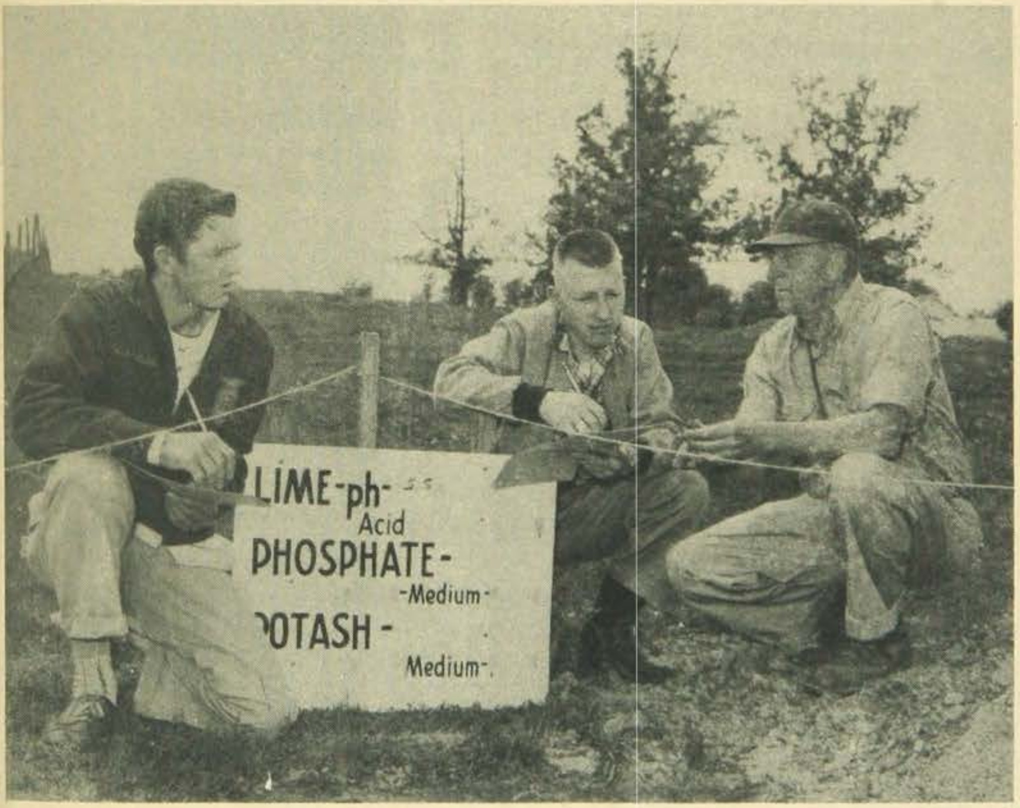
4-H soil and water conservation



Roger S. Harris
Harold E. Jones

UNIVERSITY OF MINNESOTA
Agricultural Extension Service
U. S. DEPARTMENT OF AGRICULTURE

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INTRODUCTION

The soil and water conservation project is one of the three phases of the 4-H Conservation Program. The other two phases are the 4-H Conservation Activity and the 4-H Forestry Project. All three emphasize these three broad objectives. Our responsibility as 4-H Club members is to:

1. Develop an appreciation of our natural resources.
2. Restore our natural resources to normal where they have been depleted.
3. Protect those natural resources we now have.

This pamphlet has been prepared to give you some help in your Soil and Water Conservation project. Regardless of whereyou live in Minnesota, farms need a balanced soil-conservation program. Maybe you have always thought of soil conservation in terms of contouring, strip cropping, and terracing. Valuable as these practices are, they alone do not control soil erosion.

In Minnesota a six-point soil fertility and conservation program is recommended:

1. Draining, clearing land, and cultivating.
2. Liming acid soils.
3. Rotating crops.
4. Maintaining organic matter.
5. Adding commercial fertilizers.
6. Practicing erosion control.

The importance of each will depend on the place you live, the condition of the soil, and the kind of farming. It is up to you to determine which of these practices you need for your farm. If you follow this program carefully you will be doing your part to keep the soils of Minnesota permanently productive.

You will want to keep this pamphlet handy and use it as a guide while you are enrolled in this project.

So first of all write your name in this box.

This pamphlet is the property of
____
of the ______________ 4-H Club, to
be used in my soil conservation
work.

Here are listed the things you will find in this pamphlet:

1. What is our soil?
2. Keeping our soil permanently productive.
3. Control of soil erosion.
4. Demonstration suggestions.
5. Exhibit suggestions.
6. Activity suggestions.

AGRICULTURAL EXTENSION SERVICE
University of Minnesota U. S. Department of Agriculture
University Farm St. Paul, 1 Minnesota

WHAT IS OUR SOIL?

Soil supports plant growth.

We all know what soil is but can you describe it so that everyone understands what soil does for us?

Soil is the surface covering of the earth capable of supporting plant growth. It consists of solid mineral or rock particles, organic matter, water, air and, in addition, contains a teaming population of tiny plants and animals.

Plant growth is the main reason for our interest in soil. The soil teams up with the sun and the rain to provide materials for our food and clothing. We gauge the value of the soil by its capacity to produce crops. Our survival depends on how well we conserve the soil and its fertility.

As a medium for plant growth soil serves to anchor the roots. It also supplies water and minerals to the plants and air for their roots to breath. How can soil store water, air, and plant nutrients, be permeable enough for the tender rootlets to push through it and yet be so powerful that it keeps large trees from being blown over by the wind? Only by knowing how soils are formed, their properties, and how the microbes function in the soild can we answer this question. Let's see what we can learn about the soil.

How soil was formed

No one knows exactly how long, but some have guessed that it took Mother Nature 500 years to form an inch of soil. No wonder we must take care not to waste it.

In Minnesota the first steps in making soil were done by great glaciers or ice sheets that began in northern Canada and moved southward. They scraped down hills, filled valleys, and ground the rocks to sand and dust. This mixture of gravel, sand, clay, and boulders was spread in a layer over the surface of the land. We call this layer "glacial till." Sometimes the weather got warmer and the ice melted as fast as it moved down from the north. If this happened for a long time, the material carried by the glacier piled up in a low ridge where the end of the glacier stood still. This ridge we call a moraine. Is there a moraine on or near your farm? Great streams of water came down out of the glaciers as the ice melted carrying with them all sizes of rock particles from big boulders to tiny sand and silt. These were deposited in level areas which we call outwash plains. Near the end of one of the glacial periods, severe dust storms carried fine soil from the flood plains of streams upland to some of our southeastern and southwestern counties. This coating of wind-blown material, or ~~"loess"~~ "loess", ranges from 1 to 15 feet deep.

The next step in forming soil was performed by the tiny microbes and larger organisms like earthworms within the soil and by larger plants and animals on the land. When these plants and animals died, their bodies furnished the organic matter for the soil. This organic matter gave life and activity to the soil.

When all these things were done by Mother Nature the rock particles, organic matter, water, air, and microbes became an orderly, well-defined body capable of growing crops. This we call the soil.

There are many kinds of soils

Soils are different in many ways. In Minnesota we actually have over one hundred kinds of soils. Some are good, some are poor, some will produce more of certain kinds of crops and less of others. Minnesota Experiment Station Bulletin 392 tells us about many of them.

The kinds of plants growing on the land while the soil was being formed helped make soils different. Where tall grasses grew, prairie soils developed. Our prairie soils in southern and western Minnesota have a dark-colored, deep surface, rich in organic matter and nitrogen. Trees grew in most of eastern and northern Minnesota counties. These timbered soils are generally light colored and are lower in organic matter, nitrogen, and other plant foods than prairie soils. Where shallow lakes or swamps stood, water plants like the reeds grew and died. Because of the water these plants did not decay completely and deep beds of what we call organic, or peat and muck, soils were formed. We can tell the kind of vegetation that grew on a soil by the color and depth of its surface layer. We must take care that this rich layer (topsoil) doesn't erode.

The kinds of rocks and whether they were moved to their present location by wind, water, or ice also influence the kind of soil. Soils formed from sandstone are coarse and sandy; those from shale very heavy and sticky. Limestone, granite, and many other rocks give soils with a mixture of sand, silt and clay. The famous Red River Valley was once a great glacial lake called Lake Agassiz. There now is Minnesota's largest area of "lake-laid" soils. To the east of the Red River Valley sandy soils were fromed from coarse materials which old glacial streams poured into Lake Agassiz. North of Minneapolis, including parts of Anoka, Sherburne, and Isanti Counties, are sandy soils formed on one of the glacial outwash plains.

Soils may be young, middle-aged, or mature according to how long the soil-forming processes have been working on them. We recognize the age of soils not by actual years but by how well the soil is separated into layers (called horizons) and by how much of the original minerals have been leached (washed) from the surface down into the subsoil by rainfall.

Soils are also influenced by the kind of climate (temperature and rainfall) which predominated during their formation. The prairie soils in the western part and those in the south central part of Minnesota were formed under the same type of grasses. However, those of the west had less rainfall and much less of the lime was leached from the soil.

The slope of the land, or topography, leaves its mark on the soil. Those on steep slopes are not as deep because the organic matter and decomposed rock is continually being carried away by erosion.

<u>How can we tell soils apart?</u>

Just as we can tell horses apart by looking at them, we can also separate soils by their appearance. Such things as the texture (size of soil particles), color, amount of organic matter and depth of surface soil, permeability (ease with which water and air move in the soil), and kind of parent material vary enough so that soils can be recognized. Other things like how close lime comes to the surface and how steep the land is are also used in separating soils since all these things affect the way crops will grow.

We give soils names to indicate their differences in appearance. The first name comes from a town or place near where they were first located; the second name from the texture of their surface soil. An example is Kenyon silt loam, a soil near the town of Kenyon in Goodhue county. This soil looks different from any other in Minnesota. Is there a soil named for your community?

If you were to dig a posthole in an old fencerow, a permanent pasture, or a woodlot where the topsoil has not eroded you would find the soil divided into layers running parallel to the surface. We call this series of layers from the soil surface down to the unchanged material below (the parent material) the soil profile.

The suface layer of the soil is dark colored because of the organic matter left by plants and animals. From this topsoil with its organic matter comes much of the nitrogen crops need for their growth. Its depth varies from a few inches to 15 or 20 inches. Crumble some of it in your hand and notice how it falls apart in little clumps or "aggregates." This is because of organic matter which makes the soil open and porous. This soil will take in lots of water and air and will not erode easily.

Rub some of the moistened topsoil between your finger and thumb. In this way you can tell its texture. Gravel feels coarse, sand gritty, silt velvety, and clay sticky. Soils with over 80 per cent sand are called sands; those with over 40 per cent clay are called clay. All others are called loams (sandy loam, loam, clay loam, etc). The best soils are generally those which contain 10 to 20 per cent clay, with silt and sand in about equal amounts. It takes much less clay to influence the properties of a soil than silt and sand because clay is chemically active. It acts just like an acid in the soil - can react with many other materials or can absorb nutrients on its surface. Soil clays and organic matter are the two most important storehouses of plant nutrients in the soil.

The second layer of soil, or subsurface, has much less organic matter and thus is lighter in color. It may be from 10 to 24 inches down in the soil according to how deep the surface soil is.

Next examine the layer from about 24 to 35 inches down in the soil. This is the subsoil. When we buy land we can tell how well drained it is by the color and texture of this subsoil. Soils that have good drainage will be bright brown or reddish in color because air has rusted the iron in the soil. If the subsoil is grey in color it means that water stands at that level in the soil all year long. This soil has poor drainage and needs tile. If the subsoil has lots of clay, water may not move through it even if tile is used. If the subsoil has some grey and some bright colors we say it is mottled. This mottling indicates moderate or medium permeability. Water has stood in this subsoil only during the wetter parts of the year.

Below the subsoil you will find material that hasn't been weathered much. This is the parent material from which the soil was formed. Don't be discouraged if the soil you examine doesn't show all the layers. No two soils will look exactly alike in their profile.

Plant food and our soil

Plants, including alfalfa, corn, oats, and the rest of our farm crops must have food if they are to live and grow, just like people and animals. We now know of 14 chemical elements which are needed by our crops. Some of these, such as carbon, hydrogen, and oxygen, come from water and the air. A green plant, because of its green coloring matter (chlorophyll) can combine carbon dioxide (CO_2) from the air with water (H_2O) from the soil into sugar, fat, and other carbohydrates by a process called photosynthesis (light-formed). Sunlight furnishes the energy necessary for this process. We don't usually worry about the supply of carbon, oxygen, and hydrogen because they are abundant in air and water.

Magnesium, sulfur, iron, manganese, boron, copper, and zinc are elements that either are present in the soil in abundance or are required in such small amounts by plants that keeping up the supply is not a serious problem. We do, however, have an area in north central Minnesota where the natural supply of sulfur is too small for our crops. Here we have to use sulfur in the form of gypsum as a fertilizer.

The elements we have to consider most in maintaining our soil are nitrogen, phosphorus, potassium, and calcium. Plants use large amounts of these nutrients and they are the ones most likely to be short in the soil.

Nitrogen is a gas that is present in large quantities in the air above the earth. Crops like corn, small grains, and grasses get nitrogen from the supply stored in organic matter. The legumes, such as red clover, alfalfa, and sweet clover, can take nitrogen out of the air with the help of a special kind of bacteria which grow in nodules on their roots. In order to be sure that a good supply of these bacteria are present, farmers should inoculate their legumes before seeding. Barnyard manure is another good source of nitrogen. Chemical fertilizers may also be used to supply nitrogen but costs about three times as much as getting it through legumes.

Plenty of nitrogen in the soil is indicated by a vigorous growth of plants and a dark green color in the leaves and stems. Unusually small size and a light green to yellow color indicates a lack of nitrogen. When corn is deficient in nitrogen the middle of the lower leaves gets yellow, dries up and dies.

Phosphorus, potassium, and calcium used by our crops comes from minerals in the soil. Their supply is depleted when grain, milk, or livestock are sold from the farm. Sooner or later when we farm land a reduction in these nutrients results in lower crop yields. These nutrients can only be replaced by adding lime to supply calcium and commercial fertilizers to supply phosphorus and potash.

A lack of phosphorus early in the growth of plants results in stunted, spindly growth and usually a greener than normal color. Corn may have some purpling on the lower leaves if phosphorus is short. A lack of phosphorus later in the season will give lightweight or shriveled kernels. The phosphorus in our fertilizers is manufactured by treating phosphate rock from Tennessee, Florida, and some of the western states with sulfuric acid. We call this material superphosphate. Many soils in Minnesota, especially those of the western counties that are high in lime (alkali) need phosphate fertilizers.

Potassium doesn't form any part of the plant but must be present in considerable amounts if plants are to use other nutrients. Many of our sandy soils and those formed in swampy areas (peats and mucks) are low in potash. A lack of potash causes the outer edges of the lower leaves of corn to turn brown and die. It also causes the corn plant to weaken at the nodes or joints. On alfalfa the symptoms show up as white dots around the edges of the leaves. These leaves later turn brown and fall off. Red clover and soybeans don't get the white spots but do have brown edges on their leaves when potash is short.

Calcium is used in large amounts by legumes as a plant food but has a greater function in sweetening acid soils. We will tell you more about liming acid soils and what it does in a later section.

How many of you think you could recognize symptoms of nitrogen, phosphorus and potassium needs on crops? Be sure to watch those on your farm to see if any of these telltale signs show up.

Organic matter and microbes of the soil

In earlier sections we told about organic matter or humus and how it came to be a part of the soil. Now we want to tell more about the many ways in which organic matter helps crops grow.

As organic matter decays, it makes new supplies of plant food available to growing crops. It also helps the soil take in and store more water. This is a very important service since our crops require large amounts of water when they are growing rapidly. We have described how organic matter causes the soil particles to clump together in granules or aggregates and, thus, allow water to pass through the soil more quickly. As a result fields high in organic matter dry faster after a heavy rain. Deep-rooted crops like sweet clover and alfalfa punch holes in heavy subsoils. When these roots die they leave little channels through which water may drain away. Crops like the grasses which have a network of fiberous roots help tie the soil together and prevent erosion. Crops like corn and soybeans can't do this. Examine the roots of some grasses and compare them with the roots of corn or soybeans.

One effect of organic matter that is quite noticeable to the farmer is that it makes the soil easier to work and a good seedbed can be prepared with less effort. Clods are less likely to form and the surface of the soil is less likely to crust over. Good seedbeds, too, are necessary if we are to have high crop yields.

No soil is without microbes. There are many, many kinds that live on legume roots and fix nitrogen from the air. Another very important group decomposes organic matter in the soil. Since most of them cannot create organic matter (photosynthesis) they are dependent on the residues of other plants and animals as a source of food. The more of this type of microbes there is in the soil and the more active they are, the more fertile the soil usually is. It is said that the carrying capacity of a pasture is equal to the weight of these tiny plants and animals in the soil.

When fresh plant residues are mixed with the soil this sudden increase in food supply increases the activity of the bacteria and results in their using lots of plant nutrients, especially nitrogen. Much of this is quickly tied up in the bodies of the bacteria and a temporary shortage is created in the soil. Have you noticed how plowing under oats straw sometimes results in reduced yields of the next crops. These crops show the slow growth and pale green color which we described as symptoms of nitrogen hunger. After the supply of energy-food materials like sugars and starch in the residues are exhausted the bacteria die and release minerals and nitrogen. Crops prosper once more. Legumes have much more nitrogen in proportion to energy materials and for this reason can usually be plowed under without cutting yields of succeeding crops. A wise farmer adjusts the plowing under of organic matter in such a way that its most violent decay does not come at the same time as rapid growth of his crops. If he cannot do this he is careful to make up the needs of the plant by supplying commercial fertilizer.

Water and the soil

All life, from tiny creatures within the soil to humans like us, must have water to live and grow. Water is one of the best friends both men and soil have. But it can also destroy the soil we are trying to save.

In a later section we will tell you how to prevent water from destroying the soil. Let's talk here about what water does in the soil and how it helps us. Soil stores water. When rain and snow fall, they become a part of the soil. When some soils become dry, they are hard to plow and cultivate. When moist, they are soft and crumbly and even sticky. When soil that is too wet is plowed, it looks shiny because it has run together. This soil will hold only a little additional water.

Why do some soils store or hold water better than others? If we look at soil closely, we can tell that soil is actually a network of small particles separated by tiny spaces. These spaces are connected. Thus, when the soil is wet, each piece is surrounded by water. Sandy soils (coarse) have only a few large spaces. Clay soils (heavy) have many very tiny spaces. Loams, a combination of the two, have more medium-sized spaces.

The size of these spaces determines how much water a soil can hold. Water in the large spaces (sandy soils) drains out rapidly and helps crops very little. Water in the medium-sized spaces (loam soils) moves fairly easily but stays in the soil. Crops can use this water. Soils with tiny spaces (clay) cannot hold much water for plant growth. Earlier we discussed how organic matter and plant roots help form medium-sized pores in clay soil.

When it rains, water moves into the soil the fastest if there are some large spaces present. During drought, water moves up from the moist subsoil. Put one of a straw in a glass of water and see how the water rises higher inside the straw than it is in the glass. Water moves in the soil much the same way. This is an important way plant roots keep well supplied with water and plant foods.

Plants get thirsty for water. One corn plant can drink nearly a barrel of water during a growing season. This water moving from the soil into the plant helps carry food from the soil up to the leaves of plants. Plants, like people, also need protection from the sun's heat. Plants keep cool by losing water through tiny pores in their leaves. This is called transpiration and is much like our sweating. A field of corn may give off as much as 15 inches of water during the growing season.

Counting the water lost by plants "sweating" and by evaporation from the soil, we need 20 inches of rainfall to raise a bumper crop of corn. A heavy soil can store 6 to 8 inches of water while a very sandy soil can store only one inch. Dry spells, therefore, are harder on sandy soils than on heavier soils. Likewise, the maximum yields which we can expect from a crop like corn depends upon this stored water plus the rainfall that comes during the growing season. Organic matter helps soil to store more water.

Not only does water protect plants against heat, but it also helps to change food in the soil, such as nitrogen, phosphorus, and potassium, into forms plants can use. We have already discussed how microbes act in decomposing organic matter. These organisms need water if they are to live and work.

When the soil ~~have~~ has a lot of water, some moves down, carrying away plant foods. In heavier soils this movement is slow, but in sandy soils it is fast. When soil is too dry, plant foods do not move to the roots fast enough to take care of the plant needs. For example, during dry seasons, it is the lack of the plant food, nitrogen, not the lack of water, that causes injury to plants.

KEEPING SOIL PERMANENTLY PRODUCTIVE

Soils need wise use

We have seen how much soils differ according to the way in which they were formed. We have discussed what this means in terms of producing crops. This should make us realize that every farmer needs a land-use program of his own. He must consider what kind of soil he has, whether it is hilly or level (topography), how series the erosion is, and how satisfactory crop production has been.

Here are some of the things that farmers can do in using their soil wisely. Some are permanent changes in farming practices that should be made to save soil; some are changes that farmers can make from year to year.

(1) Drain land if necessary so that more crops can be grown on level land and less on steep, erodable slopes.
(2) Use proper seedbed preparation and good cultivation methods to protect the soil and insure better yields.
(3) Lime acid soils for better growth of legumes and more effective use of phosphate fertilizers.
(4) Use commercial fertilizers where necessary. Soil and plant tissue tests help determine nutrient shortages.

(5) Seed legumes and grasses and change crops (crop rotations).
(6) Plow under legumes, grasses, manure, cornstalks and straw to build up organic matter.

(7) Use other erosion control such as grassed waterways, contour cultivating, strip cropping, or terracing, if necessary.

Not all of these practices are needed on every farm. Some are more necessary on one farm than on another. If this land-use program is properly applied on every farm, Minnesota soils will be kept productive permanently.

Drainage makes for good land use.

Good soil often suffers because it has too much water. Almost every farm in the better agricultural areas of the state has drainage problems. In many sections of southern and western Minnesota it is difficult to plan a land-use program without making better use of the wet lands on the farm. Drainage makes it possible to use this soil.

The purpose of farm drainage is to use soil moisture so as to increase crop yields and to improve crop quality. This is done by installing tile drains or open ditches to remove the extra water from the upper 3 to 4 feet of the wet soil.

Natural or artificial drainage does not distrub the useful water so essential to plants. A mineral soil suited to farming cannot be overdrained. Since most of the water that falls as rain or snow on the farm comes from oceans and seas, drainage has little effect upon rainfall. Drainage does not cause excessive floods or droughts. Farm drainage has little or no effect on the deep ground-water supplies we depend on for many things.

Drainage improves the chemical and physical condition of the soil. To obtain maximum yields from drained land it is necessary to follow well-established fertility practices.

The installation of a drainage system is expensive and should be supervised only by experienced drainage engineers. A good drainage system will pay for its cost through increased yields in from one to five years.

By improving the yields of row crops from flat, wet acres, the slopes where erosion is serious can be planted to soil-saving and water-conserving crops such as grass and forest. Thus, drainage actually adds land to farms.

Good seedbeds and proper cultivation improves crop yields.

Unlike the hardy weeds that overrun our fields, crop plants must be planted carefully and cultivated if they are to grow. Failure to get crops, particularly the legumes, to grow makes it difficult for farmers to protect the soil or to feed their livestock properly. Preparing good seedbeds is wise land use.

A good seedbed is fine, firm, free from weeds, and protected from wind or water erosion. A firm seedbed helps get seeds covered to a proper depth so that they can come up. It also helps seeds germinate by preventing excessive drying of the surface soil. A seedbed that is fine, or free from big clods, also aids crops to come up uniformly. We must be careful, however, not to work the soil until it is powdery fine or crusts will form when it rains. Weeds should be killed before the crop is seeded or they will smother the crop and use valuable plant food. Crop rotations with legumes and grasses help control these weeds and the organic matter added to the soil helps keep it in good tilth.

Plowing or cultivating soils when it is either too dry or too wet destroys its tilth. We told you how organic matter and plant roots clump soil particles together in aggregates.

Plowing the land so dry that big clods turn up or so wet that the plowed land looks slick destroys these aggregates and their power to keep the soil open and porous.

Heavy (clay) soils should be plowed in the fall (unless they are on steep slopes) so that freezing and thawing in winter helps them to mellow and firm. Fall plowing of heavy residues also helps firm the soil at the bottom of the furrow so that no air pockets are left to cause drying of the soil. Sandy soils need more protection from erosion even on level land and should generally be spring plowed. Where wind erosion is a problem surface tillage which leaves stubble and residues on the surface is the best practice.

Proper cultivation, especially of row crops, after the crops are seeded helps preserve soil tilth and increases yields. Have you ever noticed how corn wilts just after it has been cultivated deep and close to the plants? Cultivating corn over 3 inches deep and within a foot of the row will prune roots and prevent the crop from getting water and plant food. Don't cultivate more often than is necessary to kill weeds and break up soil crusts and don't cultivate deep.

Liming acid soils is essential for crop growth

Many of our soils in eastern and north central Minnesota have had most of the lime (calcium) leached away by rainfall. Use of lime on these acid soils is essential if we are to make legumes grow and if the nodule bacteria on their roots are to live and fix nitrogen from the air. Lime is also helpful in decomposition of organic matter since the microbes that do this job work best in a sweet soil. We find, too, that crops can use the supply of phosphorus in the soil better if the soil is not too acid.

Plants vary widely in their tolerance of soil acidity. Some, like roses, raspberries, and red sorrel, grow well in quite acid soils but poorly in sweet soils. Others, like the legumes, spinach, cabbage, and onions, do best in soil that is only slightly acid. There are big differences even in the same kinds of crops. For example, farmers in southeastern and northern Minnesota often grow red clover because they say alfalfa won't grow. Red clover can do well in a more acid soil than can alfalfa. Alfalfa, in turn, doesn't need quite as sweet a soil as does sweet clover.

The scale we use to express the acidity or sweetness of a soil is called "pH". It is stated somewhat like the sizes or gauges of wire. In wires, the smaller the gauge number, the heavier the wire. Likewise, in the case of pH, the smaller the number of the pH scale the more acid is the soil. The pH scale runs from 0 to 14. A soil which has a pH of 7 is neutral. Below 7 the soil is acid and above 7 it is alkaline or sweet and may contain free lime. The scale is set so that each number indicates 10 times more acid than the next larger number in the scale. Thus, a pH of 6.0 is 10 times as acid as a pH of 7.0. Most surface soils in Minnesota range from about pH 5.5 to pH 7.5. The high lime or "alkali" soils of western Minnesota range from pH 7.5 to 8.0.

What causes a soil to become acid? The most important acid in the soil is the fine clay it contains. Remember, we told you that clay could act as a chemical in the soil? This clay doesn't wash (leach) out of the soil, but the calcium, magnesium, potassium, and other plant foods fastened to the surface of the clay do leach away. Rainfall and removal of plant foods by crops, then, are mainly responsible for soils becoming acid. The longer we farm a soil, the more acid it becomes.

The more clay there is in a soil, the more lime it takes to correct this acidity. For example, it takes only 1 to $1\frac{1}{2}$ tons of limestone to decrease the acidity level of a sandy soil from pH 5.0 to pH 6.5. It takes from 4 to 6 tons of lime to do the same thing in a heavy clay soil.

Lime must be in the soil for some time before it can correct acidity enough to permit legumes to grow well. For this reason, farmers apply lime at least six months or a year before seeding legumes.

We can sometimes tell if lime is needed by the kinds of plants that grow best on a soil. However, an easy and sure way is to have a soil test made. The University of Minnesota maintains a soil testing service for this purpose.

Fertilizers return lost plant foods to the soil

More than 250,000 tons of commercial fertilizers are used each year by farmers in Minnesota. Large as it may seem, this use of fertilizer returns to the soil only a small part of the plant food lost by erosion, crop removal, and leaching. To keep producing all the food we need, we must use more fertilizers to replace these losses.

We have discussed the foods that plants need. How can we tell which ones to supply, how much to apply, when to apply them, and where they should be applied? Farmers should watch their crops for the deficiency symptoms we described and test their soils before applying commercial fertilizers. In this way, they can be sure they are using the right kind and the right amounts.

Whether or not any given field needs fertilizers depends upon three important things. The first of these is the kind of soil. We know that the ways soils were formed makes them different. Sandy soils are generally low in all the nutrients supplied by commercial fertilizers (nitrogen, phosphorous, potassium) and lime (calcium). Practically all Minnesota soils need phosphate, particularly the "alkali" or high lime soils. Most peat and muck soils are short in potassium. These differences in soils and their requirements must be kept in mind when using fertilizers.

The second thing which tells us what kind of fertilizer to use is the kind of crops we are raising. Some crops use more of one plant food than of others. They also demand different balances or proportions of these nutrients at different stages of their growth. Legumes, for example, use a great deal of potassium and calcium but less phosphate. If inoculated with legume bacteria, they can furnish their own nitrogen. Corn requires much nitrogen and phosphorus and less potassium. Small grains require lots of phosphorus and fair amounts of nitrogen but seldom starve for potassium.

The third thing determining the need for fertilizers is the way in which the farmer has managed the land. Such things as the amount of erosion, kind of crops, lime, manure, and fertilizers, use of green manure crops, and plowing under crop residues all change the balance of nutrients available to crops. Soil fertility is not only a combination of favorable chemicals in the soil but also an expression of its tilth.

Fertilizers are sold according to the amounts of N(nitrogen), P_2O_5 (phosphate) and K_2O (potash) they contain. The composition of a fertilizer is described as the per cents of these nutrient elements in this same sequence. Minnesota law specifies that companies selling fertilizer print its composition on each bag of fertilizer. For example, a "6-24-12" fertilizer contains 6 pounds of nitrogen, 24 pounds of phosphate, and 12 pounds of potash in each 100-pound bag of the fertilizer.

Because of the many, many different soils, crops, and management practices, each farm presents a separate problem in regard to the correct fertilizer use. Soil scientists at the University of Minnesota are continually studying the needs of these farms and their soils. They tell you about these findings in bulletins and in magazines. Why don't you or your class start a collection of these bulletins for your library? You can also learn more about the soil on your own farm by having its soil tested and by trying different fertilizers in small plots on various crops.

Changing crops keeps soil healthy

One thing many good farmers do is to change crops. Just as we change clothes from one day to another, farmers have to change crops on one field to another from year to year (called crop rotation). Crop rotation can prevent erosion, improve the organic matter and tilth of the soil, and help grow better crops.

Here's how one rotation works. A farmer might grow a row crop like corn the first year, a small grain like oats the second year, and hay or pasture the third year. This is a three-year rotation. A good rotation must include a mixture of grass and clover or alfalfa because the hay crop is the most important crop in the rotation.

Changing the kind of crops every year or two means that the land is covered by soil-conserving crops at least part of the time. This prevents wind and water erosion. The grass and legume crops add organic matter and nitrogen. Organic matter binds the soil together and helps to prevent water and soil from washing away.

Not only the land we normally plow and plant to crops like corn and legumes but also our permanent pastures need improving. Where old bluegrass pastures can be plowed or tilled with a field cultivator to kill the bluegrass, reseeding with a good legume and grass mixture like brome and alfalfa gives a big increase in feed for our livestock. They like it better, too, because of its high quality. Where pastures are too rocky or steep to reseed, they can often be improved by using the proper amounts of lime and fertilizer.

Organic matter adds life to the soil

Most Minnesota soils have only about 60 per cent as much organic matter as they had before they were first plowed. The loss was very heavy the first few years because opening a soil rich in organic matter is just like opening the draft on a stove full of fuel--the fire burns more rapidly because there is more oxygen available. When air, moisture, and temperature are favorable, soil bacteria digest organic matter faster.

We have already discussed the many things that organic matter does for the soil. We see now that farmers should not plow or cultivate their land any more than is necessary to kill weeds and prepare good seedbeds or they will "burn up" the organic matter supply faster. They must also be careful to replenish the supply of organic matter in the soil.

The most important way to supply organic matter is to grow grass and legume crops in the rotation. These crops, with their heavy root growth, build up organic matter in the soil at the same time they provide hay and pasture. Sometimes when the tilth of the soil is very bad or when the farmer has no livestock to use the feed, legumes and grasses are grown and plowed under. We call this "green manure."

Ordinary barnyard manure is a valuable soil builder. It is one of the farmer's most valuable possessions because it adds both organic matter and plant food to the soil. A ton of the average manure contains about 10 pounds of nitrogen, 5 pounds of phosphate, 10 pounds of potash, and, in addition, adds about 450 pounds of fresh organic matter to the soil. There is enough manure produced by livestock in Minnesota to grow an additional $700 to $800 worth of crops on every farm if it were properly used.

Manure must be taken care of properly. Nearly 65 per cent of the fertilizer value of manure is in the liquid portion. Use of straw or other bedding helps save this part of the manure.

Manure should be hauled to the fields when it is fresh. If possible, it should be plowed under as soon as it is spread on the fields. If the soil is frozen or snow is on the ground it is still better to spread the manure than to leave it in piles along the field or in the barnyard.

Manure ferments or rots when left in piles or in the barn. When this happens, nitorgen and organic matter are lost as gases. The strong odor in barns and, particularly, chicken houses is due to a loss of nitrogen as ammonia from manure during fermentation. If it is impossible to haul the manure out to the fields, storing it under a roof in a closed shed will prevent loss of plant food by leaching. Packing the manure well will shut out air and keep bacteria from rotting it as fast. Some farmers spread ordinary superphosphate (0-20-0) on the manure. This helps keep down loss of nitrogen and adds some of the phosphate which manure lacks for a well-balanced fertilizer.

Unfortunately, some people think it is easier to burn cornstalks, straw, and other residues than to work them into the soil. If these materials are plowed under, they will feed many millions of helpful bacteria and help keep up the organic matter content of the soil. They will also help protect the soil from beating rains and prevent it from being washed away.

Reducing soil and water loss by erosion is good soil management

Your doctor will tell you there are many things you must do to keep healthy. You must eat the right food, and you must take care of yourself. Soil experts, who really are land doctors, say the same thing about soil. Soil must be fed correctly by using crop rotations, keeping organic matter high and feeding fertilizers. Controlling water and soil losses on steep land by using grassed waterways, contour tillage, strip cropping, or terracing is taking care of the soil.

In the next section of this manual we are going to tell how these practices control soil erosion and how best to apply them to the land.

CONTROL OF SOIL EROSION

Soil erosion takes place when the valuable topsoil (which feeds plants) is either washed or blown away. Water erosion tells us that not only soil, but moisture has been lost. A good soil conservation program should allow us to get the best crops that the land will give and should protect and improve the soil and save moisture.

Good soil conservation includes erosion control but other things should be considered, too. Some of these are: selecting proper crops, rotating them correctly, keeping organic matter built up in the soil, and testing and fertilizing properly.

Returning to erosion control, let's look at three ways to save the soil.

1. Cover and protect the surface against wind and water damage.
2. Make the soil absorb more water thereby reducing the amount of runoff.
3. Conduct the surplus water slowly off the field in protected channels.

(References:* Minn. Ext. Bul. 254, Soil Fertility and Conservation. U.S.D.A. - SCS Bul. PA-71 Use the Land and Save The Soil)

Here are some soil conservation practices we may use to carry out an erosion control program.

Some Land Needs Plant Cover

Some land is too steep or is located in hard-to-get-to places which should not be farmed in the ordinary ways. Keeping areas of this sort in continuous sod for pasture usually will control the water erosion. In certain cases trees should be planted to protect the slopes, if not pastured, and to promote useful wildlife.

(References: Farmers' Bul. 2035 Making Land Produce Useful Wildlife, Minn. Ext. Folder 62, Legume and Grass Mixtures, Minn. Ext. Folder 115, Pasture Renovation.)

Shingle the Waterways with Grass

Most fields have natural channels where surplus water runs off after heavy rains or during the spring thaws. These waterways should be kept in a good sod to protect them from washing. They make ~~soil~~ water walk, not run, downhill. Without sod, gullies that damage our land are formed.

In preparing a sod waterway, the channel must first be shaped with a broad, farily flat bottom. It should be extended from the top of the slope to the bottom, or final water disposal area. In filling gullies be sure to remove debris, since these materials will cause the waterway to wash out. After shaping, work the soil into a fine, compact seedbed. Then fertilize it properly and disk in straw or strawy manure. Seeding and packing may be done either in spring or late summer, if possible avoiding the period of heavy rains. The seed mixture should be adapted to the area and should contain more grass than legumes because grass roots hold the soil better and form a denser sod. Hay cut from the waterway will pay.

* Bulletins listed in this booklet may be obtained for study from your leader or the County Extension Office.

Keep the waterway in repair and cut it at least twice a season. Do not use it as a roadway and always lift digging implements when crossing it.

(Reference: Minn. Ext. Folder 107, (Grassed Waterways).

Farm On the Level

Contour farming means farming across the slope, on the level, instead of up and down. As a result, all implement marks, such as plow, disc, drill or cultivator, are on the level. This helps to hold back the water and gives it more time to soak into the ground. Considerable soil washing is prevented also.

Sheet erosion, that is, erosion which takes the entire surface of the soil away in sheets, is even more dangerous on some fields than gully erosion. This is particularly true since we often don't realize the loss until light-colored subsoil begins to show through in the field.

Contour lines must first be laid out on the field, using an inexpensive hand level or one made from a carpenter's level. For simple contouring follow the line in your field operations, working up from and down from the line established. A new line must be established if slope varies considerably.

To strip contour (make alternate strips of sod, small grain, or row crops) mark a line on the contour and then mark off the strip widths (60 to 120 ft.) from the original line with a clothesline or other light rope. Should the lower line be off the contour to any extent, replace it with a newly run contour line. Field work like plowing starts at each line leaving the dead furrow in the center of the strip. Short furrows or "point rows" will usually be at the center of the strip.

On cropland, which does not slope much over 15 ~~feed~~ feet drop per hundred, contour strips control water erosion well. There should be a strip of sod land between small grain or row crops to slow the water runoff. Each grain or corn row also slows water runoff.

Stress sod crops in

1. Preventing beating action of rain drops.
2. Slowing down runoff of water.
3. Increasing uptake of water by the soil.
4. Tying soil particles together to prevent erosion.

(References: Minn. Ext. Folder 108, Contour Strip Cropping.)

Terraces Are Good

Terraces usually consist of a series of low ridges across the slope, with a channel above each ridge to carry the water off to the side of the field. The ridges and channels are laid to a carefully determined grade or slope, so that the excess water will move slowly off the field onto a sodded area or outlet. Terrace channels usually have a "fall" of three or four inches per hundred feet. Terraces have the effect of breaking up a long slope (not steeper than twelve feet drop per hundred) into a series of shorter slopes.

An entire terraced field may be planted to the same crop. The farming operations must still be contoured. The terrace acts as the contour line. The terrace ridges and channels can be farmed but operations should be with, not across, the terrace. Terraces must be accurately laid out and constructed, usually with professional help. Proper maintenance is also necessary.

In no case should terraces be constructed until adequate and proper outlets are provided.

(Reference: Minn. Ext. Folder 159, Build Your Own Terraces.)

Give the Soil Wind Protection

Nowhere is it more important to use land wisely through proper crop rotations than on soil which blows or drifts.

Strip cropping to control wind erosion consists of strips of different crops 15 to 20 rods wide usually run east and west. It is very effective and simple to maintain. One strip in three should have winter and spring cover such as hay or winter grain. Have the cover strips between strips of row crops.

Large fields of low-growing row crops such as sugar beets, soybeans, or potatoes should have four rows of corn replacing the other crop about every 10 rods. Leave the corn stalks standing to rebuff the wind at the soil surface and to catch snow. These are called buffer strips.

We can control much wind erosion by cultivating soil that will blow easily so that the surface is rough or covered with crop residue. The wind is slowed down at the soil surface, many clods remain unbroken, and moisture is conserved so that less drifting takes place.

Shelterbelts on the west and south sides of medium-sized fields protect well. These belts may be made up two or three rows of fast-growing trees with a row of dense shrubs at either side of the trees. Trees 20 feet tall will protect for 25 rods. For large fields strips of two or three tree rows every 40 or more rods will give additional protection in severe situations.

(References: Minn. Ext. Bul. 235, Wind Erosion Control.)

Dispose of Surplus Water

Ordinarily, land drainage is not considered an erosion control practice. But it does allow better land use. For instance, some of our low land, if drained, would be usable as high quality cropland subject to little or no erosion. Land drainage would enable us to move some crops, especially row crops, from the slopes. Then those slopes could be protected with sod crops.

In many instances a tile drain running parallel to a sodded waterway helps to dispose of excess underground water. The seepage water areas, usually surfacing low on slopes, act almost like springs in hindering farm implements. Tile placed fairly deep and above the wet area along the base of the slope, outleting below, will often correct the difficulty.

Remember these points on good drainage.

1. Always have a good outlet with enough fall to drain water readily.
2. Whether made of open ditches or tile, the outlet must be properly located and large enough to handle the surplus water.
3. Carefully and regularly inspect and maintain the system to keep it working properly.

(Reference: Ext. Bul. 149, Farm Drainage Practice.)

DEMONSTRATION SUGGESTIONS

1. The value of contour tillage -- To show how rows, running on the level around a slope, will hold a good part of the rain, giving it a chance to soak in before running off and carrying soil with it.

First Method

Equipment: a washboard, pitcher, water, and a pan

Procedure: Hold the washboard nearly flat, its legs in the pan, and sloping toward audience pour water on it. Water will be held by the ridges. Tilting the board slightly to right or left to show how crop rows (ridges in board) not truly on the level will lose water quickly. Lift the rear of the board and, even if rows are level, the steeper slope will lose water fast. Turn the board so that the rows run up and down - now the water runs right off, as it does in rows up and down a slope.

Second Method

Equipment: Two shallow pans, soil, sprinkling pot, and water

Procedure: Build a mound of soil in each pan. With your finger make some furrows running around one mound. Run the furrows on the other mound from peak to base. Let the same amount of water run onto each peak. The contoured rows in the first pan hold much more water and lose little soil.

2. To measure the per cent of slope - - Land which slopes more than 25 per cent (25 feet drop in 100 feet) seldom should be used for row crops. If the slope is between 4 and 12 per cent, terraces might be recommended.

Equipment: Small carpenter's level, two wooden slats 5 feet long. Mark one slat into 100 equal divisions (1.20 of a foot between each mark).

Procedure: Select the area to be measured or, if indoors, lean a long board from fllor to table. Place one end of the plain slat on the ground (or board) with the level on it. Raise the other end until this slat is level. Stand the marked stick at the raised end of the plain slat. Count the spaces from where the sticks intercept to the ground - that is the per cent of the slope.

3. Running field contour lines - - To farm on the level, contour lines must be run, which will be followed in farming operations.

Equipment: a hand field level (made or purchased), stakes, and charts showing a contoured field. If indoors, a plank laid with one end on a chair is needed to represent the slope.

Procedure: One member of the team displays and explains the contours shown on the chart. Then he explains that how if using the hand level, one demonstrator sights through to his partner (to his eyes if he is about the same height). The level operator, standing on a small box then "sights in" his partner who moves up the sloping plank to proper level. Explain bubble and mirror arrangement if hand level is used or tell about plumb bob method if simple T level is used. (See part on homemade T level.)

Follow method outlined in part 2 of Ext. Folder 108, Contour Line Laying.

4. How to lay out contour strips - - Using contour strips in field operations uses the basic contouring, or on the level, principle. In addition, strips along the slope are arranged (as regular as possible) so that sod strips alternate with grain or row crops.

Equipment: Hand field level, light rope, stakes, a sand box ($2\frac{1}{2}$ feet square) three-fourths full of sand with the back 10 inches high and front 5 inches, sawdust in three colors, parlor matches for miniature stakes. Note that first three items are for outdoor use.

Procedure: Shape the sand in the box ahead of time to represent the field to be stripped. Using matches as stakes run the first line and successive strips by following instructions under part 3 of Ext. Folder 108, Contour Strip Cropping.

Explain the method as you spread various colors of sawdust, green for hay strip, red for row crop and yellow for grain. Leave natural sand with something of your own choice to represent woodland. Make necessary fences with matches and string. After colored sawdust is applied remove match stakes on strip lines.

5. Making a homemade level - - Levels, more or less complex, may be made at home. But with well constructed and accurate hand field instruments available at reasonable cost, we recommend purchase of the item. For illustration, the construction of an extremely simple level may be demonstrated.

Equipment: Two pieces of 3/4-inch board 18 by 3 inches (one to be perfectly squared), one piece of 1/4-inch wood 18 by 3 inches, light 2-inch stove bolt with nut, several 3/4-inch nails, two small screw eyes, and a carpenter's square.

Procedure: Using the squared piece of board as the crosspiece of a T, nail the piece of 1/4-inch board on as the upright of the T. Before nailing use the square to get the pieces at right angles. Loosely bolt an end of the other 3/4-inch board at the T joint to be the handle. Weight the outer end of the 1/4-inch board with metal of some sort. Carefully insert the screw eyes at each end of the top of the T at the same depth for sighting.

By holding the outer end of the bolted handle, with the top of the T at eye level, you may sight through the screw eyes to a distant point at your eye level. Be sure that enough weight is attached to the lower T stick to act as a plumb bob. You can check the instrument on a level place, sighting something exactly at your eye level.

6. Proper soil sampling for testing - - The best guide for lime and fertilizer applications is the test run by the Minnesota Soils Testing Laboratory. The reliability of the test and resulting recommendations depend upon a properly taken sample.

Equipment: Charts made up from Tables A and B and the Field Outline shown in Soil Sample Information sheet (S. T. 2) of central Soil Testing Laboratory, University Farm, (obtain from County Extension Office) spade, trowel, 10-quart pail, soil sample box, box about 18 inches square and a foot deep containing a block of field soil taken as undisturbed as possible.

Procedure: First discuss and explain the information to accompany each sample sent to laboratory. Using field map, explain method of obtaining a composite sample described in Information Sheet. Sampling of garden soil to follow sheet S. T. 4. With soil in box show how to dig a V-shaped hole to plow depth and take an inch slice from surface down 6 inches as a part of composite sample. Fill out information sheet, put soil in mailing carton, and label. From an enlarged chart of the recommendation sheet received from laboratory point out fertilizer grade and amount to use. Study ratio of nitrogen, phosphate, and potash shown. Comment on lime needs.

7. How soil absorbs water - - The faster water enters soils and percolates downward, the less runoff takes place. Soils well supplied with organic matter not only allow water to sink in easily but also hold the moisture well. As a result less water erosion takes place.

Equipment: Quart sample of soil from an overworked, poorly handled field and one from a nearby area, such as an unworked grassy fence row, 2-pint or quart clear plastic containers, 2 wide mouth clear glass quart jars, water, and measuring cup. Drill 8 or 9, 1/8-inch holes in bottoms of plastic containers.

Procedure: Fill each drilled container 3/4 full of soil - one with low organic content soil and the other from the sample of virgin soil. Tap each sample the same to pack it slightly. Place the plastic jars on top of glass jars and pour the same amount of water onto each soil sample. While the water is percolating into the soil and dripping through into glass jars, charts may be used to discuss how organic (vegetable) matter can be increased or maintained in the soil and its advantages. Then display the high organic matter soil, showing how water has entirely entered the soil and some passed on through it into glass jar below. Then show the low (overworked) organic soil, pointing out that no water has filtered through it (or very little) and that some is still standing on the surface. The water on top would have been run-off water causing water loss and soil erosion.

8. Value of granular soil - - The arrangement of soil particles in a manner favorable to water and air movement within the soil is important. Organic matter in good supply, whether from green manure, sod plowed down, and proper rotations or fertilization contribute to the valuable condition known as good tilth. Soil low in organic matter tends to puddle, bake, and seal easily from falling rain drops. Loss of water, seedbed crusting, and erosion are results of that condition.

Equipment: Four saucers or small pie tins, samples of soil similar to those in demonstration number ~~8~~ 7 and water.

Procedure: The day before the demonstration put about 1/4-inch of each soil in each of two pans. Add enough water just to cover the soil. With a pencil stir each mixture six or seven times. Let the soil settle. Then pour off excess water and let mixtures dry out. At the time of the demonstration repeat the process with the other two pans. After pouring water off, point out how one soil immediately took up more water and how the other (low organic) soil seemed to run together badly. Now exhibit the dried, previously prepared samples. The finer soil is crusted and probably cracked while the more granular sample has kept its good structure. Emphasize use of crop rotations, grasses and legumes, crop residues, barnyard and green manures, fertilizers and conservation practices to keep our soil in good tilth and production.

9. Build a rain gauge - - When we know the exact amount of rain which falls and then observe the nearby fields as to resulting erosion, the erosion story is impressive. Reading a rain gauge after a rain tells us how much fell and how long it fell.

Equipment: Sheet metal to make a cylinder, closed at one end, about 8 inches by 2 inches or a tall tin can with one end removed, soldering kit, ruler marked in tenths of an inch, and support post for gauge.

Procedure: A rain gauge may be any diameter, as long as sides are straight. One inch rain means that enough water fell to cover the ground with a layer of water one inch thick. Roll the metal into the desired cylinder and hold it with clamps or cord while soldering the seam. Cut a circle of metal and solder it over one end (the bottom). If tin can is used as the gauge, paint it inside and out to prevent rusting. Construct a small frame to hold the gauge upright on the top of a solid post about four feet above ground. The gauge sits in this and is easily removed for emptying. It must be erected perpendicularly in the open away from trees and buildings. Can be placed in the open lawn or garden.

Mark off a strip of metal or hardwood into inches and tenths of an inch as rainfall is measured in that manner. During the demonstration a sprinkling pot may be used to imitate a rain on the gauge as it stands in a pan. Then insert the dry measuring stick and quickly read the height of water collected. In practice, make readings once a day or after heavy rains and keep a record by weeks and months.

10. The value of topsoil - - The topsoil, usually the soil in which plants grow, must be fertile, of good tilth, well supplied with organic matter, and sufficiently deep to give us good crop production.

Equipment: Two large flower pots, soil for each - one sample of topsoil and the other from about 2½ feet down, oat seed and large picture of a soil profile or an actual mounted profile.

Procedure: About a month before the demonstration plant 15 or 20 oat seeds in each pot of the two soils. Put seeds at uniform depth in both pots and from time to time apply equal amounts of water to each. Difference in growth will show up by demonstration time, due to soil variation, as food in seeds will have been exhausted by that time. Observe, with the audience, difference in growth and color. Point out results in relation to topsoil and soil from which it has been eroded. To show what was done previously it is well to use two other pots and soil samples and go through the planting procedure.

11. Water Runoff - - As water runs off a field, two damaging factors are involved. First is loss of the moisture from the field and second, soil erosion resulting from the moving water. The speed at which watermoves and the distance it runs tells how much damage results.

A dense sod, made up of grass such as brome, along with some alfalfa or clover does a good job of protecting slopes from erosion.

First Method

Grass Holds Rain Like a Blotter

Equipment: Green blotting paper and hard surface white paper, each 6 by 12 inches, a board about 12 by 12 inches, a 4-inch block, water colored with ink, medicine dropper, and thumbtacks.

Procedure: Place the board on the table with block under the edge the edge away from audience. Tack a green strip, up and down, on the board and a white strip alongside the green one. Place some old newspaper under lower edge to catch the drip. The green paper represents a sodded slope while the white paper represents a slope of bare soil. Put a dropper full of the colored water near top of white paper and it runs quickly down the slope (water runs off bare soil quickly). Then put a dropper full on the blotting paper (it starts to run but soaks in quickly). Explain that in letting water run slowly and sink in, the sodded slope holds water for plant growth and prevents erosion.

Second Method

Sod Cover Saves Soil and Water

Equipment: Two boxes, using boards 6 inches by $2\frac{1}{2}$ feet for the bottoms Use 6-inch boards for sides and one end of each box and 4-inch pieces for the other ends, soil from a cultivated field, a slab of good sod (box size), a 4-inch block, water, pint measure, tin strips for gutters at lower ends of boxes, glass containers to catch runoff.

Procedure: Fill one box with packed soil, so that it is one inch below box sides. Put the sod slab in the other box with extra soil underneath the sod to allow the top to be one inch below box sides. Pack soil and sod around the edges well, with a piece of board to seal the edges so that water will not leak or run down edges because of rocks or open spaces. Raise the 6-inch end of each box by inserting the 4 inch block underneath. This sets up a slope of about 13 per cent (13 feet fall in 100 feet). Put the glass containers in position at lower ends to catch runoff. Pour water at a rate of a pint per half minute near top end of plain soil. Add the water until it starts running over lower end of box, counting the time it takes and amount of water used. Apply water in same manner to sod box, keeping the same count as to time and amount of water. Examine water runoff as to muddiness and erosion damage. Discuss the value of close growing crops for erosion control.

Third Method

Building A Sodded Waterway

Equipment: Charts, diagrams, seeding and fertilizing tables, 2 boxes about $1\frac{1}{2}$ by 2 feet by 4 inches deep, soil to fill boxes, grass seed, fertilizer, toy tractor and implements.

Procedure: Both boxes are to be filled with soil and a similar gully dug out in each, the long way of the box. About three weeks before demonstration, seed the gully area in one box after forming the waterway according to the outline below so that the plants will be showing up as green cover when demonstration is held. Carry on demonstration (in other box) by forming the waterway area in miniature from the gully, as outlined in Ext. Folder 107, Grassed Waterways. Using the toy tractor and plow, disc, and harrow to illustrate (although doing the actual work with some small hand tool such as a case knife), the waterway should be flat bottomed, 2 to 3 rods wide (in actual field) and extend up to the top of the slope and down do the bottom.

After it is shaped, fertilizer can be applied with a sifter-top can and manure (use coarse cut smoking tobacco) spread before last disking and harrowing. Seed is then spread and rolled with a toy roller (you may have to make this) or scratched into the soil with a toy hand rake. A toy roller can be made by cutting a quarter inch off each end of about 6 thread spools of the same size and running a bolt through the holes to hold them together.

Now show charts and diagrams and a list of the steps in waterway formation. While you display the box with the waterway seeded and growing, it is well to point out the care of waterways such as lifting implements when crossing, cutting twice a year, etc. On the growing model it is effective to show the rest of the slope in contoured corn. To make the corn plants cut pieces of green crepe paper about 1/2 by 1 inch in size, dip a half inch of the end of a toothpick in glue and wrap the crepe paper piece over glued area. When dry, stick the bare ends of prepared toothpick in soil to represent corn plants.

12. How Organic Matter Reduces Soil Erosion - - Field soils which have not had a good sod turned under regularly or other organic matter added from time to time erode easily. Those soils low in organic matter are easily "puddled" and packed by rain and as a result the water runs off before it can soak in, causing excessive erosion.

Equipment: Two extra wide-mouth quart glass jars or fish bowls, two pieces of 1/4-inch mesh hardware screen, 3 by 10 inches, one piece of native grassland topsoil about the size of a goose egg, one piece (same size) of subsoil from a depth of 4 to 5 feet (from a road bank), water to fill jars within an inch of the top.

Procedure: Point out that the dead and decayed roots have given the topsoil its dark color and helps hold the soil together. Soil low in organic matter is more easily carried away by water. First bend the pieces of screen to form a U-shaped cradle so that the piece of soil on it will be suspended below the surface of the water. Place each piece of soil on a cradle and lower carefully into the jars - one in each. Notice which piece starts to fall apart in the water first - and how fast. After 3 to 5 minutes tap each jar with a pencil and notice the results. Explain it.

13. How to Control Wind Erosion - - Certain soils, if left bare through fall, winter, and spring are easily damaged by wind erosion. The fine sandy or silt-type soils are most often moved by wind eroision. Alternate strips of sod between other crops, trash cover, rough tillage, or shelter strips of trees or standing corn reduce the surface cutting power of the wind. The fine dust blown contains considerable organic matter.

Equipment: A box about 2 inches deep and 18 inches square, fine, dry soil that blows easily, two or three handfulls of grass cut into 1-inch pieces, dried, and an electric fan with about 6-inch blades.

Procedure: Spread the fine sand or soil evenly in the box, level with the sides. Turn on the fan and hold it so that breeze blows over the soil. Arrange so that people see the soil blowing off. With the fingers make parallel ridges in the soil representing rough tillage. Start the fan again and allow its blast to blow along the ridges. Soil will move. Turn the box so that the air current blows across the ridges. Less soil will blow so that we show how soil should have ridges left crossway to prevailing wind. Now smooth the soil again and sprinkle lightly with the grass clipping. With a thin stick or knife blade, at random, press the trash into the soil slightly so that it is partly imbedded in the soil. Turn on the fan again. Now even less soil will blow than when ridged, due to the trash cover, which in true practice might be corn stalks or stubble. One good method is to put the trash in the soil on only half of the box and with the fan show how much wind erosion is prevented by alternating the fan air current from the bare to the trash-covered soil.

14. Farm Conservation Planning - - To demonstrate the application of the soil and water conservation practices which fit a farm it will be necessary for the one demonstrating to know about the practices involved. It is best to have available the soil and capability (land use) maps of the farm to be discussed. Also, have a field layout map of the farm as a guide in setting up the conserving practices. It may be best to take a portion of a farm to keep the demonstration simple so as to not include more material than can be handled. Keep in mind that a farm conservation plan in its simplest form should include arrangement of the recommended soil and water conserving practices.

Equipment: A double frame of 1 inch by 2 inch strips, each half frame being about 30 inches square. The two halves of the frame should be hinged together and each fram corner reinforced with flat angle-irons such as are used on house screens. Tack pieces of beaver board or similar material (3/16 to 1/4 inch thick) over each half of the frame, to be used as backing as frame is opened. On one half of the farm tack light green outing flannel or light felt of the same color. A map, on paper, the same size as the frame should be prepared of the farm as it was before practices were installed. Also prepare a frame-size map, on paper, of the farm arrangement as the conservation practices are planned or applied. There should be constructed on an easel to hold the doubel frame in a horizontal position, tipped slightly back.

Procedure: Before the demonstration, thumb tack the "before" map to one side of the frame. Then, using tan, dark green, and yellow outing flannel or light felt, using the "after" map as a guide, cut out each strip, sodded waterway or field of one crop. For example, for hay area use dark green; corn or row crop to be yellow and tan for small grain. Farmstead area to be black; woods or wildlife area to be grey with small green circles (trees) stapled on it.

Now, to the demonstration proper. Explain the "before" map and problems of soil conservation. Then step-by-step, starting with the farmstead, carefully place each cutout on the part of the frame covered with light green cloth. Each strip of field as put in place will adhere to the light green flannel or felt backing by friction. After fields are applied, add the sodded waterway strips and wooded areas. Any parts not covered will show the light green backing material, which represents the pasture.

As the demonstrators build the flannel-graph many orginal ideas may be used with this description as a guide. Almost all soil conserving practices may be worked out, including contouring, contour strips, terraces, sod waterways, wind erosion control strips, shelterbelts, woodlots, game protection areas, pasture renovation, and rotations.

EXHIBIT SUGGESTIONS

1. Top soil and crop yields -- Areas from which considerable topsoil has been eroded will ordinarily yield less than undisturbed land. This is principally because the crop has to grow in soil low in organic matter and fertility and does not absorb water readily. Attempt to show yield comparison both on grain and stalk for small grain or corn or for hay.

Preparation: Pictures showing eroded and noneroded areas might be used as a background. Charts also may be prepared showing yields obtained from the two soil situations.

On the table should be displayed small piles of grain or bundles of hay to show the comparison in yield. Local yields may be used as data or the figures quoted in bulletins.

2. Gullies and sod waterways - - To show damage done to a field by gullies and also the protection afforded by sod waterways.

Preparation: Spread dirt (finely sifted) evenly over the entire surface of a table with built-up sides. On one half, open a gully. Place a small dimestore tractor, overturned, in the gully. On the other half of the table show a sodded waterway with a toy tractor crossing it without harm. The waterway sod may be shown with green sawdust.

3. Conservation methods stop losses - - To indicate the principal causes of loss of income due to improper soil management or land use; also, to point out remedies for each.

Method I: - - Obtain a full-sized wooden barrel and place it in an elevated position in the exhibit space. Set it with the closed end up; then pile soil on the head to cover it completely to make it look like the barrel is full. Cut five large corks in half and glue them to the barrel to look like stoppers for holes. Discard the small half of the corks. With thunbtacks place a small placard just above each cork to indicate the income "leaks" such as: Fertility, Erosion, Land Misuse, Moisture, and Unproductive Pasture.

Prepare small placards, each listing a soil and water conservation practice. Distribute these cards on the table in view of the people. Run a narrow ribbon (different color for each practice) from the placard to the "leak" it will help stop.

Placard suggestions are: Rotations for fertility, erosion, and land misuse. Fertilizer for fertility and unproductive pasture. Pasture Improvement for unproductive pasture, erosion, and land misuse. Sod waterways for erosion and moisture. Contouring for erosion and moisture. Wind stripping for erosion, moisture, and land misuse. More grassland for erosion, land misuse, and unproductive pastures.

4. Farm models - - A complete modeling job would ordinarily show a farm before and after soil conserving practices were applied. Do not attempt to show many types of practices--only those most appropriate to the area or to the farm.

Preparation: A low-sided box 30 x 30 inches will, roughly, represent a quarter section (160) at 1 inch to 6 rods. To use this size box for a single field, the scale may be multiplied (let 1 inch represent one rod for instance). First draw the map as the area was before the practices were applied and then draw one showing changes made or to be made. Arrange sifted soil to represent the contour of the land. Toothpicks and thread may be used as fences, and bits of green crepe paper glued to toothpicks as corn plants. Natural color sawdust, sprinkled over an area will depict small grain, and green sawdust, the hay, pasture and sod waterways. Pieces of sponge, dyed green, with toothpicks for trunks are often used for trees, windbreaks, etc. Colored sawdust may be purchased or dyed at home. Each time the model is set up, new sawdust will be needed.

Much originality is needed for this exhibit, such as for the buildings and cattle in pasture. Be sure to have them approximately in scale with the model. If the model represents a square 160 acres a cow, or even a tractor, would not be over 3/16 of an inch long. At 1 inch to 1 rod a tractor would still be less than an inch long.

5. Roots in the soil - -

Crop root mounts - - The principal value of this exhibit is that it shows a comparison of the amount of roots within the tilled part of the soil. Specimens of annual crops such as small grain, soy beans, or corn can be mounted alongside legumes such as alfalfa or the clovers. The other mounting would be of fibrous rooted grasses like brome grass or Kentucky bluegrass.

The lesson to learn, or the story to tell, from this exhibit has principally to do with the soil holding and organic matter supplying ability of the various types of crops.

Preparation: Dig entire amount of soil surrounding a plant of your choice to a depth of $1\frac{1}{2}$ feet and carefully lift the clod out without breaking. Cut off the tops of all samples at about 3 inches above ground level. If the soil is dry, a light tapping will knock off some of it, but be careful not to break the fine roots.

With care, put it into a tub or trough of water and let the soil soak off from the roots. A light spray from a hose will help. After cleaning, dry the specimen between layers of newspaper. When dry, the sample may be mounted with strips of transparent tape or similar material, on heavy cardboard.

Proper and informative labeling is extremely important.

b. Sod mounts - - The aim of this display is to emphasize the difference of the density of roots in a section of thin overgrazed bluegrass or mixed grass sod with that from a heavy legume-brome hay or pasture.

Preparation: To obtain the mount select a representative portion of each field and mark a 16-inch square on the surface. With shears, clip the stems close to the ground. Using a sharp spade, cut a trench 8 to 10 inches deep around the square. Then slice the top 6-inch layer off, keeping it intact and place it in a box. Wash the soil from the sod using a light stream of water on the upturned sod layer. Soil may be soaked off in a tub of water if running water is not available. Perform this operation slowly. Lay the samples out to dry, turning them several times.

To mount the two specimens obtain a light board, such as plywood, about 20 x 36 inches and bore several pairs of holes a couple of inches apart within two 16-inch squares. Mount the specimen sections, with stems toward the board by threading pieces of fine wire through two holes and twisting at the backside of the board.

After the mount is prepared, label it and insert a wire for hanging it in a horizontal position. Proper labeling again, is of utmost importance.

c. Soils low and high in organic matter compared - - Soils which are high in organic matter (decayed roots, etc.) are lighter in weight for a similar cubic measurement than those low in organic matter. Soils which are high in this vegetable matter are usually more fertile, have good moisture-holding capacity, work better, warm up earlier, and are less subject to erosion.

Preparation: Select two areas of similar soil--one having been cropped heavily for some years with little or no manure added or sod turned under; the other from the same area but has been a long time in sod, either pasture, hay, or well rotated as to crop management.

To exhibit the difference in weight of the two soils, it is necessary to have two samples of exactly the same size taken from the topsoil of each area. This may be obtained by using two identical syrup pails of the 5# size, or similar containers. Go into the overworked field when soil is not too dry and dig a 10-inch deep trench, leaving a pedestal of undisturbed soil slightly larger than the small tin bucket. Invert the pail over the column of soil and carefully work the container, with a rotating motion, down over the section of soil. When the pail has gone completely down, with care, use a spade to undercut the soil pedestal and lift the bucket full of soil out and reverse it so the pail is in normal position. Be sure that the pail is completely filled with a section of soil from the surface down.

Next, repeat the process with another pail, but take the sample from an area which has not been mishandled. A pasture with good sod or in an old fence row, with about the same slope as the field, will be a good spot to obtain the sample.

Now take about two quart bulk samples of each of the soils for pan displays. To arrange the exhibit, hang two similar milk scales at the same height in the exhibit space. Place the two pails on the scale hooks and note that the high-organic soil weighs less than the low-organic soils for identical volumes.

Place the other samples in pans so that observers may see and handle the two samples.

Either by placards or by explanation of attendants, or both, point out that the soil well supplied with organic matter is lighter due to more air spaces, a higher percentage of vegetable matter, and general looseness.

6. <u>Water Needs of Crops</u> - - This exhibit might emphasize the amount of water needed for corn and for hay. Not only should we consider the water in the plant itself but we should include the soil moisture necessary to transport the soil plant food upward into the plant, (much of the water passes out through the plant pores).

Preparation: Set a barrel in the exhibit space alongside a stalk of corn with one ear attached. The placard should indicate that "it takes a barrel of water to make one stalk and one ear of corn." Another placard may state "20 inches of water are needed for a bumper crop of corn." Add another statement to the effect that "the water used must first get into the soil, runoff doesn't count."

This exhibit might contain a bale of hay with a placard stating "it takes 125 barrels of water to produce a bale of hay."

Or this comparison might be set up: a bushel of corn (125, 6 to 7 inch ears) and stalks requires 125 barrels of water as does a bale of alfalfa hay. Or an acre of 50 bushels of corn, with stalks, requires about 6250 barrels of water as does 2 tons of alfalfa.

7. <u>Soil Sample Display</u> - - An exhibit of this sort is set up to show how a locally prominent soil appears at various levels. People can see and feel the soil

samples taken from each 6 inches from the surface down 3 feet.

Preparation: Carefully select a site on soil typical of the farm or community and dig a pit 4 feet deep or find a roadcut of the same soil class. The face of the soil is cut off with a spade to a vertical surface. Then with a trowel, obtain a 2- or 3-quart sample of the soil at each 6-inch interval. Have extra heavy double paper sacks or small cloth sacks for the samples. Mark cards with sample identification and place in each sack.

Fill each of six clear glass quart jars (or similar) with soil obtained. Carefully label each jar with a china pencil. Large placards for each will be made later. Slightly tamp the soil in the jars so that the color shows well through the glass. The rest of the samples may be put out into pans set in the same order as the jar samples so that observers may handle the soil obtained from the different depths.

It is well to expand the exhibit to 12 samples by taking the second set from an area having the same soil orginially but now has lost most of the topsoil through erosion. In this case the sample of the first 6 inches might well appear as the one from the second 6 inch level in the first group.

Careful placarding as to erosion damage, need for control, etc. should be a requirement of the exhibit.

8. Grass-legume exhibit - - A collection of identified specimens of grasses and legumes recommended for the club area make a worthwhile exhibit. Sod crops are conserving crops.

Preparation: Obtain the samples by clipping close to the ground. The display may be of individual plants or of small sheafs of each. Dry them in an airy, dark room. Bundle them or mount them with tape on stiff paper before they become dry enough to crumble.

If the specimens are taken about blooming time, the labeling will be relatively simple and the exhibit more easily understood by visitors.

9. Scrapbook of soil conservation - - A scrapbook should tell the story, as localized as possible, of the club member's soil conservation activity and interest. It could also be a club project rather than of an individual.

Preparation: In developing a scrapbook, use a book large enough to accommodate good sized pictures or several smaller ones per page. Ordinary notebooks for $8\frac{1}{2}$ x 11 paper are not large enough, either for good display or proper grouping of material. A book can be made by obtaining two or three large (2- or 3-inch) ring binders; extra heavy cardboard covers, which may be covered with cloth; and heavy stock sheets of construction paper for leaves. Punch the holes for the ring binders. Attach tapes at each cover edge to tie covers together.

A large book is ideal for a club exhibit while a smaller one might be used for the exhibit of an individual member. We like the larger one, about 24 x 24 inches, as best for all purposes. They may also be purchased.

Several types of paste might be used, but a thin application seems best for general use on papers of various sorts.

Newspaper and magazine article clippings on soil and water conservation are appropriate. Stories and themes on conservation as well as drawings will give a scrapbook the personal touch of the club member.

Instead of pasting items in the book helter-skelter, organize them by subjects. Here is a list of subjects, each one of which might be a section in the book:

1. Contour farming
2. Wind stripcropping
3. Gully control and sod waterways
4. Windbreaks
5. Liming
6. Fertilizing (Commercial, stable and green manures)
7. Legumes
8. Grasses
9. Pasture management

10. Contouring controls soil loss - - As simple contour cropping or contour stripping saves much soil (prevents it from washing down hill), such an exhibit is of considerable importance. The exhibit shows the amounts of soil lost per acre by both up and down slope farming and contouring.

Preparation: Set two square shallow boxes of soil on a table with the rear side of them elevated on blocks. The rear elevation for a box 2 feet square might be about an inch to indicate sloping land. In one box indicate contoured corn by using toothpicks, with green crepe paper glued on the ends, to make the rows. In the other box place corn plants as if the corn were check rowed (up and down hill). The placards for the exhibit should tell that the slope is 9 per cent and the soil a silt loam.

Now to show the soil loss for each method due to water erosion, place piles of soil in front of each box. As the soil loss per acre for non-contoured corn was 27.9 tons and the loss from contoured corn land was 15.2 tons, one pile should be about twice the size of the other. A placard in front of each pile should tell whether it was "contoured" or "not contoured" and list the tons of soil lost per acre for each.

ACTIVITY SUGGESTIONS

The activities outlined below may be done by individuals or the group (club) as a part of the requirements for the standard 4-H Soil and Water Conservation Project.

1. Procuring soil samples for testing - - A representative soil sample is necessary for worth while test results. To properly sample the soil, follow the instructions given on the "Soil Sample Information Sheet" (obtainable from the county agent). The equipment needed: spade, bucket, and a pint-sized container, (an ice cream carton is satisfactory), for each sample to be taken. In addition to giving directions for sampling, the instruction sheet is to be filled out and sbumitted with the sample of soil.

2. Explain a soil profile - - A soil profile is a slice of soil from the surface down about 4 feet. See page 7 of Extension Bulletin 260, Our Soil to Use for an explanation. If you are telling a group out-of-doors about soil profiles it is most easily done by the use of an open roadcut or bank. With a spade, slice the bank to make an even surface to show the various sections of the profile. If you are explaining a local soil profile indoors, it can most readily be done from a mounted profile. The Soil Conservation District office will loan you one if at all possible.

3. Compare growing power of topsoil and subsoil - - To show comparative plant production value of the topsoil and subsoil get a box of soil (at least a foot square and a foot deep) from the top 6 or 8 inches of a field. Fill a similar box with soil from the same field but taken about 3 feet below the surface.

Large pails may be used instead of boxes if drainage is provided.

Plant 15 or 20 oats seeds in each container and water each equally from time to time as growth proceeds. Four or five corn kernels may be used instead of oats. As time goes on, observe the difference in growth, color of plants and texture of the soil in each container.

4. Estimating the steepness of a slope - - On a sloping field have a companion walk 34 or 35 steps unhill from you (about 100 feet). Face the person uphill and extend both arms out wide and bring them together, hands extended flat, at your eye level. Now, estimate how many feet below your companion's head your hands are pointing. The number of feet estimated will be the guess as to the percentage of the slope. A rise (or drop) of each foot in 100 feet of slope length is 1 per cent.

   It is possible to combine this activity with the method of slop measurement as shown in the Demonstration Section of this publication. To check further for accuracy, some person may have a slope measuring level to determine the per cent of slope accurately.

5. Runoff water samples - - Immediately after a heavy rain collect a sample of water running off a corn field and one of water running off a well-sodded hay field or pasture. Keep the samples for use at club meetings or with other groups. A few teaspoons of lime water will speed up the settling in the jar of muddy water.

6. Building a farm model - - Either at a club camp or in the school yard is a good place to build a conservation farm model. Notice the picture of one on page 33 of Extension Bulletin 260, Our Soil to Use. Club leaders or soil conservation district farm planners can offer considerable advice and help for this activity.

7. Show splash erosion by raindrops - - As rain falls on bare soil, the impact of the drops damages in two ways. The splash effect starts soil movement and also pounds puddles or firms the surface so that runoff (with loss of soil and water) starts more readily.

   Paint two 3-foot stakes, made of about 4-inch lumber, white. Drive one into the bare soil on a field and the other (to the same depth) into a well-sodded pasture or hay field. After a heavy rain, dry the stakes carefully and exhibit them at your club or other gatherings. The stake from the bare field will show soil marks from splashing while the one from the sod may be practically clean.

   Place flat stones, a couple of inches in diameter, on a slope of bare soil. Small bits of board may be used, too. After a heavy rain show the folks that the stone or board is resting on a little pedestal of soil--the surrounding area has washed away somewhat due to the splash and runoff on unprotected soil.

8. Land-use judging contest - - Your county agent or club leader may set up this event for all club members, not only enrollees in the 4-H Soil and Water Conservation Project. The chief value of this activity is that it teaches you more about soil and how to use it properly. Field events like this are fun and valuable. Score cards and instruction material are available through the Extension office.

9. Contour line contest - - It is a relatively simple job to lay out a contour line, but practice is the best way to learn. Leaders, county agents, and farm planners will help instruct you and stage the contest. Area and state contests are held from time to time.

10. Skits and Plays - - A group of young folks can learn about soil conservation and at the same time instruct others with an activity like this. Page 36 of Extension Bulletin 260, Our Soil to Use may help you. Also, see the fertility skit on page 21 of the "Manual for Local Leaders, 4-H Soil, and Water Conservation Program." Why not write your own play?

11. Tours - - Farm tours are a familiar 4-H activity but too seldom do we have a soil conservation tour. Show the soil conservation practices, such as contouring, sod waterways, etc. on one or two farms. Also notice a farm or field in need of soil conservation. Decide what should be done. Do not make the tour too long, either in miles or time.

PEOPLE AND SOIL CONSERVATION

Productive soil is the most valuable resource on earth. Most of our food, shelter, and clothing comes from materials produced by the soil. Thousands of everyday things like footballs, pencils, paper, tires, and plastics have their origin in the soil.

Soils must be kept fertile if they are to produce in abundance the plants that furnish most of the things we eat and use. Such practices as draining wet lands, liming acid soils, applying commercial fertilizers, using crop rotations, conserving soil organic matter, and controling erosion help to keep soils fertile.

Too few people realize how important the thin layer of rich topsoil is to the production of good crops. Improper land use hurts our soil by allowing soil erosion to carry away the topsoil. Soil erosion alone costs our nation more than four billion dollars a year. Erosion has ruined fifty million acres; it has almost ruined another fifty million acres and is now damaging 200 million acres more of our land. Growing crops use up soil fertility by removing plant foods and organic matter. Good land use also means replacing these things in the soil.

Our soils produce plenty of food for our people now. Very soon we may have to fill five food plates instead of the four we now are filling. In 20 years we could be short seventy million food-producing acres for our growing population. The "fifth plate" must be filled!

Soil and water are of vital concern to all people----those living <u>on</u> the land plus all of the rest who live <u>by</u> the land. People on the farms have a tremendous job to do to produce food and clothing in addition to other needs. People living in cities have an equally important job in seeing that our soils are used properly.

You will help by studying and learning more about the soil on the farm and how to keep it productive.