The change from rock layers to soil is a slow process—nearly 1,000 years of weathering to make an inch of soil. Soil is broken and weathered rock material, together with some decaying roots, leaves or organic matter in which grass, trees, crops and other plants grow.

(Cover cut) Dale Olsen of Greeley, state 4-H crops club champion in 1939, followed soil-saving practices and harvested 39 bushels of pinto beans per acre. Happy young farmers in the future will be found only on good land. We must take care of our soil now in order to have good land in the future.
Saving Colorado's Soil

A Soil-Conservation Handbook
for Young People

BY T. G. STEWART, Extension Soil Conservation Specialist

What is soil?
How is it formed?

In general, soil may be regarded as broken and weathered rock, together with organic material in which crops, grass, trees, and other plants grow.

When rock is exposed to the sunshine in the daytime, then cools at night, small pieces of rock may break off because of pressure caused by expansion and contraction on the outside and inside of the stone. On cold nights among the rocky cliffs in the mountains, one is sometimes startled by a sound like a pistol shot caused by a large rock which has bursted because of a difference in temperature or because water inside has frozen, expanded, and suddenly forced the rock to pop open.

Rocky surfaces in the mountains or on the slopes of hillsides are subjected to the grinding action of snow and ice or glaciers and rushing water. Frequently trees and other plants send their roots down cracks or openings in layers of rock. The growth of the roots forces the rock to break apart. Wind blowing sand will wear down small pieces of rock and gravel or the surface of exposed rock like a grindstone.

All soil is underlaid by rock, though sometimes the rock layers are at great depths. Water in the soil combines with gases of the air, such as carbon dioxide which we force out of our lungs when we breathe. This water and carbon dioxide gas form a weak acid which helps to dissolve rock in the soil. Stronger acids or liquids may be formed from some of the mineral material and we may have a more rapid formation of soil by the dissolving of rock layers underneath.

A long time ago, Mother Nature experimented with grass, shrubs, trees, and other plants, and discovered one or more plants most suitable for each soil, whether above timberline, on the plains, or at sea level. When these plants died, the roots decayed in the soil. The broken leaves and stems gradually became mixed in the topsoil by earthworms and rodents, or

Acknowledgment.—The author wishes to express appreciation for the helpful suggestions offered by Prof. Alvin Kezer, Chief Agronomist for the Colorado Experiment Station, to other members of the Agronomy Staff, and to the Soil Conservation Service, U. S. D. A., for some of the pictures used in this bulletin.
by dropping into cracks which formed as the soil dried after rains. This organic matter, or humus, as it is called, may be in sufficient amounts to make the topsoil black or dark in color.

The topsoil is alive. It breathes with the changes in temperature during the day. In a thimbleful of black, fertile topsoil, it is estimated that there may be 600 million germs, or micro-organisms of decay tearing down the humus, creating juices and solutions which help to dissolve the fine rock or soil particles so that the mineral material can be taken up by plant roots. The germs die and their bodies supply materials for a part of the soil solution or soil soup, from which plant roots feed. The death and decay and release of plant food from rock particles occur more abundantly in the topsoil and are essential in order that we may have new life and growth, new plants and growth of animals which eat the plants.

The soil has three duties to perform in plant growth. It furnishes plant foods for grass, trees and crops of all kinds.

The soil acts as a storehouse for water, air and fertilizers which may be added.

Try to push over a small tree—what holds it?

Roots spreading in all directions find anchorage in the soil, and trees, stalks of corn or other plants are held upright with their leaves exposed to the sun and air.

The top 12 inches of soil is one of the most valuable things in all of the world because plants cannot live and grow in quantities without it, animals cannot live without the plants, and most of the food which we eat comes from plants or animals.

Natural forces working night and day may require from 600 to 1,000 years to break down the rock and add the humus in 1 inch of topsoil.
Imagine Columbus taking an airplane trip across the new land which he dis­covered! What would he have seen?

Why we have soil-conservation problems

Suppose Columbus could have taken a summer-time airplane trip across this new land which he discovered! He would have noticed that the mountains in the East were so weathered down that soil was deep enough to support forests, bushes, grass, and plants of all kinds, even on top of the mountains and on the hillsides. In the Mississippi Valley, he would have noticed more trees, grass, and many different kinds of plants so thick that he could see no bare soil.

Flying westward over the country which is now Kansas, Nebraska, Oklahoma, and eastern Colorado, he would have noticed millions of acres of grass—the Great Plains. Occasionally this expanse of grass would have been broken by a crooked line of darker green, marking rivers and creeks, all hidden by trees, willows, and other brush.

There were probably no dust storms, as there were no large cultivated fields to supply loose soil to blow, so Columbus could have seen clearly those black dots scattered over some of the grassy places below. The black spots were alive! Buffalooes! Some standing, many lying down! Flying lower, Indians might have been seen skinning a buffalo for their food supply.

That blue mass with white patches which resembled clouds in the west would prove to be high mountains—the Rocky Mountain ranges as far north and south as the eye could see. Columbus from his airplane could have seen the snow-patched, rough peaks which appeared barren above timberline.

Upon closer examination, as today, something green and growing could have been seen even above timberline and near the patches of snow.
Columbus could have seen forests covering mountains in the East as well as in Colorado, dwarfed plants above timberline where soil lodged, grassy plains and valleys, plants everywhere protecting the soil.

where soil had formed and lodged. A heavy growth of trees would have been noticed farther down the mountainsides except where cliffs and crags were too steep for soil to lodge. In the valleys or parks below were grass, deer, elk, buffalo, antelope, and those crooked lines of trees and brush which marked tumbling streams of clear, ice-cold water.

Purple and gray sagebrush, grass, and trees covered the mountainsides and valleys to the white sandy beach of the blue ocean at the end of this newly discovered land.

When Columbus discovered America, the soil was nearly all protected and held in place by trees, brush, grass, other plants and leaves so that it could not wash or blow away.

The Mayflower Landed. Colonies were established along the east coast. Some Spanish explorers came up from the South. Land was cleared of trees and grass was plowed up. The protecting cover of the soil was disturbed, though this was done only on small farms because the Pilgrim fathers did not have any big farm machinery or tractors.

Americans did not fully realize the vastness of America until gold was discovered in the new territory purchased from Mexico, now known as California—350 years after Columbus.

Following the Civil War, President Lincoln and his cabinet encouraged the development of the West through the building of railroads. Great herds of cattle had replaced the buffalo on the grassy plains of the West. Railroads were needed to ship the cattle to the East. Railroads were also needed to ship supplies to the miners in the far West. Grants of land and loans of money were provided to encourage the building of railroads.

The first homestead act which provided 160 acres of free land for soldiers and 80 acres for others was signed by President Lincoln. "Go West, young man, go West," was a
suggestion needed by thousands. Homesteads were "proved up" by plowing a few acres with a walking plow and team of oxen, horses, or mules. Some fencing and residence on the homestead were required.

**Gold Discovered.** — The discovery of gold hastened the development of agriculture in Colorado because miners, cowboys, and travelers from the East and West needed food for themselves and feed for their horses. They

Trees were cut for mine timbers, building of homes, or deliberately burned in order to clear the land. Erosion began. (Courtesy U. S. Forest Service.)
were willing to pay high prices for it. Colorado forests were cut for mine timbers and for the building of homes. Some forests were deliberately burned to get the trees out of the way in the hopes that gold could be more easily found or that grass would replace the trees for livestock.

Homesteaders generally settled on the best land—land which had the best grass growing upon it. Their fences, together with the plowing of thousands of acres of good grass, worried the stockmen who permitted their cattle to roam over unlimited range. Sheep were on the increase. The result: More livestock on less range and sometimes gunplay to decide who had the right to desirable ranges.

The World War, beginning in 1914, created an unusual demand for American wheat, beans, corn, potatoes, meat and other agricultural or manufactured products. The United States entered the war in 1917 and soon there was a shortage of help on farms as well as in factories. Labor-saving machinery was needed; it was a patriotic duty to plow and plant to the limit of one’s ability. We were told that, “Food will win the war.”

Our inventors gave us big machinery and we did plow and plant in the plains and in the mountains. We plowed and planted sod land without regard to the kind of soil, possible drouths and windstorms or heavy rains. We plowed hillsides where once heavy forests grew. We doubled the number of cattle and increased the number of sheep by two-thirds; more livestock on less range.

High prices for agricultural products during the war stimulated the sale of land. Many farms were sold four or five times during the four-year period, 1917-1920. Each time the farm was sold, the price increased. Many times, land in the plains which was actually worth less than $10.00 per acre sold for $50.00 or more. Irrigated land doubled or trebled in price. Farms were divided, many farms and ranches becoming

A World War tractor which helped to destroy the protecting cover of grass on the plains. A “fifth column” machine which stayed at home to destroy. Wind erosion followed.
too small for the family to make their living when prices of farm products became lower. Much land was mortgaged for more than the farm could be sold during normal times. Land taxes increased.

Cash-crop production was stimulated as farmers attempted to pay off mortgages and pay for their big machinery. It required more acres of crops to make a living when the prices for farm products became lower and the cost of things which the farmer had to buy remained the same or increased.

Grazing homesteads of 320 and 640 acres were permitted, which further divided and fenced range land, thereby crowding livestock on less native pasture in some sections.

A summary of land development since the landing of the Pilgrims, 320 years ago, includes:

1. The bringing of 986 million acres into farms and ranches with about 415 million acres in crops each year. Most of the crop land has been brought into production without regard to the depth or kind of soil and with little thought given to the prevention of erosion or maintaining fertility. We thought our 1,900,000,000 acres in the United States was plenty of land to meet our needs for thousands of years.

2. Nearly 57 million acres have been essentially destroyed for crop production in the United States because the valuable topsoil has washed away or blown away and deep gullies prevent many fields from being cultivated. Mother Nature's protecting cover of trees and grass has been destroyed or plowed on 225 million additional acres and severe erosion is occurring. Moderate erosion is occurring on 700 million acres. We are attempting to graze more livestock on less range and, therefore, during drought years, much range land has been severely damaged from erosion. It is estimated that 3,000,000,000 tons of valuable soil move from cultivated fields and overgrazed pas-
tures into reservoirs, rivers, lakes, and oceans each year.

3. Through trial, we have discovered that 76 million plowed acres do not have the right kind of soil—there is not enough rainfall, or the land is too steep to be profitably farmed when crop prices are low.

4. American farmers have become more efficient in the production of crops than any farmers in the world. Only 25 percent of the population lives on farms, compared with 50 percent in 1870, but the 25 percent now on farms cultivates more acres than the farmers of 70 years ago. The danger lies in erosion and in planting, harvesting, and sale away from the farms of an excessive acreage of soil-depleting crops—crops which take minerals and other plant foods out of the soil faster than the little germs of decay can release a new supply from the soil particles.

In Colorado our agriculture is only about 70 years old, but many of our farms are not producing like they used to, according to older farmers. A total of 12,790,787 acres have been plowed, with 3,393,619 acres under irrigation. Soil-depleting crops are grown on 80 percent of the farm land.

Surveys conducted by the Soil Conservation Service indicate that 678,935 acres of farm land in Colorado have been abandoned because of erosion. This same survey shows severe erosion is occurring on 12,346,777 acres of crop and range land, and nearly one-half of the state—30,282,800 acres—is suffering from moderate erosion.

A 1940-model streamlined cow—thin and speedy so she can graze over 60 to 80 acres of damaged range in her attempt to live. Where is her calf?
Crops sold off the farm remove minerals and plant food which they have drawn from the soil. Selling crops draws upon our deposits of plant food, like writing checks upon a bank account. Unless the deposits of plant food are renewed, the “account” will some day be “overdrawn”—then we have a rundown farm.
Soil-conservation problems in Colorado

Definition.—Soil conservation is the saving of soil and the maintenance of productivity.

Nearly every boy and girl knows what a bank account is, and everybody would like to have one. Those who have bank accounts know that if one continues to write checks without depositing more funds in the bank, a simple notice, “Account overdrawn,” is sure to arrive, and then trouble begins.

The soil may be looked upon as the farmer’s bank account. Since business in town is dependent to a large extent upon successful crop production, everyone is interested in this soil bank account.

There are deposited in the soil all kinds of minerals, water, and gases which make plants grow. This bank account of plant food, released by weathering and the decay of humus, is drawn upon whenever farmers harvest and sell crops. It is easy to understand that if crops are continually harvested and sold from a field for a number of years, the deposit of plant food may be nearly exhausted, and the farmer gets reduced yields—his notice of “account overdrawn”—which means the supply of at least one of the plant-food minerals is reaching a low level.

Sometimes the reduced yield is due to the fact that the organic matter or humus, which is the food for the germs of decay, is gone and there are not enough of these workers actively engaged in releasing the mineral matter to make plants fully grow. The application of irrigation water usually hastens the decay of humus and

A 30-bushel yield of wheat, when sold off the farm, removes plant food which costs $5.41 per acre if replaced by purchasing commercial fertilizers.
A big load of hay—23 tons, 530 lbs.—the largest load of loose hay ever delivered to market in Colorado. Alfalfa is worth $8.25 per ton as a mixed fertilizer. At $10 per ton, how much did this load net the farmer?

Increases yields of crops. Therefore, more of the plant-food minerals and humus are taken from the soil on irrigated farms than are used in crop production on non-irrigated land.

Some crops draw out more of the

Sugar beets draw upon our bank account of soil fertility at the rate of about $1.00 per ton.
Removal of Fertilizing Elements in Crop Production and Cost to Replace

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield per acre</th>
<th>Nitrogen lb.</th>
<th>Phosphoric Acid lb.</th>
<th>Potash lb.</th>
<th>Nitrogen to Replace</th>
<th>Phosphoric Acid to Replace</th>
<th>Potash to Replace</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley . . .</td>
<td>70 bu.</td>
<td>61.82</td>
<td>28.56</td>
<td>24.86</td>
<td>$7.02</td>
<td>$1.57</td>
<td>$1.36</td>
<td>$9.95</td>
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<tr>
<td>Corn, grain</td>
<td>50 bu.</td>
<td>45.36</td>
<td>19.32</td>
<td>11.2</td>
<td>5.15</td>
<td>1.06</td>
<td>.61</td>
<td>6.82</td>
</tr>
<tr>
<td>Corn silage</td>
<td>12 tons</td>
<td>81.6</td>
<td>38.4</td>
<td>105.6</td>
<td>9.26</td>
<td>2.11</td>
<td>5.80</td>
<td>17.17</td>
</tr>
<tr>
<td>Beets . . . .</td>
<td>15 tons</td>
<td>78.0</td>
<td>24.0</td>
<td>96.0</td>
<td>8.86</td>
<td>1.32</td>
<td>5.28</td>
<td>15.46</td>
</tr>
<tr>
<td>Wheat . . . .</td>
<td>30 bu.</td>
<td>35.64</td>
<td>15.48</td>
<td>9.54</td>
<td>4.04</td>
<td>.85</td>
<td>.52</td>
<td>5.41</td>
</tr>
<tr>
<td>Alfalfa . . .</td>
<td>5 tons</td>
<td>238.0</td>
<td>54.0</td>
<td>223.0</td>
<td>27.03</td>
<td>2.97</td>
<td>12.26</td>
<td>41.26</td>
</tr>
<tr>
<td>Potatoes . . .</td>
<td>300 bu.</td>
<td>63.0</td>
<td>21.6</td>
<td>95.4</td>
<td>7.15</td>
<td>1.18</td>
<td>5.24</td>
<td>13.57</td>
</tr>
<tr>
<td>Rye . . . .</td>
<td>20 bu.</td>
<td>21.16</td>
<td>8.17</td>
<td>6.38</td>
<td>2.40</td>
<td>.45</td>
<td>.35</td>
<td>3.20</td>
</tr>
<tr>
<td>Hog millet .</td>
<td>20 bu.</td>
<td>21.16</td>
<td>8.06</td>
<td>5.82</td>
<td>2.40</td>
<td>.44</td>
<td>.32</td>
<td>3.16</td>
</tr>
<tr>
<td>Milo grain</td>
<td>20 bu.</td>
<td>19.15</td>
<td>8.73</td>
<td>4.81</td>
<td>2.17</td>
<td>.48</td>
<td>.26</td>
<td>2.91</td>
</tr>
<tr>
<td>Kafir grain</td>
<td>20 bu.</td>
<td>19.93</td>
<td>6.38</td>
<td>3.47</td>
<td>2.27</td>
<td>.35</td>
<td>.19</td>
<td>2.81</td>
</tr>
<tr>
<td>Field peas</td>
<td>25 bu.</td>
<td>36.6</td>
<td>8.4</td>
<td>10.1</td>
<td>6.23</td>
<td>.69</td>
<td>.83</td>
<td>7.75</td>
</tr>
</tbody>
</table>

*Prices: ammonium sulphate, $46.60 per ton; treble superphosphate, $49.75 per ton; potash, $55.00 per ton.

If farmers had to buy commercial fertilizers, the cost to replace nitrogen, phosphorus, and potash—three very important fertilizing elements which are removed from the farm when crops are sold—is shown in the accompanying table.

The cash values of fertilizing elements removed by crops as calculated are based on the composition of crop products as determined by chemists. If a sufficient supply of these plant-food elements is made available for crops by maintaining the supply of humus and proper soil management, an application of commercial fertilizer may have no value because it is not needed.

**Leaching.**—When irrigation water soaks through the soil, it may dissolve plant minerals and carry them.

A 600-bushel per acre yield of potatoes removes plant food valued at $27.14 per acre, and this high yield of onions checks out about the same amount of fertility.
on down into drain water or below the reach of plant roots. **This is called leaching.** The amount of plant food lost through leaching and seepage has not been measured in Colorado, though on some fields where excess irrigation water is applied, the loss is estimated to be high.

If crops are produced and then plowed under, there is no loss of fertility from the soil except possibly some loss from seepage on irrigated land. When such crops as clovers, alfalfa, peas and beans, are plowed under, the soil is made more fertile because such plants have helped to...
take nitrogen from the air and fix it in the plants and in the plant roots which decay in the soil. These crops are recommended as green-manure crops or crops to be grown in the rotation as pasture or hay crops since they help to keep the soil fertile more than other kinds of crops such as corn, small grain, potatoes, vegetables, or beets.

When crops are fed to livestock, nearly 90 percent of the plant food contained in the crop plants remains on the farm in the form of barnyard manure. When the manure is spread out on the land and plowed under, most of the fertilizing materials contained in the crops which were fed to livestock are deposited back into the soil to be used by the next crop.

Several tons of grass, hay, silage, and grain containing plant food which would cost, as commercial fertilizer, $40 to $45, may be fed to produce and fatten a 1000-pound steer, but only $4.02 worth of fertilizing materials remain in the body of the steer. The bodies of 1000 pounds of fat lambs contain fertility valued at about $2.94 and 1000 pounds of fat

Yield and Composition of Manure from Farm Animals

<table>
<thead>
<tr>
<th>Animal</th>
<th>Tons per year</th>
<th>Water %</th>
<th>Nitrogen lb.</th>
<th>Phosphoric Acid lb.</th>
<th>Potash lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow, 70 lb. daily</td>
<td>12</td>
<td>86</td>
<td>12</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Steer, 60 lb. daily</td>
<td>11</td>
<td>86</td>
<td>12</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Horse, 44 lb. daily</td>
<td>8</td>
<td>78</td>
<td>14</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Hog, 9 lb. daily</td>
<td>1.5</td>
<td>87</td>
<td>10</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Sheep, 4 lb. daily</td>
<td>.75</td>
<td>68</td>
<td>19</td>
<td>7</td>
<td>20</td>
</tr>
</tbody>
</table>

*Table shows composition of solid and liquid manure as it comes from the animals.
Barnyard manure is fertility which is not hauled away from the farm in the sale of crops. Nearly 90 percent of the fertility contained in crops which are fed to livestock on the farm can be returned to the fields as barnyard manure.

Hogs remove about $1.71 in fertilizers when sold off the farm.

Manure plowed under helps to maintain the supply of organic matter or humus in the topsoil in addition to returning most of the fertilizing materials which were taken out by the crops which the livestock consumed. There is usually some loss of fertility in harvesting and feeding crops and in the handling of manure produced by livestock. Therefore, if we want to more nearly maintain our deposit of fertility, it is better to pasture off crops with livestock whenever possible.

If livestock is not pastured or fed on the farm, then farmers will need to consider other methods of keeping the soil fertile and productive by maintaining the supply of organic matter in the soil and by replacing some of the fertility removed by crops.

Organic matter can be supplied on irrigated land by plowing under stubble, straw, cornstalks, or occasionally a heavy growth of sweet clover, last cutting of alfalfa, or other green-manure crop. However, in order to make our deposits of fertility equal to what we check out in crop production and lose from seepage, it may be necessary in the future to find some other source of plant food.

Commercial fertilizers can be bought as needed and applied to the land to renew the plant-food minerals removed by crops from our soil bank account. There are many fields that have produced crops continuously for 30 to 50 years with only a small amount of manure and no commercial fertilizer added, with the result that the yields are not as big as they used to be—the “account is overdrawn,” or the farm is known as a “run-down” farm.

Knowing the amount of fertilizing elements removed by crops when harvested from fields and the composition of average barnyard manure, it is possible to calculate fertilizer needs or balance the deposit of fertility with the outgo. Generally, it is believed that 5 or 6 tons of Colorado
feedlot manure applied to each acre of row crops in the rotation, together with plowing under a cutting of alfalfa and crop refuse, will maintain the nitrogen and humus supply in irrigated fields. This amount of manure will not replace the plant-food elements removed in high yields of crops on irrigated land. The difference will need to be made up through the activity of the soil germs and the application of commercial fertilizers which may be needed.

When the humus supply has been kept up and still the field fails to produce like it should or like it used to, it is time to try an application of phosphate, nitrogen, or mixture of the two, on a portion of the field to find out if the fertilizer will give a profitable response. Experiment stations have not developed a method of measuring the kind and amount of plant food released from soil particles by decaying organic matter, though soil tests can be made which indicate fertilizer needs quite accurately.

Humus in soils on dryland farms can be supplied where needed by a light application or top dressing of manure every three or four years, together with stubble and other crop residues which are gradually worked into the surface soil. The amount of plant food removed by crop production on drylands is less because yields are lower. There is little loss of plant food through seepage; therefore, in most dry-farming sections of the state, there is no need for applications of commercial fertilizer.

A fertilizer has no value to a farmer unless it increases yields or improves the quality of crops. The best way to find out if a fertilizer is needed is to try it on a part of the field.
Lost: Two of Colorado's most precious resources—topsoil and water. How would you stop this loss from a field like this?

**Water erosion**

Erode means to cut away or gnaw away. Soil erosion means the cutting away or gnawing away of soil by water or wind.

Geologic erosion is erosion that is occurring slowly and naturally as soil is being formed and as water is slowly cutting into rock layers in the bottom of streams and hillsides.

No one knows how many million years were required for the water
Water is like youngsters on Hallowe’en night—keep the raindrops scattered—no damage occurs, but when they get together, look out!

in the Colorado River to cut out the Grand Canyon. Perhaps the Thompson River canyon, the Black Canyon of the Gunnison, or other deep canyons in Colorado are one or two million years old.

It makes very little difference to us whether the soil in eastern Colorado or in the mountains was formed and transported by slow geologic weathering and erosion over a period of two million years or only one million years. But we should view with alarm the washing away of an inch of topsoil in one rainstorm or the blowing away of two inches of topsoil in a single dust storm. Erosion not only draws upon our bank account of soil

Irrigation water flowing between rows of potatoes on a slope of about one percent washed this pile of soil (about 12 tons) from 1.16 acres during one season.
minerals—it takes away the entire bank.

Accelerated erosion is the gnawing away of the soil, hastened by some activities of human beings. Farmers, without thought, often help to speed up erosion by plowing and planting up and down hill. Every row is a ditch to help the rainfall and soil to race to the stream below. An inch of topsoil may be lost from a slightly sloping field of fallow as a torrential rain loosens the soil and sheet erosion occurs over the entire field. Some land is so sloping that it should never have been plowed for row crops which encourage run-off and erosion.

Erosion is occurring on many irrigated farms. Too frequently, farmers fail to recognize soil losses when water is run down rows of potatoes, corn, beets, or vegetable crops in irrigation. When soil washes away as row crops are irrigated, the stream of water in each row is too large. When the speed of water running down hill is doubled, the soil carrying capacity may be increased as much as 50 times.

A good irrigator has the ability to locate the high spots in the field, and by turning the head of irrigating water out on these high places, the water will spread to the low land. Sometimes, a large stream of water, turned out at one place, instead of being scattered in several small
Bunches of grass standing above the soil level because water has washed away about 2 inches of the surrounding topsoil.

streams, will cause severe erosion on the top and sides of higher ground. This system of irrigation followed for 20 or 30 years may leave the high parts of a field unproductive because of the loss of topsoil. Erosion in irrigation ditches and field laterals is a problem on many farms.

Grass Stops Run-off.—Each bunch of grass growing on sloping range or pasture-land stands in the way of water from rainfall when it tries to run

Cactus, weeds, and on some ranges, poisonous plants, indicate overgrazing, even before erosion begins.
Who owns the water that falls on a farm or ranch? Rain water needed to produce grass, crops and trees quickly runs together in erosion channels—the result, floods below.

together and race down hill. If bunches of grass are close together, broken leaves and stems form little dams when it rains with each end of the dam braced against grass stems. When the bunches of grass are too far apart or the growth is short, the little dams cannot form as it rains, or they may break and the cupful of water which they are holding back is dumped into the little reservoir below. Small channels pointing down hill open up, the mat of broken leaves and organic matter floats away, soil is picked up, the water becomes muddy, and the bunches of grass are left high and dry with exposed roots. Each rain that follows rushes easily down these small channels instead of soaking into the soil.

Millions of acres of native pasture and range land in Colorado have been closely grazed by livestock during the drouth period and the grass roots in the soil, together with the small plants above, are not sufficient to keep the soil from washing away. Deep erosion channels have been cut through range land and crop land during the past 30 years and now water from any sudden downpour of rain on many watersheds quickly runs together to become a flood below. Such floods sometimes drown people.

Water which is badly needed on range land to grow grass and shrubbery or on crop land to produce crops is destroying bridges, roads, railroads and homes which cost annually millions of dollars to repair or replace. Fast-running water picks up tons and tons of rich topsoil and deposits it in irrigation reservoirs, or ditches and rivers, and carries some of it to the Gulf of Mexico or to the Pacific Ocean. If the storage reservoirs fill up with soil in 30 or 50 years, then new dams will need to be built if sites can be found.

If the 6 inches of fertile topsoil, which Mother Nature required 3,600 to 6,000 years to make, washes away in 20 or 30 years, the farm may be abandoned because crop yields may not be enough to pay the cost of planting and harvesting.
Keep the raindrops where they fall, or make "running water walk;" then we have very little erosion and no floods.

**Stopping soil losses from water erosion**

Keep water where it falls, or make running water walk, and soil erosion from water will be stopped. The principle of water-erosion control is simple, but when put into practice over the entire farm and pasture land, it requires careful planning. Colorado is in a low-rainfall area, though sometimes the rain comes as cloudbursts or torrential thunderstorms. The cloudburst or heavy, sudden rainfall makes the problem of keeping water where it falls more difficult.

The soil may be looked upon as a reservoir. Between the little particles of soil, there are millions of open spaces, just like the spaces be-

Cropland listed on the level or contour to keep water where it falls.
A heavy rain kept where it fell on this field. It has been planted by listing on the contour with damming attachments.

tween marbles in a sack. Water can go down into the soil through these little openings. A slow rain will all be absorbed by the soil, especially if there is a good supply of organic matter mixed in with the soil particles. Humus or organic matter helps to keep the soil open and ready to receive rainfall, and acting as a sponge, it quickly absorbs water. Sandy soils take up water faster than heavy-clay or adobe soil because the openings between the sand particles are larger.

The total water-holding capacity, however, is greater in the clay or adobe soil.

In the surface 3 feet of a sandy loam soil, there is enough total air space or openings between the little pieces of soil and humus to hold 14 inches of water if we can get the rainfall to soak in, and none escapes into the subsoil below. All of the water which may be stored in the soil does...
Pasture corrugations, three little furrows together on the contour, catch and hold water where it falls—more moisture means more grass.

not become available for plant use. However, each inch of rain which we store in the soil and make available for the use of crops is enough to pro-

A diversion ditch and water-spreading system to take water from a run-off channel and spread it over range or meadow land below.
duce two to four bushels of wheat or similar quantity of other crops or grass.

Every plowing or cultivation on crop land should throw up little dams to prevent rainfall from running down hill or slow it up until it has had time to soak into the soil. Plowing, planting, and cultivation across the slope, instead of up and down hill, is the simplest method of maintaining millions of little dams which hold back the rainfall on crop land. Strips of drilled crops like small grain, pasture, alfalfa, sweet clover, sudan or millet, planted across the slope on contour, alternating with row crops such as beans, corn, sorghums, or summer fallow, help to slow down water. Every crop, plant, bunch of grass, tree, or shrub is a little dam standing in the way of flowing water and holding soil in place. If the little dams cannot hold the water until it has time to soak into the soil, then larger structures like pasture furrows, terraces, check dams, and small reservoirs may be needed.
The wind, like youngsters playing marbles, hunts a smooth, barren place to start a game. Games with sand and dust particles for marbles are the start of a dust storm.

Wind erosion and its control

Why do boys and girls hunt a smooth, barren place to play a game of marbles? The answer, of course, is, “So the marbles will roll more easily as the game is played.”

A “black blizzard.” The wind has found wide, barren fields to start sand and dust pieces to rolling.
What a wonderful place to play marbles! The breeze has already started some marble games with little pieces of sand.

When the wind begins to blow across the yard or farm land and pasture, it seems to hunt smooth, barren places to start pieces of weeds, chaff, or light material to rolling. The little pieces of straw or weeds roll along as the shooter or taw in a marble game. They strike the soil as they bounce along, jarring loose bits of dust and sand as they move rap-

Fertile topsoil which does nobody any good—causes damage, covering the fence, because fields were left smooth and barren.
idly along the smooth, bare surface of the yard or field. The moving bits of dust and sand particles strike others as the wind pushes them along at increased speed; some glance off into the air. The wind is playing millions of games with her tiny dust or sand marbles—we call each a dust storm.

Dust storms mean that valuable topsoil which Mother Nature required several thousand years to make is being blown away. The farm is not so productive when topsoil blows away. Ranges and pastures are covered up by the deposits of dust and sand from the smooth, barren fields. People may get dust pneumonia, infected eyes, or other diseases during dust storms. Livestock suffers. Many animals die as a result of sand and dust. Crops are destroyed; highways, buildings, and railroads are covered up. Irrigation ditches are filled up—
A once prosperous farm family "gone with the wind" because the owners of nearby land made no effort to control soil drifting.

all because the wind found plenty of smooth, barren places to roll the tiny dust and sand marbles.

How shall we stop these marble games? We are doing many things today which were believed impossible 50 years ago, but we have not discovered a method of keeping the wind from blowing. Remember — if we slow down water, we lose very little topsoil in water erosion.

Are wind currents along the smooth, bare fields like flowing water from a heavy rain? Can we throw up thousands of little dams and slow down the wind at the surface of the fields? Yes, it can be done, and we have the principle of controlling erosion by wind — reduce the speed of the wind at the surface of the soil and erosion by wind cannot occur.

But how reduce the speed of the wind as it sweeps across fields and pastures? Marble games cannot be played very well on a rough, cloddy yard or listed field — the marbles will not roll. A marble game is not very satisfactory in a stubble field, pas-
Why not plant crops in strips on plains farms and fallow between the strips with a damming lister to keep water where it falls or stop wind erosion?

ture, or field covered with weeds. Crops in strips so that stubble will be left to reduce the speed of the wind and protect strips of clean, harvested land or fallow between, prevent wind erosion on many Colorado farms. Rows of trees across fields which may blow will protect wide spaces for farming between the rows of trees after they become 10 to 15 feet high.

A plan of farming to keep soil from blowing away, carried out on every field and every farm in wind-erosion areas of the state, is the only way to solve the problem of wind erosion. The development of a cropping and land-management plan to reduce the speed of the wind at the surface of the soil in all fields on the home farm certainly is a challenge to any young farmer or his father.

Breaking the speed of the wind on a bean field by planting strips of sorghums which leave a protecting stubble.
Soil-conservation efforts in Colorado

Farmers and ranchmen in Colorado generally realize the need for soil conservation. Educational programs among farmers have been carried on by the Extension Service of the Agricultural College, calling attention to soil-conservation problems and methods of solving them. Thousands of farmers have adopted crop-rotation systems which help to keep up the fertility of fields as a result of the educational programs. Many farmers in eastern Colorado plant their crops in strips or manage their lands to reduce soil blowing. The suggestion of rough, cloddy fallow came from experiment stations. Many ranchers have learned from experience that it does not pay to over-graze range land and encourage run-off and erosion.

The Soil Conservation Service of the U. S. Department of Agriculture has established demonstrations in the state to show farmers and ranchers how to save soil and water on the entire farm and in an entire area. In addition to the demonstration areas, CCC camps have been established in order that soil and water-conservation work may be done by the young men in this corps as they work and learn. The soil-conservation demonstrations and the CCC camp areas are easily accessible to farmers and ranchers who wish to observe and study new methods of soil and water-conservation.

The national Agricultural Conservation Program or AAA provides “benefit” payments to cooperating farmers who wish to carry on soil-conservation practices. These payments help to pay the costs of adopting soil-conserving practices and changes in cropping systems which aid in maintaining fertility.

Various agencies which finance farmers encourage soil conservation. Banks which finance livestock feeding on farms are encouraging soil conservation through keeping fertility on the farm. Banks that finance the purchase of dairy cows, farm
Space marked off for a broad-base terrace—the terrace to be made by the farmer when he has time. Terraces are wide, level dams across fields to keep water near where it falls.

flocks of sheep, brood sows, or herds of beef cattle, are encouraging soil conservation because soil-building crops such as alfalfa, sweet clover or grass pasture, must be grown on some of the land for the livestock. The National Farm Security Administration, through its facilities for financing farmers, is encouraging increase in the size of farms in some areas so that soil conservation can be practiced. Soil conservation is encouraged on the farms of all of the FSA borrowers.

The U. S. Forest Service, which controls 13,547,537 acres in Colorado, adopted soil-conservation practices soon after establishment of the national forests in 1905. Soil and water conservation on national forests results from protection of forests from fire, by regulated cutting of timber, and protection from insects and animals which may destroy trees. Rapid run-off from quick-melting snow or from sudden cloudbursts cannot occur from mountainsides which are well covered with forests. Graz-

Sorghums growing on top of a broad-base terrace. Rainfall cannot leave a field which is properly terraced and planted on the contour.
Deferred and rotation grazing on millions of acres of rangeland is advised to permit ranges to recover from overgrazing damage.

ing is regulated on the 9,198,700 acres of the national forest land suitable for livestock use during the summer so that plenty of grass protection is maintained to reduce soil erosion and floods.

The Division of Grazing, U. S. Department of the Interior, was established by Congress in 1934 for the purpose of providing organized control over the public domain, the land which was not taken up under the homestead laws. The 7,233,184 acres of public domain in Colorado are used largely for grazing purposes, and soil conservation through controlled use by livestock is a major problem which is being solved.

National parks and monuments, including 312,589 acres in Colorado, are administered by the National Park Service, U. S. Department of the Interior. The parks and monuments are maintained for educational and recreational purposes; therefore, forest, soil, and wildlife conservation is rigidly practiced. Livestock is not permitted to graze in national parks and monuments.

Stock-water supplies, located in all sections of a pasture, reduce trampling and overgrazing damage and encourage complete use of the range.
The outlook for soil conservation in Colorado

There is plenty of soil-conservation work yet to be done in the state. A study of the best methods of maintaining fertility on our irrigated land is under way but certainly not completed. The proper use of irrigation water, Colorado’s second most-precious resource, needs more investigation and study. New and better ways of keeping water where it falls or slowing down run-off will be discovered by the young folks of today. Many problems of wind erosion and establishing grass on land that should not have been plowed must be solved if some young people are to inherit farms and ranches instead of sand dunes.

Someone may ask, “Why worry about soil conservation when we are told that we produce in the United States each year more wheat, more cotton, more tobacco, more corn, more potatoes, more vegetables, more pork, more milk, and more beef and lamb than farmers can sell profitably?” The answer most often given is: “If we will correct our land abuses of the past 300 years and maintain our soil resources, there will not be surpluses when everybody in America is properly fed, properly clothed, and properly housed, and a reasonable foreign trade is developed.”

Definite reasons why young people should become concerned about soil conservation at this time may be listed as follows:

1. There is no more “West” to go to, no new land upon which to homestead, or locate and develop with the country. As far as we know, farm families must make their living and grow food for those living in towns and cities on the same farms for the next 500 or 1,000 years.

2. The productivity of our best land is threatened by loss of topsoil in soil erosion, loss of fertility through failure to maintain the supply of humus and plant food in the soil, and lack of drainage to remove excess alkali.

A good weed growth on a listed field will prevent wind erosion but how can farmers pay taxes and make a living by just growing weeds?
3. Our inventors have given us efficient machines for large-scale production of crops. These machines do not encourage the production of crops which will build up the soil. We have not yet learned how to pay for them with low-priced crops and at the same time maintain our soil resources.

A few individuals can decide that soil conservation shall be practiced on publicly owned land. Policies and regulations are issued by the administrators of public land and conservation practices become uniformly carried out on millions of acres.

When we consider the 63,644 farms and ranches in Colorado, soil-conservation problems become more complex because each farmer or rancher has his own ideas regarding conservation practices, and he has the right to manage his land as he desires. Each farm or ranch is a conservation problem in itself to be solved with first consideration given to the welfare of the farm family which occupies the farm or ranch.

Obstacles Must Be Overcome.— There are some real obstacles or reasons why farmers and ranchmen do not adopt conservation practices in Colorado. Young people must help to solve these problems if they expect to inherit fertile, productive soil. A few of the reasons why farmers or ranchmen do not adopt a plan of conservation on farms and ranches may be listed as follows:

- Young people must help to solve these problems if they expect to inherit fertile, productive soil. A few of the reasons why farmers or ranchmen do not adopt a plan of conservation on farms and ranches may be listed as follows:

Bromegrass planted along an irrigation ditch to prevent erosion and keep down weeds.

Not much chance for a marble game on this blowfield which has been deep chiseled. What should be done to keep this field from blowing in the future?
Check dams have been built in this gully, the steep sides graded down, trees and grass planted. We have thousands of gullies that should be controlled. An excellent place for pheasants, quail, and other birds to hide when the trees grow.

1. Many farming and ranching units are too small. On the small farm or ranch, the operator cannot manage the land and save the soil as he would like to because every acre must be under forced production to make a living and pay the expenses of the farm family.

2. It costs something to increase the size of the farm or ranch or reorganize the system of farming which will maintain rather than deplete the soil resources.

3. Many farmers do not own the land which they operate—many do not know whether they will continue to live on the farm which they now occupy or whether they will need to move next year. In 1935, there were 24,840 farms operated by tenants and 10,605 more farms were part owned and part rented. A lease which encourages soil conservation is needed.

4. In the United States, farmers pay an average of three and one-half billion dollars annually—more than one-third of the farm income—for rent and interest on mortgages. Very little of this payment finds its way back to the farm for soil conservation.

5. Land is taxed into misuse. The taxes per acre on thousands of acres of grazing land are higher than the rental which stockmen are willing to pay or higher than the return possible from grazing livestock. Many acres are taxed as crop land when they should be classified as poor grazing land. Other land-tax adjustments are needed.

6. Land speculation increases land values and forces an attempt to increase production in order that increased taxes, interest, rent, and other expenses may be paid. Forced production too often means soil depletion. Young people of today will be called upon to give land its true value and suggest its best use.

7. The average age of Colorado farm operators is above 50 years. It is difficult for an older person to change his attitude and ideas regarding the operation of his farm. General soil conservation is new because in the past, we have had plenty of new land to develop. The attitude toward soil conservation, the willingness to demonstrate conservation practices and assume the leadership in organizing for conservation will be determined largely by young people of today.
Investigations and activities for young folks

A study of soil conservation in school or in 4-H clubs may be made more interesting if the student will carry on some investigations and activities in the schoolroom or field at the same time. School teachers or 4-H club leaders will always find the county extension agent willing to supply additional reference material for classroom or field study. Some suggestions follow:

1. Members of 4-H clubs or other young farmers who have crops projects should practice soil and moisture conservation as they grow their crops.

2. Observe and make a list of all of the places where erosion is occurring on the home farm or along one mile of road. Why is the soil washing or blowing away in each case where erosion is noticed? What plants, which Mother Nature established to protect the soil, have been destroyed around the places where erosion is noticed?

3. If farmers had to buy all of the plant food removed from the fields when crops are produced and sold, what would be the cost of the nitrogen, phosphoric acid, and potash to replace those removed in crops sold from the home farm during the past year? Calculate the amount of sheep manure needed to replace these three elements when only beets from 25 acres yielding 18 tons per acre are sold off the farm.

4. Interview some early settlers in the community and write a story or English theme of the development of agriculture, changes in farming methods, and erosion conditions.

5. How many abandoned farms and fields can be found in the community? Determine why they were abandoned. Draw a map of the farm which you consider to be the best farm in the community. Note the acreage of pasture and crops grown in each field, numbers of livestock and farm equipment.

6. Dig a level trench 10 feet long, 8 inches wide, and 6 inches deep and measure the amount of water needed to fill it. Dig another level trench across sloping grass land and allow it to stand until a good rain occurs. Compare the depth that moisture has soaked down in or near the trench with the depth of moisture 25 feet away from the trench where the land is sloping.

7. Lay out a system of contours, terraces, strip-cropping, and water spreading on the slopes of the sand pile or pile of soil in the yard. The effectiveness of your systems may be studied by the use of a sprinkling can to make it "rain."

8. Determine the average slopes of fields and pastures on the home farm or near the schoolhouse. Equipment needed: a straightedge board or 2-inch x 2-inch strip, 100 inches long, a carpenter's level, and a yardstick.

9. Assemble and make equipment and run contour lines on a field or pasture. A good reference is, "How to Run Contour Lines," Extension Circular 123-A, which can be secured from your County Extension Agent.

10. Calculate the number of gallons of water lost from a 100-acre pasture in a 2-inch rain if one-half of the water flows away. A gallon of water measures 231 cubic inches.
Livestock, 2 years' feed supply, water—a scene like this on every farm and ranch in eastern Colorado will help to save the soil. Will you help to bring this about?

11. Draw a map of your home farm showing the divisions of pasture and plowed fields. With the help of your father, develop plans for keeping all of the water on the farm approximately where it falls. Will these plans need to be changed when other crops are grown on the fields?

12. In September, compare the depth of moisture in 10 fields that have been summer-fallowed with the depth in 10 fields where crops have been harvested.

13. Scatter some flour, talcum powder, or dust on a smooth table top; notice how easily the powder or dust may be blown off. Prepare a low, flat box with enough soil in it to hold small-grain stubble upright like it appears in a field. Blow across the rows of stubble and see if the powder or dust can be easily blown off the table. A bellows or an electric-sweeper blower is useful in this experiment.

14. Make note of all the places on your home farm or along a mile of road where you believe the wind can start dust to moving. How would you try to prevent the dust from moving?

15. Map your home farm and plan a cropping and cultivation system that would reduce soil losses by wind. Perhaps your father will help you.

16. What practices, which help to keep water where it falls, also help to prevent the loss of soil from wind erosion?

17. Field trips in connection with soil conservation and nature studies should be organized under capable leaders for the purpose of studying soil formation, erosion conditions, and erosion control in the community. County extension agents or Soil Conservation Service representatives are willing to aid teachers or 4-H club leaders in organizing such tours.