. Measurements of soil erosion losses show that only one-third as much soil is lost from fields which are contour-strip-cropped as from fields which are completely contour planted to a cultivated crop.

Terracing—Most Effective Conservation Practice

There is yet another way to decrease soil and water losses. It is more effective than any other conservation practice. We call it *terracing*. A terrace is a low earthen dam with a broad base. It is about 1 foot high and 30 feet wide at the base. It decreases soil loss more because it can store more water until the water soaks into the porous soil or slowly flows down the terrace channel and out of the cultivated field.

Usually, several terraces are built across a long field slope. Each terrace channel collects runoff water from that part of the field between it and the next terrace up the slope. Crops are grown on the terrace sides and channel just the same as the rest of the field.

All terraced fields are contour farmed because the terraces are constructed across the field slope. Contour farming plus terraces means about twice as much soil saved as contour farming without terraces.

Terraces are made level, on the contour, when the soil is porous enough to soak up the water held behind the terrace ridges. If the soil is not porous enough, the water would remain in the terrace channel too long and kill the crops. In this case, the terrace channel is sloped to a grassed waterway or terrace outlet. The sloped terrace is an earthen eaves trough which carries the water in a gently flowing stream to the outlet.

Fig. 10. Terracing is the most effective erosion control practice.

A larger and high, non-cropland terrace is frequently built near the bottom of a steep meadow, timber or pasture land area. This larger terrace protects the cropland below it from erosion by collecting the runoff water from the steep land above. Level basin terraces without outlets are built on porous soils. Sloping terraces, called graded terraces, are built on the less porous soils to carry the water to a grassed waterway.

Grassed Waterways Prevent Gullies

Wherever water collects and moves rapidly down a natural waterway, the soil can be quickly eroded to leave a gully. A gully is a deep cut in the ground surface.

Grassed waterways are useful wherever gullying is a problem. When the water starts flowing down a waterway, the grass acts somewhat like shingles on a roof. And the water flows away without causing damage.

Piling junk, tin cans, brush or corncobs in the waterway will not prevent gully erosion. The surface of the waterway must be smooth, firm and well sodded. The roots of the grass sod hold the soil in place. If gullies have already formed, a grass sod will generally stop further cutting after the gullies have been filled, shaped and sodded.

Structures for Water Control

Sometimes a waterway is too steep for the grasses to prevent gullying without the help of some type of structure to control the flow of water. Water control structures of various kinds are used to "drop" the water from a higher to a lower level. Each drop structure flattens the slope of the grassed waterway so that the water does not flow so fast. Slowly moving, controlled water does not cut gullies.

Structures for water control are built of earth and concrete or metal. An earth dam with a concrete or metal overflow tube is one example of a drop structure. Sometimes the water is dropped over a vertical concrete wall onto a concrete floor. The water flows from the concrete floor into the grassed waterway. A structure such as this is called a concrete drop spillway.

Let's Review

Let's review the causes and prevention of soil erosion. What causes most of the soil erosion in Iowa? Running water. The faster the water flows and the deeper it is, the more soil will be carried away. To prevent erosion, farmers must reduce the rate of flow and the depth of running water. There are many practical ways of doing this.

Some soils do not wash nearly so easily as others. Soils with good granular structure will soak up large amounts of water and thus reduce the amount which has to run off. We can improve soil structure. The most practical ways of improving soil structure are by adding organic matter to the soil through crop residues and manure and by growing grass. Soils protected by thick-growing crops will not be loosened by the falling raindrop "bomb." Also, plant roots hold the soil particles so they will not erode easily.

Fig. 11. Grassed waterways prevent gullies.

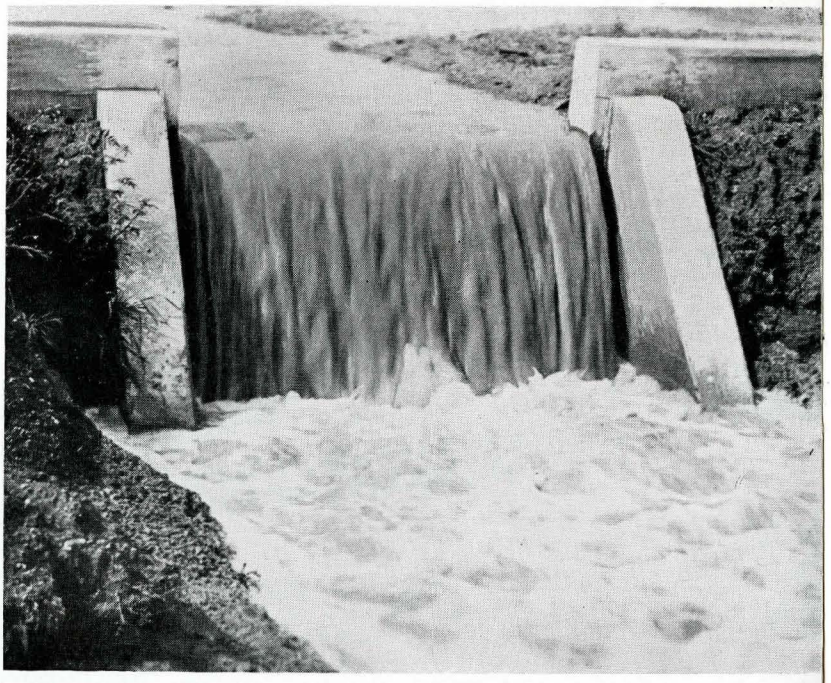

Fig. 12. Structures of various kinds are used to "drop" the water from a higher to a lower elevation.

Fig. 13. Unprotected waterways often allow large gullies to develop.

Instead of letting water flow rapidly down the hillside, we can store it behind ridges which act like small dams. Ridges are made by contour farming and by special practices such as listing, ridge planting and terracing. These ridges or small dams store some of the water and let the excess water move more slowly from the field.

After the runoff water reaches a natural waterway, it can still do much damage through gully erosion. Waterways covered with a thick-growing grass sod are generally protected from gullying. If the waterway is steep, water-control structures may also be needed to slow down the flow of water. Slowly moving, controlled water does not cause erosion.

WE CAN KEEP IOWA SOIL PRODUCTIVE

Farm to Conserve

Much of Iowa's best topsoil has been lost, but we need not continue to lose it. Some methods of farming will (1) prevent serious erosion, and (2) provide for the addition of needed elements. Such farming is *conservation farming*.

Some people think that it costs much more money to farm using conservation methods. But this is not true. Conservation methods help farmers make money as well as save soil. Conservation farmers have larger yields per acre and make more money over a period of years than farmers who go along in the old careless fashion.

But this does not mean that conservation farming is simple and easy. A farmer must make his plans carefully if they are to be successful; to do this he must know his soil and how to conserve it.

In his planning, a farmer must try to do three things. First, he must plan for the wise use of all of his land; second, he must plan to build up and hold the productivity of his soil while he grows big crops; and third, he must plan to prevent soil and water losses. Let us take up each of these things in turn.

Plan Well, Then Farm Wisely

Every field and every farm is a problem in itself. Each must be handled according to the kind of soil, the lay of the land and the extent and nature of the erosion. In order to make a good plan, the farmer must know his soils well.

A soil map is a great help, especially on a new farm where the farmer has not had time to learn much about the soil. State and federal soil scientists have made soil maps of most counties in the state. The Soil Conservation Service furnishes soil maps as the first step in developing a conservation farm plan. Local soil conservation districts help farmers get soil maps of their farms.

We must realize that just building a dam or a terrace here and there is not enough. Such things are useful only when worked into a complete farm plan. Moreover, the plan must fit the land. The farmer who grows too much corn on steep land will surely

Fig. 14. The conservation farmer is interested in growing high yielding crops.

lose out in the long run. Erosion will soon rob the land of its productivity and reduce yields; then the farmer won't be able to make a profit. But if he puts his land to its proper use and applies the needed conservation and soil management practices, he will get the best possible return over a long period of time. He will also build up and protect the productivity of the soil even on steep slopes.

The conservation farmer is interested in growing high-yielding crops which are profitable to him. Also, he wants to conserve the soil and leave it productive for those who follow. He can take several steps to do this. What are some of the most important of these steps?

If It's Too Wet

When soil is too wet for the healthy growth of crops, the water can be removed from the land by drains. These drains may be either open ditches or tile drains laid in the ground. You probably have seen drain tile. The tiles are laid end to end in the bottom of a ditch which has been dug with a uniform slope so that the water will flow in the direction you want it to go.

A drain tile system is like a river system with branches or tributaries flowing into larger streams until they reach the main river. The branch lines are called laterals, the larger lines, mains.

It is a good idea to have an engineer or one trained in drainage work to help plan and lay out a drainage system. Unless it is properly planned and installed, it will not work well; then the money and labor invested in it will be largely wasted. An accurate map of the system should be made, showing the location of each drain. This map should be kept as a permanent record, in case repairs are needed later.

How We Till

Tilling the soil is working it with implements. Although it causes erosion, it is necessary in the growing of many crops. Most crops require a smooth, firm seedbed which can be prepared only by working the soil thoroughly. Crops like corn grow best in rows where they can be cultivated to keep down the weeds. A good farmer often tills sloping land, but only on the level—across the slopes rather than up and down them. He does not till his soil when it is too wet, because he might puddle it.

The conservation farmer may grow row crops year after year on level or near-level land where erosion

Fig. 15. When soil is too wet for the healthy growth of crops, the excess water can often be removed from the land by the use of tile drains.

is not a problem. But on sloping land he rotates them with close-growing crops like alfalfa and bromegrass. The grass-legume crop slows down soil losses, and makes the soil more resistant to erosion when it goes back to a row crop.

Plow Under Residues and Manure

Crop residues should be returned to the soil by plowing them under. They contain nutrients taken from the soil; they help build up the organic matter in the soil. The organic matter is lost whenever crop residues are burned. Cornstalks and straw are good examples of crop residues which should always be returned to the soil.

In a livestock system of farming, about three-fourths of the minerals from the soil that are eaten in feeds by livestock can be recovered in manure. Manure from barns and feedlots spread on fields usually returns about one-half of these minerals. It also adds organic matter to the soil.

There's Green Manure, Too

Green manures are crops plowed under while green to enrich the soil. Green manures add organic matter. If the green manure is a legume (clover, alfalfa, soybeans, etc.) it will add nitrogen to the soil. You will remember that the legume plants take nitrogen from the air with the help of the bacteria on their roots. In Iowa the most common green manure crops are alfalfa and sweetclover. Farmers who grow green manure crops usually grow them with a small grain such as oats. After the oats are harvested, the green manure crop is plowed under in the fall or early spring. Then it is followed with corn.

Sometimes Soils Need Lime

Lime contains calcium, one of the 13 mineral elements which plants must have. Lime also makes acid soils nonacid; this is a good thing, since most of our crops grow better on nonacid soils. We call acid soils "sour" and nonacid soils "sweet." Some of our most important soil-building crops, like alfalfa and sweetclover, will not grow in real sour soil until after it has been treated with lime.

The amount of lime needed to make a sour soil sweet can be determined by a test. Soil samples can be sent to the Iowa State University Soil Testing Laboratory for this test and for recommendations on the amount of lime to apply. Sometimes county extension directors help farmers determine how much lime their soils need.

Plant Nutrients Must Be Replaced

Each year soil erosion, drainage water and the sale of crops and livestock remove plant nutrients from the soil. This happens even though the farmer has been very careful. He must keep plenty of usable nutrients in the soil for high yields. When there is not enough of any one nutrient, crops will suffer. When a certain nutrient element is needed, the farmer must add it to the land. Except for nitrogen, the only way of adding new supplies of nutrient elements to the soil is by applying fertilizers or lime. Since fertilizers are substances that contain one or more essential elements in a form usable to plants, it is important for you to know about them. Lime

Fig. 16. When plant nutrients are needed, the farmer must add them to the land.

serves a double purpose. It supplies the soil with calcium, one of the essential nutrients; it also makes sour soil sweet.

The Three Fertilizer Nutrients

In Iowa soils there are three elements that are most likely to be needed in fertilizers. They are nitrogen, phosphorus and potassium. *Nitrogen* encourages rapid growth and gives plants a dark green color. It becomes a part of proteins and is needed in every plant and animal cell. *Phosphorus* is also found in every animal cell; it is an essential part of bones. *Potassium,* like nitrogen and phosphorus, is needed for plants to grow. It probably helps in the movement of plant food from one part of the plant to another. It helps the plant to keep healthy and to resist attacks by insects.

All three elements must be in the right proportions. A proper balance between the amounts of available nitrogen, phosphorus and potassium is needed for best plant growth.

Most fertilizers contain one or more of these elements. Fertilizers can be bought to fit the soil needs.

You can have tests made to tell what fertilizer the soil needs. The Soil Testing Laboratory at Iowa State University will make these tests and recommend the kind and amount of fertilizer to apply.

CONSERVATION TAKES TEAMWORK

Farmers who wish to farm by conservation methods may either work alone or with their neighbors. There are good reasons for neighbors to work together wherever possible. Conservation practices used on one farm often affect and are affected by nearby farms. Running water and gullies do not stop at farm boundaries.

Soil Conservation Concerns All of Us

Because of this and because conservation farming helps the whole community, it seems wise for all neighbors to work together in fighting erosion. The productivity of the land affects all of us. So, we should all help protect the soil. Communities both large and small may organize for soil conservation work. Some of these problems requiring community action might be silted reservoirs, streams choked up with silt and debris, and damaging floods. Today many of these problems of a community nature are solved by watershed development programs. We will discuss watershed programs a little later.

The best way to organize for community action on erosion problems is through the Soil Conservation District. All of Iowa has been organized into soil conservation districts, and many people are now working together on land and water problems.

Soil Conservation Districts Promote Teamwork

Soil conservation districts have been very successful in Iowa. One reason is that they are governed and controlled by the farmers in the district. One of the duties of the soil conservation district is to develop a soil conservation program which will give farmers the kind of conservation help they need.

Many agencies of the United States Department of Agriculture help the soil conservation districts. The Extension Service of Iowa State University carries on the educational program in soil conservation. The county extension director is the Extension Service representative in the county. The Soil Conservation Service helps farmers plan and apply soil conservation and good land management practices. The Agricultural Conservation Program Service (ACP) helps farmers by sharing costs of conservation practices. There are a number of other Department of Agriculture agencies which also help soil conservation districts, but there isn't space to mention them all here.

WATERSHEDS

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 and its tributaries, which covers nearly 40 percent of the United States. We all live in watersheds of various sizes. It takes many small watersheds to make up larger ones. A watershed is more than a combination of hills and valleys, streams, forests, grass, farms and towns. It is a natural community of men, plants, animals and soils that receive their water supply from a single watershed drainage area.

All of us depend on our watershed, and we in turn influence what happens there, whether it's good or bad. Recently we have been working on some of our erosion and flooding problems on a watershed basis. By working together we can achieve even better results in conserving soil and water on a watershed basis than we can individually. As we shall see, there are some things a farmer cannot accomplish when working alone.

Water—Friend or Enemy

We have learned that water can be a friend or an enemy. If it runs off the land too fast, it cuts gullies and carries off topsoil which should be kept on the farm to produce our food and clothing. Soil and debris which the runoff water carries into streams and lakes may spoil fishing and recreation. It may reduce the amount of water the stream or lake can hold and thus decrease the community water supply. The cost of filtering and treating the community water supply may be increased. If it interferes with a hydroelectric power plant, it may increase our electric bills. Farther downstream, rushing water may cause a flood which damages farms, ranches, crops, property, homes, highways and utilities. It may take lives. The clogging of stream channels with mud and debris makes future floods more serious. This is because the choked-up stream bed can now carry less water than before. When water does this kind of damage, it is an enemy. One or two farmers working individually cannot solve these problems. These are community problems. All must join hands and work together.

The Problem Starts on the Uplands

Now you see that our problem starts where the raindrop falls. We must encourage more water to soak into the ground where it falls. In this way it can be available later for growing crops. We can do this by using the good soil management methods we learned about earlier. We can use conservation practices such as contour farming, strip cropping, and building terraces and grassed waterways to slow down the runoff water. We learned that water moving slowly does not carry soil.

Under today's watershed development programs, large dams may be necessary to catch and hold water that is rushing too fast. This water can then be

Fig. 17. Farm ponds and watershed reservoirs furnish good fishing, boating and recreation.

allowed to run through a small outlet over a long period of time, causing little or no damage by flooding. Water supplies are then protected, and more abundant supplies of clean water are available for communities to use.

Wildlife and Recreation—a Part of Conservation

When farmers farm the conservation way, wildlife can thrive in greater numbers than ever before. Farm ponds and watershed reservoirs furnish stopover spots for thousands of migrating ducks and geese. These same waters provide good fishing and boating. Grassed waterways furnish nesting places for quail and pheasants. Living fences such as multiflora rose furnish homes for song birds and rabbits. Protected woodlands may support deer, grouse, squirrels and other wildlife. Strip cropping furnishes food and shelter for many upland birds and animals. The many farm windbreaks protect not only farm buildings, but also wildlife, from the winter snows and blasts of cold wind.

Wildlife thrive best when the community watershed has been fully developed under conservation methods. When wildlife thrive, the opportunities for hunting, fishing, hiking, camping and other forms of recreation are better. The wise and full development of the resources of a watershed put fun in conservation for everyone.

Protection and Development of All Natural Resources

Watershed development stresses the protection and development of all natural resources in a watershed. The soils are conserved on farm lands. Water is made to run slowly as it moves downhill. Damage to streams and reservoirs is prevented. Flood prevention dams and reservoirs are built where needed

Fig. 18. Wildlife thrive best when the community watershed has been fully developed under conservation methods.

to prevent flooding. Permanent pools of water are often made available for fishing and recreation. Every citizen of the community benefits from such a program. The entire drainage area is treated according to its needs.

Remember that in watershed development programs, much help is available to supplement local community effort. Agencies of the United States Department of Agriculture are ready to help. Much of this help is made available through the local soil conservation districts. Assistance from agencies of state government and sometimes state-appropriated funds are also available through soil conservation districts. When federal and state governments help communities develop and protect watershed resources, everyone is benefited.

WE NEED GOOD FARMERS

Iowa farmers use our valuable resource, the soil. Iowa produces more food than any other state. So it's important to Iowa people and to all others in the nation, not only that our farmers raise big crops, but also that they save our soil for future use. Both of these things can be done if farmers appreciate the value of the soil and are willing to use it properly. We must have good farmers on the land.

Good Farmers Use Conservation Practices

The good farmer knows the importance of soil; he knows what has happened to farms, communities and countries that have wasted their soils. He knows that erosion control is only part of good farm management. He knows that such practices as drainage, cropping systems, and keeping steep land in grass or woodland are also necessary. He knows that conservation farming means using lime and commercial fertilizers where they are needed. He knows that he must not lose the soil on his sloping land. He knows he can keep his soil from washing away by contour farming, terracing, grassing the natural waterways and following other approved practices.

The good farmer knows all these things and practices them. He arranges his fields and does his farming to control the rain which falls on his land. He knows it's not enough to build a dam in a gully or grass a few waterways. He makes plans to control water above the dams and on the fields before it reaches the waterways.

Good Farmers Work Together

The good farmer knows that while he may be able to do many of these things alone, he can do them more effectively by working with his neighbors. So he joins with them in the soil conservation district program and in forming a neighborhood team. This team may sooner or later be the community group that will develop the natural resources of the community watershed for the greatest good of all the people.

Only the farmer who knows and does all these things can truly be called a conservation farmer. Such a farmer will be rewarded by a bigger income and by the satisfaction of knowing that he has done his part as a good citizen. He has not only provided food and clothing for the people who are living today, he has made his community a more secure place in which to live. He has helped keep the United States a prosperous, free and happy land for those who will come in the years ahead.

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