

BOY SCOUT TROOP 236

Soil and Water Conservation

1. Do the following:
 - a. Tell what soil is. Tell how it is formed.

 - b. Describe three kinds of soil. Tell how they are different.

 - c. Name the three main plant nutrients in fertile soil. Tell how they can be put back when used up.

2. Do the following:
 - a. Define soil erosion.

 - b. Tell why soil erosion is important. Tell how it affects you.

 - c. Name three kinds of soil erosion. Describe each.

 - d. Take pictures of or draw two kinds of soil erosion.

3. Do the following:
 - a. Tell what is meant by “conservation practices.”

- b. Describe the effect of three kinds of erosion-control practices.

 - c. Take pictures of or draw three kinds of erosion-control practices.
4. Do the following:
- a. Explain what a watershed is.

 - b. Outline the smallest watershed that you can find on a contour map.

 - c. Outline, as far as the map will allow, the next larger watershed that also has the smaller one in it.

 - d. Explain what a river basin is.

Tell why people living in a river basin should be concerned about land and water use in the basin.

5. Do the following:
- a. Make a drawing to show the water cycle.

- b. Demonstrate at least two of the following actions of water in relation to soil:
percolation.

capillary action.

precipitation.

evaporation.

transpiration.

- c. Explain how removal of vegetation will affect the way water runs off a watershed.
- d. Tell how uses of forest, range, and farmland affect usable water supply.
- e. Explain how industrial use affects water supply.

6. Do the following:
a. Tell what is meant by “water pollution.”

b. Describe common sources of water pollution and explain the effects of each.

c. Tell what is mean by “primary water treatment”

“secondary water treatment;, and

“biochemical oxygen demand.”

7. Do TWO of the following:

a. Make a trip to two of the following places. Write a report of more than five hundred words about the soil and water and energy conservation practices you saw.

(1) An agricultural experiment.

(2) A managed forest or wood lot, range, or pasture.

(3) A wildlife refuge or a fish or game management area.

(4) A conservation-managed farm or ranch.

(5) A managed watershed.

(6) A waste-treatment plant

(7) A public drinking-water treatment plant.

(8) An industry water-use installation.

(9) A desalinization plant.

b. Plant one hundred trees, bushes, and/or vines for a good purpose.

c. Seed an area of at least one-fifth acre for some worthwhile conservation purposes, using suitable grasses or legumes alone or in a mixture.

d. Study a soil survey report. Describe the things in it. Using tracing paper and pen, trace over any of the soil maps and outline an area with three or more different kinds of soil. List each kind of soil by full name and map symbol.

e. Make a list of places in your neighborhood, camps, school ground, or park having erosion, sedimentation, or pollution problems. Describe how these could be corrected through individual or group action.

f. Carry out any other approved soil and water conservation project.

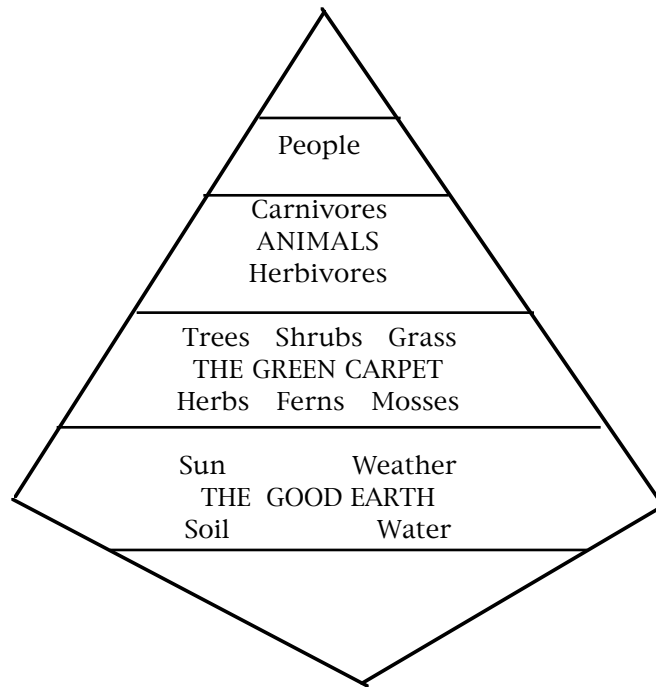
INTRODUCTION

For billions of years, the earth has been providing its inhabitants with self-renewing life cycles, air, water, plant and animal life, energy and growth, even the process of life and death.

All life forms on the earth are tied together. Each of them --- plants, animals, birds, insects, and organisms too small to be seen without a microscope --- depends in some way upon the earth's environment for its existence. Air water, soil, and sunlight are needed in some form.

Because all life forms are closely linked and depend upon one another for their existence on the earth, some scientists speak of the "web of nature." If one strand of the web is damaged or destroyed, all the other strands will feel the result in some way. If the web is strong, with all parts working well, there will be a wholesome environment on the earth for people and all other living things.

People have learned to use natural resources such as soil, water, plants, and animals to supply them with the things they need and desire. It takes the help of many people to keep the earth's environment in good working order to support the growing numbers of people on our planet who must have air, water, food, clothing, shelter, and living space.



THE PYRAMID OF LIFE

Our Responsibility to Learn

Since each of us has a place in the great web of nature, we should be concerned about what happens to the soil, water, and all things we call natural resources. Each of us has duty to learn more about the natural resources upon which our lives depend so that we can do our share to make sure these resources are used intelligently and cared for properly.

Conservation --- intelligent use and proper care --- isn't just the job of technicians, soil scientists, hydrologist, foresters, wildlife managers, plant scientists, and other specialists. It's not the job of the city planner or parks superintendent, the farmer or rancher, the forest or mine owner alone. It must be your job, too, wherever you live --- city, suburb, or country. If we are going to have woods, wildlife, and flowers to enjoy; clean water for drinking, fishing, and recreation; natural open spaces near our homes for playing and learning; and a good supply of the food we all like so much, then you, too, must help by becoming a conservationist.

To think intelligently and act responsibly for natural resource conservation, you must have a good knowledge of natural resources.

Working for your Soil and Water Conservation merit badge will introduce you to the fascinating world of soil and water --- and to the plants and animals that share the earth with us. To understand soil and water conservation as a whole, we must first study parts of it. This is why soil and water are discussed in separate sections before they are considered as an inseparable whole. As you learn more about soil and water conservation and carry out your conservation projects, you will begin to see that it is nearly impossible to separate soil and water as parts of the earth's natural resources.

WHAT SOIL IS

We walk, play, travel, and build upon it. On it falls everything that is dead, useless, or rejected. You probably call it dirt, but your life and that of all other creatures depend completely upon the relatively thin layer of soil that has developed on most of the land surface of the earth.

If you look closely at some soil, you'll see much more than "dirt." There are many bits of rock, mineral crystals, plant roots, decayed leaves and other materials, worms, tiny living and dead plants and animals, water, and air. Though the proportions vary, every soil consists of mineral and organic matter, water, and air. We can define soil as a self-renewing complex of rock and mineral particles, organic material, living organisms, air, and moisture.

Since soil is found everywhere except under the oceans, on rugged mountain peaks, and in regions of perpetual ice and snow, we all can find opportunities to learn something about it firsthand. But if our study is to be meaningful, we need to know some basic facts about soil.

Most soils developed largely from various kinds of rocks. Over many thousands of years, the forces of nature --- sun, wind, rain, frost, glacial ice, and chemical and biological reactions --- act upon rocks to break them into increasingly smaller pieces. The sun warms the rock and the rock expands; at night the rock cools and contracts. This expansion and contraction opens hairline cracks in the rock, into which moisture from rain or snow enters. As this water freezes and expands, it helps force the rock pieces farther apart. More water enters to repeat the cycle. (Have you noticed the similar effects of temperature and water on concrete: This is the reason engineers build expansion joints into roadways,

sidewalks, and other concrete structures.)

After some pieces have broke off the rock, the wind blows them, or running water grinds them, against other rocks. Huge glaciers that once moved across the northern United States twisted and shifted and ground up tremendous quantities of rock, greatly altering the landscape.

By rubbing tow pieces of rough rock together, you can get some idea of the great length of time it takes physical forces to break down rocks into the material from which soil develops. Notice the tiny particles and how long it takes to get even a spoonful of them.

Chemical Changes

Chemical reactions also help bring about the decay of rocks. Falling rain picks up a little carbon dioxide from the atmosphere, and, when this joins with hydrogen, it forms a weak acid --- yet one powerful enough to dissolve certain mineral salts. These dissolved substances cause other chemical changes to take place in the rocks. Slowly, nature's forces crumble the rocks into mineral particles of clay, sand, and silt.

In different locations, entirely different soils are built from the same rocks. The crumbling of rock is a destructive process while soil formation is a building process.

Finely ground or splintered rock is not soil. it will not become soil until it begins to surge with life, for without life there is no soil. The living and once-living plants and animals --- organic matter --- give life to soil. They help give it a physical structure that admits moisture and air and helps to retain them. To remain alive, soil must keep its structure.

As soon as a few bits of crumbled material and some moisture collect on a rock, lichens (simple plants) begin to grow. After some time, decaying lichens and more bits of mineral matter collect in the crevices of the rock. Water collects and is held there, too, and microscopic forms of plant and animal life begin to make the crevices their home. Soon mosses begin to grow on the rock and later the seeds of larger plants germinate in this loose earth material; these weeds, grasses, and other plants grow, die, and decay, thereby supplying organic matter. Plants are the real makers of soil. AT the same time, chemical reactions are taking place and bacteria, fungi, worms, tunneling and burrowing insects, and other

organisms are active. Thus the formation of a simple soil begins.

The shape, or topography, of the land on which soil develops helps determine the soil's quality. The topography --- steepness of slope, direction of slope, elevation --- determines the patterns of water movement and accumulation as well as the amount of the sun's heat that reaches the surface of the land.

The decay of rocks and the building of soil go on together all the time. It took thousands and thousands of years for the soil that now covers most of the earth to develop. To build just one inch of surface soil could take a hundred years; in places where the climate is dry and cold, an inch of surface soil might not develop in a thousand years. This is why it is so important that we intelligently use and properly care for the soil we have.

The Many Kinds of Soil

Soil scientist have identified more than seventy thousand kinds of soil in the United States. The basic factors that affect the development of soils and causes soils to be different are **climate, parent rocks, plant and animal life, topography, and time**. Particularly important is the climate, especially temperature and the amount of rainfall. Climate determines not only how fast and in what way rocks are broken into fragments, but, more importantly, in what way rocks are broken into fragments, but, more importantly, what kinds of plants grow in a particular place. In turn, the kind of plants that grow, as well as how fast dead ones decay, and the kind and activity of soil organisms determine the kind of soil that develops. (In a few places we find soils consisting almost entirely of organic matter, called peat. These soils usually occur where there were once lakes, ponds, or marshes.)

If we could look at a cross-section of our planet, we would see that the outer layer --- the soil --- is very thin compared with the diameter of the whole planet. The depth of the soil actually ranges from many feet, where wind and water have deposited soil materials over a long time, to less than an inch, in places here the climate and other factors have not favored soil development or where much soil has been lost because of careless use or natural disasters.

The Soil Profile

Soil has three dimensions. It is bounded on the top by the surface of the

land, on the bottom by rock material, and on the sides by other soils. Look at a cross-section of soil in a new road-cut or in the excavation for the basement of a new building. There you can usually see definite layers between the surface and the bottom of the cut. This succession of layers from the soil surface down to broken weathered rock is called a soil profile. To a soils expert, different layers are known as horizons. Each horizon differs in one or more properties, such as color, texture, structure, porosity, and chemicals content. The soil profile --- all of the soil horizons taken together --- carries the soil's history.

For example, a soil profile can tell a great deal about the past climate of the area and about the plants that grew there many years ago. The profile of the particular type of soil that develops in a forest looks much different from the profile of soil where only grass grew or under desert condition.s

Most soil profiles include three master horizons. The top layer is called surface soil. it is the layer we usually think of when we use the word soil. From it, many plants get most of the moisture and nutrients they need to live and grow. Below the surface soil is a layer called subsoil, and below that another layer called soil parent material, which is made up largely of loose and partly decayed rock that might some day develop into soil. In some places, if the cut for he soil profile is deep enough, solid rock, called bedrock is visible below the soil's parent material.

Soil layers can differ not only in thickness but also in color. Some surface soil layers are black or dark brown, gray, or red. Organic matter usually tends to make a soil dark. Other layers in the soil profile usually are lighter in color than the surface soil. They derive their color --- yellow, red, white, or maybe even somewhat blue --- from rock and from chemical reactions that have taken place over a long time.

Even if soils look alike on the surface, they can be quite different below the surface. To understand better the differences so that you can describe such soils, look at several different soil profiles exposed along steep road banks. You might want to do as soil scientists do and dig a soil pit to a depth of about six feet so that you can closely examine a soil profile; then you might explain some of the things you have learned about the soil to others.

Three Sizes of Particles

Another characteristic of a soil is the size of the solid particles it contains. Remember, these particles and mineral crystals come from the crumbled, decayed rocks that are now a part of the soil. For convenience in describing soils, the different-size particles are given names: sand, silt, and clay.

Take some soil between your fingers. If it feels coarse and gritty and you can barely see individual particles, it must contain a large proportion of sand --- particles that range from 0.05 to 2.0 millimeters in diameter.

If the soil feels fine and smooth like flour, moisten it a little and try to work it into a thin ribbon between your thumb and forefinger. If the ribbon breaks off near your fingers each time, chances are the soil is largely silt --- particles ranging from .002 to .05 millimeters in diameter. You cannot see the individual particles without the aid of a strong magnifying glass.

Does the soil between your fingers feel like fine powder when dry? After you moisten it, will it make an inch-long ribbon before breaking when you work it between your thumb and finger? If so, you have mostly clay --- particles smaller than silt and less than .002 millimeters in diameter. When soils experts refer to soil texture, they are talking about the size of the soil particles. When a soil is identified as a loam (this term refers only to the size of particles it contains), it means the soil contains a relatively even mixture of sand and silt and a somewhat smaller proportion of clay. This is generally a desirable quality in soil. A silty clay loam soil is one that contains a fairly high proportion of clay particles -27 to 40 percent --- with the remainder being sand and silt-size particles.

Naming Soils

Just as we give names to people in order to identify them, soil scientists have given names to the seventy thousand different soils they recognize in the U.S. Soils usually are named after the towns or localities near where they were first defined. Because several soils in the same locality might have similar texture, descriptive words are added to give specific soil names, such as Miami silt loam, Houston sandy clay, or Mohave sand loam.

Soils vary widely in their ability to support plant life and in how well they are suited to our purposes, such as building playgrounds, highways, and homes. To manage a soil intelligently and care for it properly, people must know something about its characteristics. This is the reason for making soil surveys --- inventories of soil resources that show the extent and location of different kinds of soil.

The soil scientist bores holes in the soil with an auger, usually to depth of 3 to 5 feet. From this soil core and from the study of exposed soil profiles, the scientist can determine many soil characteristics and thus can outline on aerial photographs the boundaries of different soils. Samples of the soil are sent to laboratories for chemical and physical tests that cannot be made in the field.

When a soil survey is completed, all the measurements, observations, and test results are published in a soil survey. This report includes maps showing the boundaries of different kinds of soil; the description, name, and classification of each soil in the area; and information to help landowners, conservationists, engineers, and others, who will work with the soil decide what possible safe uses can be made of the land, and how it needs to be cared for when used for different purposes.

Using a Soil Survey

Soil surveys have been completed on about 60 percent of all land in the U.S. Usually, these reports cover one county. If a soil survey for your area has been published, you can see a copy in the office of your local soil conservation district, the county extension service, or a major library. Or your counselor can get a copy for you and others to study by writing to the Natural Resource Conservation Service office in your county. From this report, you can learn the names and the characteristics of some of the soils in your part of the country. Find out if there is a published soil survey for the area where you live. If there isn't, a soil scientist might now be making one, and you might be able to make arrangements to watch them for a few hours as they work.

Published soil surveys are for people who use the land for any purpose. In information on soil maps is explained in the survey so that it is

meaningful to the user. These explanations are called interpretations. People who want to use the land for different purposes need to know about different characteristics of the soil. For example, a soil might be excellent for growing pine trees but not stable enough to build a house upon; it might be good for growing crops, but a point built on it might never fill up because the water drains away quickly; or it might be suitable for a park but could not be used to support a highway or large building.

Soil interpretations tell the landowner or land user whether a piece of land can be put to a certain use or something about how to manage a tract for a use that has already been decided. Though soil interpretations can help a homeowner learn what kind of plants he can expect to grow successfully, more is at stake than growing things where office buildings, housing developments, factories, airports, highways, and other land uses are planned.

Each soil has specific characteristics that set it apart from other soils. Some soils give excellent support to buildings; others sink or slide under weight. Foundations or even the upper parts of buildings can shift or crack if situated on soils that expand when wet or shrink when dry. Septic systems for the disposal of household wastes work well in soils with good drainage characteristics, but some soils dry so slowly during periods of the year that septic systems cannot be used. And there are soils, containing minerals and chemicals that quickly corrode gas, water, or electric conduits or cause concrete to disintegrate.

Land-Capability Classification

The most widely used soil interpretation is the land-capability classification, which is designed primarily for agricultural purposes. Farmers, ranchers, and others use this classification scheme in developing conservation plans for their lands. Individual soils are classified according to what they are capable of producing and according to their limitations, such as the risk of erosion damage if they are mismanaged.

The land-capability classification system used throughout the U.S. has eight separate classes of land, each designated by a Roman numeral. The risk of soil damage and the limitations to use increase from class I to class VIII. For example, land in capability class 1 is the best for farming. It is almost level and not subject to erosion; generally it is fertile, and there

are no water management problems. Land in capability class VIII is not suitable for crops, grazing, or forestry; it is either extremely dry, wet, sandy, stony, steep, rough, or badly eroded. Desert areas, swamps, some rugged mountains, and sand dunes are examples of land in this class.

Interpretations of soil-survey information are needed and used by many people, including city and regional planners, engineers, home builders, Scout camp officials, highway departments, farmers and ranchers, tax assessors, city water departments, construction contractors, architects, utility companies that install underground pipelines, landscape architects and many others.

Check to see if there is a written conservation plan for the property on which your Scout camp is located. If there is such a plan, study the soil and land capability maps that are part of the plan. Has the land in camp been used to its best capabilities? Are there areas where the plan hasn't been followed? If so, what can you do about it?

Plant Nutrients

The land resources of the U.S. total nearly 2.3 billion acres. (An acre is about the size of a football field.) We use only 6.5 percent of the total for such purposes as cities, roads, homes, parks, railroads, airports, camps, and industrial plants. About 448 million acres produce crops, while 663 million acres are devoted to pasture and range, and 746 million acres are in forests.

Since almost all soils have the ability to support plant life, why are some lawns lush and greener than others? Why do some orchards produce larger and more tasty fruit than others? Why do some gardens produce healthier flowers and larger vegetables than others? Why are crop yields on some farms much larger than on ones nearby? Of course, there are several reasons, but an important one is the presence or absence of available plant food --- nutrients needed by plants for growth and development.

Every green plant removes certain nutrients from the soil. If the plants are allowed to remain on the land and decompose, nutrients usually are added to the soil as the dead plants again become part of the organic matter in the soil. But in most cases, we harvest crops. We take

vegetables and flowers from gardens. Cattle graze on grass and then we eat steak and hamburger. We remove peas, beans, and tomatoes from the fields, and we pick corn and cut hay to feed the cows that provide our milk. The foods we consume are simply stored forms of energy.

Whenever we remove plants from the land, we take away nutrients that could be used in future plant growth. When animals eat plants grown on soil deficient in certain nutrients, and when people, in turn, eat the products supplied by animals, no one gets the nutrients needed for the best growth and health. Improper or careless use of soil causes rapid depletion of plant nutrients. When soil erosion takes place, water or wind removes the topsoil first, and this is where most plant nutrients are located. Also, water, moving downward through certain soils, carries soluble plant nutrients into the subsoil where plant roots cannot reach them. This is called leaching.

Plants Need a Balanced Diet

A fertile soil is one that is able to supply the complete dietary needs of the growing plant. Just as you need a balanced diet and different amounts of various nutrients, so do plants. The three principal plant nutrients are

- Nitrogen
- Phosphorus, and
- Potash.

Among the other essential nutrients are sulfur, calcium, iron, manganese, magnesium, molybdenum, boron, copper, and zinc; plants usually need only exceedingly small or trace amounts of these nutrients, but they must have them. Plants also assimilate and use small amounts of several dozen other chemical elements. of course, plants also require large amounts of carbon, hydrogen, and oxygen, but they can usually get adequate amounts of these nutrients from water and air.

Each nutrient has some specific function to perform in the life of the plant. Should an essential nutrient be absent, plants will show some sign of the deficiency. To experienced people, evidence of plant nutrient deficiencies are known as “hunger signs.” Chemical tests of the soil can be made by soils laboratories to determine how much of which essential nutrients are needed for the best growth of different kinds of plants.

As far back as the time of the statesman Cato the Censor (234-149 B.C.),

the Romans understood enough about soil fertility to recommend crop rotation, adding lime to soils to reduce acidity, adding manure, and growing legumes. For centuries, people who lived along the banks of rivers and streams recognized that the annual spring floods that covered their land with sediment-rich water brought better crops. In 1699, John Woodward experimented with plants by growing them in water containing differing amounts of sediment. He found that the plant growth improved as the amount of sediment in the water increased.

Early American colonists received help from Indians who insisted that one fish be planted with each seed. The decomposed fish supplied the growing plant with nitrogen and phosphorous. In some places, seaweed has been used for centuries as a fertilizer for crops.

Research into fertilizers picked up late in the 1880's, centering on the essential elements in fertilizers, the best time for application, and on fertilizer formulas. (Today, fertilizer research, processing, and manufacturing is a \$6-billion business.)

To fertilize gardens and crops of high value such as tobacco and cotton, naturally occurring and readily available materials --- cotton seed meal, dried blood, fish meal, guano --- were used. Animal manure and crop residues also have been returned to the land as fertilizers.

Not only do these materials help replenish plant nutrients, they supply organic matter that is essential in helping to maintain desirable soil structure. Soil that is loose and crumbly and has many pores for water and air in it has good structure.

Gardeners often make a compost pile on their property and use the decayed organic material from it to fertilize and improve the soils in which they grow flowers and vegetables. leaves, grass clippings, dead garden plants, vegetable scraps, and other organic material placed in a pile and kept fairly moist usually will rot and make useful compost for mixing into the soil within about six months.

Manufactured Fertilizers

To furnish the large quantities of the right kinds of nutrients needed to grow plants successfully, gardeners, farmers, and ranchers could not

depend solely upon the organic materials they returned to the soil. There simply wasn't enough naturally occurring fertilizer available in the quantities needed, and it rarely contained the necessary plant nutrients. In the early 1920's, use of ,manufactured fertilizers became common and has been climbing steadily every since. Most fertilizers supply one or more of the nutrients --- nitrogen, phosphorus, and potash --- that plants use in the greatest quantity. As people developed plants that were capable of producing much larger quantities of food and animal feed --- hybrid corn, for example --- they had to supply these plants with the nutrients necessary for high production. Thus, the total nutrient tonnage of manufactured fertilizer used in the U.S. increased almost eight times from 1945 to 1977, from 2.8 million tons to more than 22 million tons. (Nutrient tonnage means the actual weight of the nitrogen, phosphorus, and potash produced.) Today it is more convenient to buy manufactured fertilizer than to supply natural plant nutrients in other ways.

The manufacture of chemical fertilizers is, by volume, a large energy consumer. yet, less than one percent of the energy used in the U.S. goes to the production of fertilizers.

Annual production of nitrogen fertilizer requires nearly 490 billion cubic feet of natural gas --- 95 percent of the natural gas used in all fertilizer production. Anhydrous ammonia, made from natural gas, is the primary source of nitrogen for fertilizer purposes. Each ton of nitrogen fertilizer produced uses 36 to 40 thousand cubic feet of natural gas. About 40 percent of this gas is burned as fuel; the remainder is used to produce the hydrogen. The ammonia is normally produced by causing nitrogen gas, obtained from the air, to react with hydrogen gas, obtained from natural gas, under high pressure and temperature in the presence of a catalyst. Total energy consumption is about 42 million BTU's (British thermal units) per ton of nitrogen produced.

Production of phosphorous and potash are largely mining operations. The total energy consumption is about 10 million BTU's per ton of phosphate produced and 4 million BTU's per ton of potash produced.

Plants require different amount of plant nutrients. For example, grass on lawns usually needs a greater amount of nitrogen than other nutrients. Soybeans, a crop plant that has the ability to take nitrogen from the air and, with the help of certain bacteria, store it in little nodules, or lumps,

on its roots, will on most soils produce a much greater yield if fertilized with phosphorus. Home owners and farmers must apply fertilizers containing the proper amounts and kinds of plant nutrients for the plants they want to grow. Maintaining a proper balance among the available plant nutrients in the soil also is important; if any one is deficient, plant growth will be limited.

Rotating Crops

Since different kinds of plants have different nutrient requirements and different effects upon soil, people learned long ago that rotating crops --- growing different crop plants in a planned sequence --- was important in good management of soil. Of course, different crop rotations are used on different kinds of soil.

Because nutrients can be added to the soil in the form of manufactured fertilizers, it is no longer as important to rotate crops to maintain and improve the soil's natural supply of plant nutrients. Still crop rotation has many benefits. Insects cannot stay in the same field to dine on their favorite crop year after year when crops are rotated. On many soils, it is easier to maintain a good soil structure when shallow-rooted and deep-rooted plants are alternated. On sloping land, erosion can be greatly reduced by rotating crops.

You may hear a gardener or farmer remark that he has a "sweet" or a "sour" soil. This has nothing to do with taste. "Sour" is used to mean a soil that is acid while "sweet" refers to an alkaline soil. To measure the degree of acidity or alkalinity of a soil -- that is, whether its chemical reaction is acid or alkaline --- the pH test is used. On the pH scale, the number 0 represents an extremely strong acid reaction, 14 represents an extremely strong alkaline reaction, and 7 represents a neutral reaction.

Very few plants will grow in soils with a pH higher than 10 or less than 3.5. Roses, most annual flowers and vegetables, and most lawn grasses should have a slightly acid to neutral soil. Farm crops thrive best in soils, ranging from pH 6.0 to 8.0.

Soil reaction is important to plants because it directly affects the availability of plant nutrients. When soil is too acid, it can be made more neutral by applying ground limestone. Lime is not put on the soil each

season as is fertilizer; the effects of proper liming can last from three to ten years. The alkalinity of soil usually is reduced by applying gypsum or sulfur.

Managing and caring for soils properly so they remain productive and are not damaged in use requires a good deal of knowledge. Not every one needs to know the precise details of soil conservation management. But understanding soil formation, how soils differ, and how plants use soil will lead to a better understanding and appreciation of the importance of soil in everyone's life.

As you continue your study of soil and water conservation, you will learn how to put this knowledge to use in caring for the land.

CAUSES AND EFFECTS OF EROSION

You have watched the force of moving water from a hose or hydrant push dirt --- even pebbles and rocks --- off a driveway or sidewalk. if you happened to turn the hose on bare ground beside the pavement, you saw the water push dirt back onto the concrete.

Rain and running water act on the bare soil in a garden, on the site where a new building is being constructed, in a farmer's field, or on a cut bank along a highway in the same way as the stream from a hose. The process by which beating rain and moving water dislodge and carry soil particles, organic matter, and plant nutrients to a new location is called soil erosion by water. it can occur where and when there is enough rain or melting snow and ice so that water quickly runs off the surface of the land.

Wherever you live, you've seen the wind pick up and carry dust and larger particles of loose materials from one place to another. Have you noticed that there usually is more dust and dirt in the air when there has been no rain for a long time? Where does the wind best pick up dirt and sand particles: close to trees or buildings or out in open streets and spaces? Have you noticed where the wind often drops its heavy load of dust and dirt?

In many parts of our country, the action of wind on the soil is the cause of serious conservation problems. Whenever wind moves across a bare or poorly covered soil surface, especially if the land is dry and the soil

consists mainly of fine, loose particles, soil blowing occurs. This blowing is called soil erosion by wind. Severe wind erosion occurred in the Great Plains region in the “dust bowl” days of the 1930’s. Then, the wind carried dense clouds of surface soil more than 1,500 miles east to the Atlantic coast. In 1938, the drought was broken when life giving rain returned to the Plains states.

Geologic Erosion

In our study of erosion, we must recognize that natural erosion --- scientist call it geologic erosion --- began when the air first stirred and the rain first fell upon our planet. it continues today and is especially noticeable in dry regions where there is little vegetation, and where infrequent but intense rains carve hills and scour valleys. Throughout the ages, geologic erosion shaped the face of the earth; it helped crumble the rocks to form soils, and it wore away the mountains to make broad plains and valleys. Geologic erosion usually moves at a creeping pace --- so slowly that, when there is much native plant cover, soil is built up and seldom destroyed, and in a lifetime one could scarcely see the change it brings.

Our concern is the accelerated erosion of soil that occurs as a result of people’s activities. our problem is to control the rate of this kind of soil erosion; this is one of the important purposes of soil and water conservation project.

Soil erosion has been called the greatest scourge the world has ever known. it affects everyone. it means that soil is moving; someone’s losing it and someone is getting the mud --- and probably doesn’t even want or need it.

You’ve already discovered that a muddy creek or river is not much fun. You don’t want to play in it and you certainly don’t want to drink from it. In many small streams, sediment fills the deep pools that provide a refuge for fish during the dry season. Sediment often damages the spawning beds of game fish, ruins their eggs, and reduces their food supply. Fish eat the worms, insect larva, and other small aquatic animals that feed on microscopic plants in the water --- but muddy water filters out light and so interferes with the growth of microscopic plants. Commercial fisheries also are damaged by sediment. it is causing oysters to disappear from the

Chesapeake Bay and other places. It has greatly reduced the number of commercially valuable fish that once spawned and grew in shallow bays of western lake Erie.

A Costly Problem

Sediment in the water supply makes it much more expensive for many cities and towns to purify water before piping it to homes, factories, shops, and schools. As a result, water bills go up. Sediment in water also causes costly wear on machines, as in hydroelectric plants.

Even more important and costly to everyone is the sediment that fills lakes, reservoirs, navigation channels, harbors, and roadside ditches. Water-supply reservoirs lose storage capacity each year as a result of sediment. Eventually there is no more room for water, and the sediment must be removed or a new reservoir constructed. Some city water reservoirs have been filled completely with sediment in less than thirty years. Sedimentation can quickly cause small ponds to become nothing more than mud holes; some ponds have filled with sediment in only a couple of years.

When flood-prevention and other types of reservoirs are built, allowance must be made for the sediment that will settle in them. This costs money. Each year, more than half a billion cubic yards of sediment must be dredged from harbors, streams, and navigation channels in order to keep these vital routes open and useful for water transportation. Much of the cost of sediment removal is paid from public funds, which means sediment costs taxpayers.

Each year, more rivers flood because stream channels are choked with sediment. In addition to the damage by flood water, there is damage by sediment to streets, houses, automobiles, parks, camps, and machinery. Much of this sediment has to be removed by hand. Rain and wind also spread sediment over crop land, not only destroying the crops but making the soil less useful for growing plants. Drainage and irrigation ditches become less effective as they are clogged with sediment. Thus, sediment reduces the amount and quality of crops.

Now you can understand why sediment affects every one in some way. it

means higher taxes, transportation and energy costs, and water bills; it causes ugliness; it brings health hazards and reduces our opportunities for recreation in the water; and it damages or destroys the homes and food supply of fish and other aquatic life. Because all sediment has its source in erosion of some kind, and because erosion itself destroys the usefulness of the land, we need to know more about how erosion occurs, how to recognize it as it starts, and what to do about it.

Kinds of Soil Erosion

Dump a bucketful of water and it will make quite a splash. If the water lands on bare soil, it splashes mud away from the point of impact because it has torn loose some soil particles and taken them along. The force of a single raindrop won't move much soil. But when billions of raindrops together hammer against bare ground, they tear clumps of soil apart and separate the tiny particles from each other. As they bounce into the air after striking the ground, the raindrops carry some soil particles with them; as the bits of soil are splashed about, they gradually move downhill. This is called splash erosion. After a rain, you can see evidence of splash erosion in the small bits of soil that cling to the walls of buildings, basement windows, the leaves of plants, and picket fences. Splash erosion is largely a process of detaching and breaking up soil into tiny particles that will be carried away by water flowing over the land.

Whenever rain falls so fast or snow melts so rapidly that the water cannot soak into the soil, a sheet of water collects on the surface and moves downhill. On sloping land with little vegetation, such as a new building site, an overgrazed pasture, a cultivated garden, a newly plowed field, or a road-cut, the combined action of beating raindrops and flowing water continuously washes away thin layers of surface soil. This is called sheet erosion. The damage caused by sheet erosion often is not apparent until much of the surface is washed away. Sheet erosion is taking place wherever muddy water moves off bare ground without cutting channels in the soil.

When water moves over the land surface, collects in little streams and continues to run down the slope, it tears away more soil particles until it carves small irregular channels. This is called rill erosion. The evidence of this kind of erosion can be erased by smoothing over the land surface as a farmer does when cultivation. Yet, the soil is gone, even if the

evidence of rill erosion is erased.

On much sloping land, the small rills, or channels, won't go all the way to the bottom of the slope. Instead, they join somewhere on the slope to make larger channels. As more water collects in these channels, its force is increased; it begins to rip away larger and larger pieces of soil and, when it falls over a sudden droop, begins cutting into the slope itself. When these larger channels form, we have gully erosion. It takes more than ordinary cultivation to fill in gullies, for they are so deep that machines usually cannot cross them. Gullies often are a sign that sheet and rill erosion have been going on for a long time. Gully erosion is destructive; not only do gullies leave gapping channels in the land, but they feed huge amounts of sediment into creeks and reservoirs, they divide fields into areas too small to be useful, and they cut deep scars into steeply sloping land where new buildings are being erected. Correcting erosion after it has started is a costly and difficult conservation job.

Wind Erosion

The sand dunes we see in some desert areas and near the shores of some lakes and oceans are obviously results of wind erosion. The wind-shifted sands of these dunes are hard to control. Because plants cannot easily be established there, the sand often continues to advance and cover even larger areas. Much more serious wind erosion occurs, however, wherever loose, small soil particles are moved by the wind. Wind erosion is a major conservation problem on the Great Plains and in other regions.

Soil blowing usually starts on land with few plants and with sand soils. Once soil blowing starts, it tends to spread. The wind picks up a few loose soil particles and when these strike bare ground, they blast loose other particles, which, in turn, are bounced and swept along the ground surface, causing further erosion. The blowing soil particles can cut off tender, growing plants at the ground surface. or, they can cover both growing and dead vegetation with drifts and hummocks of dust or sand. When the growing plants are cut off, the soil they protected from the wind will erode. if high winds continue for a long time, the soil blowing that started from a few fields can spread over an entire community.

Because wind and water act on land surfaces nearly everywhere, why hasn't all the soil been splashed, blown, and washed away by this time?

You can discover the answer to this question. Have you ever seen dust blowing from a lawn that has a thick grass cover? Have you ever seen mud splash up after a rain from soil covered with grass? The grass broke the force of the falling water and the grass roots held the soil tightly in place. In the same way grass, trees, and other plants break the force of falling raindrops. Plant roots help water enter the soil by keeping it porous. They hold the soil particles together so that moving water cannot break the particles apart and carry them away. Plants also slow down the water that runs over the surface, thereby allowing some time for it to soak in. Plants growing closely together also protect the soil from the force of strong winds. The tops of the plants slow down the wind and the roots help hold the soil in place.

Though a lightning-caused fire or some other natural disaster can remove all the plants from an area and expose the surface soil to the ravages of wind and rain, the area affected is very small compared with the area people have carelessly used and left unprotected.

In fact, soil erosion often is called a disease of civilization because nearly all of it is the result of people's activities:

- cutting down forests and making no provision for new growth,
- growing crops and leaving the soil bare part of the time,
- erecting buildings and not protecting the soil during construction,
- grazing too many cattle or sheep on an area so that the vegetation is killed,
- building highways and railroads without protecting their banks,
- forcing too many wild animals to live on an area so that they destroy the vegetation in their search for food,
- trampling the grass and other plants to death on campsites and playgrounds,
- destroying trees and grass through careless use of fire,
- stripping the land surface to obtain fuels and minerals from the earth,
- and using the soil improperly for any purpose.

People indeed cause erosion in many different ways. But we can use the land to satisfy our desires without causing erosion. We can and must conserve land if we are to continue to live and to enjoy life on earth.

Erosion in Urban Areas

We often think of erosion problems as most important on farms and ranches, yet the greatest erosion problems cause by people occur when land in or near cities is being shifted to use for homes, shopping centers, and other urban purposes. For example, in the Potomac River Basin, which includes Washington, D.C., and parts of Maryland, Virginia, West Virginia, and Pennsylvania, the sediment from a square mile of city area exceeds by ten times the soil loss that occurs in rural areas. So, using soil intelligently and practicing soil and water conservation are important wherever we live.

You are seldom far from a conservation problem, large or small. The dramatic incidents get into the news. Fires sweep the big timber country - -- thousands of acres are blackened; wildlife is destroyed, residents are forced out of their homes and jobs; sometimes fire fighters lose their loves. Or, floods roar through valleys, destroying houses, shopping centers, factories, and reservoirs, and leaving in their wake human misery, disease, and costly repairs.

However, the less dramatic things happening right in your own neighborhood are no less important. Little signs might point to bigger problems on the way. Have you recently seen mud in the nearby street gutters, on sidewalks, in a corner of your yard: Have you noticed bare spots in lawns, on the schoolyard, or on sloping banks? have officials of your community lately cautioned against using water for the lawn or washing the car?: How muddy is the creek or river that you know best? Discovering the answer to these questions will help you become aware of some of the conservation problems your community faces.

CONSERVATION ON THE LAND

People are constantly changing the uses of land. There might now be a building under construction on the vacant lot where you played last year. Or, an old building might have been demolished and that land now is vacant. Perhaps a roadway that cuts through hills and fills in low places has been constructed. Changes in land use probably are being made at your Scout camp each year. Farmers, of course, grow a new crop on most of their fields each year, and as they improve the land for farming or shift it from one use to another, they can make great changes on the face of

the landscape.

As the number of people grows and more new houses, stores, factories, and schools are needed, and as people change their minds about what they want from the land, there will be more and more shifts in land use. You learned earlier that during changes in land use, the soil often can be left unprotected and subject to damage by water and wind. You've observe, too, that improper care of land results in costly and serious damage to soil and water resources.

You can now recognize many of the familiar signs of trouble that can be traced to poor use of land and lack of proper conservation measures --- mud and silt on the sidewalk and driveway after a rain, side ditches filled with sediment, muddy water in a stream or river, bare soil where there was once grass on your campsite, and small and large gullies scarring the face of the land.

Much land is wisely used, and conservation is practiced on millions of acres in the countryside as well as in cities and suburbs.

Conservation Practices

A conservation practice is any specific action or process to care for natural resources so they are protected from damage and improved for certain uses. Good conservation practices are ones that are properly designed and carefully implemented, and have been tested so that we know they will not cause adverse effects. In some instances, a good conservation practice might be complete elimination of someone's use of a piece of land, leaving it just for scenery and wildlife.

You can see good examples of conservation practices in many places. Sure signs of conservation at work on the countryside are the large, graceful, curving strips of crops seen on many farms. These winding ribbons include the dark green of grasses, gold of ripening grains, and different hues of soil exposed between crop rows. This is a spectacular sight from a high point along a highway or from an airplane. Many conservation practices help to furnish the things that all wildlife must have --- food, shelter, and water. If these needs are provided for on small areas in cities, an amazing variety of wildlife could appear.

Controlling Soil Erosion

Professional conservationists have developed many conservation practices. Some of them can be applied to solve specific conservation problems both on farms and in towns, and others are suitable only for application on crop lands, rangelands, or forest lands. Because plants are the great protectors of land surfaces, most conservation practices involve the use and management of plants so that they can hold soil in place. But, when we want to use land for such things as buildings, campsites, or crop production, we often have to use engineering to change the shape of the land surface so it will control water. Therefore, both vegetation and engineering conservation practices often must be used together to be effective. We couldn't study all the different conservation practices so we will examine only a few typical ones.

Applying a thin layer of organic material on the land surface to hold surface soil in place while grass or other newly seeded plants become established is called mulching. Often, mulching is used on road banks, new lawns, the backside of earth dams, and crop land where wind or water might erode soil.

Growing crops, fruit trees, and garden plants on sloping land, across the slope on the level (where all places along a contour line are of equal elevation) --- rather than up- and downhill --- to control runoff and thereby reduce erosion, is called contour planting. This type of planting is always practiced wherever there are terraces, and is frequently used without terraces, too. Contour planting is most effective with crops grown in rows. It is used widely on farms and should be used in gardens or wherever plants are cultivated on sloping land.

Terracing takes place when ridges of earth are constructed on contoured or sloping land to control runoff, and in dry areas to conserve moisture. Ridges can be as low as a few inches or as high as two feet or more. Specific types are parallel, level, diversion, and bench terrace. The distance between terraces must be designed so that the runoff can flow to each terrace without overtopping it. Terracing is needed on sloping soils in gardens, around homes, and buildings, and on cropped lands.

Growing temporary crops of plants that cover the soil between seasons or between rows of the main crop to protect the soil from erosion is called

cover cropping. It can be used in gardens, on farms, and on construction sites where soil might be exposed for a season before permanent vegetation can be established.

A grass waterway is a natural or artificial drainage in which runoff flows after a storm and has a permanent cover of grass. Excess water can be channeled from a field, garden, or other area. Grass protects the channel from erosion and helps keep sediment out of the water. Grass Waterways can be used wherever water concentrates and flows off the land; however, to be effective, it must be designed to carry the amount of water it will receive.

Trees and/or shrubs can be used as windbreaks to reduce the effects of damaging winds. This helps to control soil blowing in fields; protect homes, other buildings, and delicate plants from cold winter winds; reduce evaporation from soil; trap snow (necessary along farm fields, especially in the Great Plains); add comfort and beauty to suburban homes; and provide food and homes for many kinds of wildlife.

A constructed pool or basin formed by placing a dam or barrier across a waterway at a suitable location to trap and hold sediment is called a debris basin. It temporarily holds sediment on property where construction is underway and in other places to keep sediment and debris out of reservoirs, lakes, and streams. Contour diversion sometimes are used to guide runoff into basins.

A pond, a small reservoir or water made by building a dam or embankment, can be only a few feet or several acres wide. It has many useful purposes --- fish production, water for livestock and wildlife, recreation, and fire protection --- and it enhances the appearance of camps, homes, and farms.

Floodwater-retaining structures are dams, embankments, or other devices built to provide temporary storage and controlled release of floodwater.

Screens --- trees, shrubs, or vines --- can be planted to block views of unsightly things such as garbage cans, junkyards, and dumps; to shield homes and people from traffic and other noises; and otherwise to beautify an area.

A concrete, metal, or wood structure used to slow the velocity of water and control gullying and drop water to a lower level is called a drop spillway.

Strip cropping is the growing of crops in broad or narrow bands or strips across the general slope of a field or large garden. Crops are arranged so that a strip of grass or other close-growing crop is alternated with a strip of clean-tilled crop where some of the soil surface is exposed. The close-growing crop slows down runoff from the clean-tilled strip. Strip cropping often is done on the contour. Where wind causes soil blowing, the strips are at angles to the direction of prevailing winds and their purpose is to protect the exposed land from wind erosion.

Stream banks can be protected against erosion and water-scouring by using plants, rocks, or structural measures. Specific methods include establishing certain types of grass after sloping the banks, planting such trees as willows below the tops of banks, placing a thick layer of rocks along the banks, or lining the channel with concrete. This method can be used on small and large streams in suburbs, cities, and the countryside.

When range lands are used for grazing by cattle or sheep, it is wise to ensure that plant cover remains for soil protection.

Planting, thinning, pruning, and properly harvesting woodlands can provide enough growing space for good trees, eliminate poor trees, establish stands of species best suited to soil and climate, obtain wood products without damaging soil and water resources, maintain natural beauty, improve conditions for wildlife, and maintain cover for erosion control.

Planting shrubs, trees, and many other kinds of plants to furnish food, cover, and shelter for wildlife; creating water supplies; making openings in dense woods; limiting the use of an area; and many other projects to attract and provide for needs of wildlife are called wildlife habitat developments. Often they are a part of other conservation work on farms and ranches. Wildlife plantings are also made around homes, in parks, on school grounds, and in other open areas in cities.

Wildlife wetland developments improve or create habitats by ditching, diking, or other means of providing appropriate amounts of water, and by

establishing plants to provide food, cover, and shelter. This includes limiting other uses of the wetland and maintaining the measures installed. Wetland developments can be used wherever enough water and land are available.

There are many more soil and water conservation practices. As you have probably observed, many practices serve more than one conservation purpose, and for best results, combinations of practices often are used.

Even though most of the people in the U.S. live in towns and cities, they must have the food that comes from the land and the water that falls on it. Everyone, therefore, needs to be concerned about the use and misuses of all land. It's true that conservation is very important on land in suburbs and in cities, but we need to remember that most of our natural resources are where people aren't, and it is upon these resources that we all depend for comfort and survival.

CONSERVATION IN WATERSHEDS

You now know a good deal about the causes runoff, and that as water makes its way back to the oceans, it gathers in streams and rivers. The area of land from which water runs off to a specific stream or outlet is called a watershed. Wherever you live, you are in a watershed.

Watersheds come in all sizes, from those not much bigger than a football field to those that contain millions of acres of land and include several states, such as the Mississippi River watershed.

You can find a miniature watershed on your own backyard, on a vacant lot, or on the schoolyard --- any area from which water drains overland to a central point. Hundreds of small watersheds with their little streams are part of, and lie within, large watersheds that are drained by rivers. A watershed boundary may not be obvious where the land is nearly level, but in many places, the boundary might be plainly marked by high ridges. Water that flows one way from the ridge goes into one watershed, while water flowing off the other side of the ridge goes into another watershed.

One way to determine the boundaries of a watershed is to look at a topographic, or contour, map. Each contour line on such a map represents a single elevation; all points along that line are equal in elevation. If you actually walked along such a line on the land, you would

always be walking on the level, never going up-or downhill. Since you know water always runs downhill, you can locate on the topographic map the areas of high ground from which water drains in some kind of pattern to a lower elevation.

Topographic maps covering 49-70 square miles or 197-282 square miles can be obtained from U.S. Geologic Survey information centers or from the U.S. Geological Survey National Center. The watershed you live in might include hills and mountains. Or, it could be nearly flat with streams and rivers that move slowly and meander widely. Land in the watershed is used for many different purposes.

The Watershed Community

The animals, birds, plants, fish, and people who live in a watershed are part of a watershed community. We know that runoff doesn't stop at artificial boundaries such as county lines, city limits, or the fence around your yard. All the people, plants, and animals are affected by what happens to the water and land in the watershed; they depend on the watershed and influence what happens there. If the land and water resources are not properly tended and flooding occurs, nearly everyone in the watershed suffers. When poorly or improperly treated waste is release into streams from sewer systems or industry, or allowed to run off carrying sediment and harmful materials into the streams, the polluted water is a problem for all watershed residents.

Because land, water, and other resources are so closely tied together in a watershed, the most natural way for people to solve conservation problems that they, as individuals, cannot solve is to work together. For example, one individual cannot, on his or her land alone, do the things necessary to control floods; everyone must work together to do this.

When runoff from hundreds of small streams goes into a larger stream, floods often occur. In addition to slowing down runoff from individual fields, yards, gardens, and parks, watershed residents working together can do other things that will control the water once it gets into larger streams. They might build flood prevention dams. Or, to prevent damage and loss of life when a flood does occur, they might advise people not to build homes, offices, and factories on flood plains. City and regional planners who are exploring ways to make living safer and more

comfortable for people, while protecting soil and water resources, are trying to persuade local governments to set aside flood plains for recreation areas, for open space, and for other uses that cannot be greatly damaged by flooding.

Land Use is Vital

Remember, how the land is used and cared for in your watershed is important to you: careless logging, overgrazing of pasture and grasslands, and construction work that leaves large areas of land bare will increase erosion and runoff. The result will be sediment damage and possible floods along the streams in the watershed. Fires that have swept through watersheds in the western U.S. and have been followed by heavy and prolonged rains have washed huge amounts of soil down hillsides. In some places, large areas of mud and water-soaked soil slid off the hills, carrying houses and other buildings with it. Water supplies became polluted. Great amounts of money and effort were expended to repair this damage, and to establish grass and trees on the eroded slopes.

Soil conservation practices can help reduce the damaging effects of fire and erosion, but the local people must work together to protect their watersheds and the resources in them. Local, state, and federal governments offer much help in getting organized to work together and in planning and doing the work needed to control water and soil erosion. They also help individuals plan and carry out conservation plans on their property.

Because development and good use of a watershed benefits many people, including those who live far outside the watershed, the federal and state governments share with local people the cost of doing land- and water-conservation work. This program of cooperative work on watershed projects with local people is carried out under a law passed in 1954 by Congress, Public Law 566, the Watershed Protection and Flood Prevention Act.

In watershed projects, conservation measures to protect soil and water resources --- called land treatment --- might include better methods of cutting and hauling out timber; applying mulch after seeding bare land on highway road banks; controlling grazing so that enough grasses left to keep plants healthy and growing; seeding land that has been cleared for construction, overgrazed or burned; constructing terraces and other

means of controlling water; growing and cultivating crops on the contour, and planting trees to break the force of the wind.

In most watershed projects, one or more small dams are needed to hold back runoff temporarily. These dams usually are designed so they will hold and store sediment as well as water. In some cases it is necessary to build sediment traps. When people in the watershed desire, flood prevention dams and reservoirs are built larger to hold water for recreation, industry, cities, and towns, fish and wildlife, and irrigation. Other conservation practices are applied in connection with many of these reservoirs so that wildlife and recreation values are improved. Such watershed projects are called multipurpose projects.

River Basins

Earlier, we called the very large area of our country --- more than a million square miles that is drained by the Mississippi River --- a large watershed. This area is also called a river basin which means an area of land drained by a river. All river basins are large watersheds, but not all watersheds can be called river basins, because some watersheds are very small and the runoff from them is collected by a small stream. There are many small watersheds within a river basin, for a river basin includes the area drained by a major river and all its large and small tributaries.

Today, attention is being focused on river basins as areas for large-scale planning, development, and conservation of natural resources. The U.S. has 18 major river basins; in each basin are combinations of rural areas, industrial sites, and cities, and all depend on the water in that basin because there is little transfer of water between river basins.

Most rivers cross several political boundaries and many types of terrain as they flow through different states on the way to the ocean. The way that land and water are used and managed in the small watersheds in the upper part of the river basin affects the quality and quantity of water people in cities downstream will have. Similarly, the way people in cities along a river use water and the kinds of wastes, they put into the river will affect industries, businesses, and cities farther downstream. So, in dealing with the complex problems of natural-resource use and population growth, attention must be given to the needs of all the people in the river basin because the river links them all together.

River-basin planning involves state and community leaders working out a course of action for the intelligent management of the basin and its resources.

Flood control, hydroelectric power, water supplies, sewage disposal, air and water pollution, locations for homes and industry, open space and recreation areas, fish and wildlife resources, land for crops and forests---all these and many more factors must be considered in planning to make life better for the people who live in the river basin. Though each state has its own problems, states must work together to find cooperative solutions to common problems so that water resources are used intelligently.

Several states now are working together on river-basin commissions and, with the help for the federal government, are surveying the needs in a river basin and making broad plans for water and land resources in the entire basin. The amount of water available to people in different river basins varies considerably. In some rivers, the water is used much more completely than in others whose capacity is relatively untouched. In some places ground water supplies are shrinking, and the flow is uncertain and often not large enough to satisfy the water needs and desires of steadily increasing numbers of people.

Desalination

Scientists and technicians are working hard to solve the problem of water supply in areas of acute water shortage near the ocean by making fresh water out of salty and brackish water. The process of removing the salts from seawater is know as desalinization, desalination, or desalting.

Evaporation, the process by which water becomes a vapor and enters the atmosphere, leaves salt and other substances behind. If we catch and condense the water vapor from dirty or salty water, we then have fresh water. This process, called distillation, long has been understood and used to obtain small amounts of fresh water from seawater. But producing fresh water in large quantities by evaporating sea water and catching and condensing the vapor is expensive, even if the source of heat to cause evaporation is free --- as in energy from the sun. Heating seawater by using fuel oil or a nuclear reactor speeds up evaporation but

adds to the cost of producing fresh water. There are large seawater distillation plants in Kuwait, Saudi Arabia, the Virgin Islands, Guantanamo Bay in Cuba, Hong Kong, and Tijuana, Mexico.

Freezing is another method for purifying seawater. When salty water is frozen, the ice crystals formed are pure. However, when freezing is accelerated in machines, the crystals of ice formed are coated with a thin film of salt water, which must be washed from the crystals before they are melted. Thus, it is difficult (and expensive) to get large amounts of fresh water by this means.

Other desalination processes use membranes. One of these is reverse osmosis, which is used mainly for improving brackish and slightly salty water. Osmosis occurs when a dilute solution passes through a membrane into a more concentrated solution, much as water moves into plant roots through cell walls from the soil. This process can be reversed if sufficient pressure is applied on the concentrated or salty water side and fresh water will flow through the membrane out of the salty water --- hence the name reverse osmosis. Several cities on the west coast of Florida use reverse osmosis to treat brackish well waters for their city water supply.

Another membrane process is electrodialysis. It is also used mostly for brackish waters. In this process electric current is used instead of pressure. The current causes the salt ions to move through the membranes, leaving fresh water behind.

The number of desalination plants is increasing steadily, but the water is costly. In 1977, there were more than 1,500 plants, with capacities larger than 25,000 gallons per day capacity, producing nearly a billion gallons of fresh water daily. All of the water was used by cities or industrial plants;; none was produced for irrigation.

Cheaper and more efficient processes for desalination are needed. This is an exciting field for study and experimentation. Work is constantly going on to improve old processes and find new ones that will reduce the cost of desalination. Because desalting water probably will remain expensive for many years, it is estimated that by the year 2000, only about 7 percent of our nation's water will come from desalination.

WATER AND THE LAND

Of all the natural resources necessary to the existence and comfort of people everywhere, water is the one best known to all of us.

We know that water falls on the earth as rain, snow, sleet, or hail, and most of us have been outdoors in foggy weather. Have you ever wondered why there is too much water sometimes, and too little water at other times? Have you wondered how water gets into the clouds, and what happens to it when it falls to earth? And most important, is there enough water for all the plants, animals, and people/

These are the questions you will answer as you learn more about the water cycle, or hydrologic cycle --- the process by which water travels from the sea through the air by means of clouds, and falls on the earth to return again over the surface or underground to the sea and start the cycle all over again.

Our concern with water rests on our increasing need to manage carefully the water that falls on the land. The important point, which is frequently overlooked, is that we must manage the land to manage water. The fate of each raindrop and each snowflake depends largely on where it falls --- on the kind of soil and the way that soil is being used. But if we are to manage land and water intelligently, we need to know how and why water behaves the way it does.

Water Cycle

Water enters the atmosphere

- Evaporation from ocean
- Evaporation from rivers, streams and other smaller sources
- Transpiration from plants
- Respiration from plants, animals, people
- Chemical Reactions
- Burning fuels

Cloud formation

Advancing air mass pushes the clouds over the land

Rain clouds develop.

Water vapor in clouds condenses.

Precipitation in form of rain, snow, sleet

Water returns to oceans, rivers, streams

Run off

Infiltration

Percolation

Capillary action

or May enter the ground water supply

How Water Behaves

Let's begin with the sea, where the sun's energy draws up into the atmosphere most of the water that travels through the water cycle. This process is known as evaporation.

Much of the moisture evaporated into the air soon falls back into the sea during storms, but the winds eventually do carry the air mass with moisture in it over land. A small part of the moisture, or water vapor, in the air at any time might be visible to us as clouds, fog, or mist. It is when the water vapor in clouds condenses that we get the rain, snow, sleet, or hail that falls on the earth. The water that comes to earth in this way is known as precipitation.

As it moves across the land, more moisture is added to the air. Water from lakes, ponds, rivers, and even from birdbaths and puddles on the sidewalk, evaporates and returns moisture to the air. The soil itself gives up moisture as winds move across it. Evaporation is one of nature's ways of purifying water, because most of the dissolved substances in it, such as the salt in seawater, remain behind when water evaporates.

In addition to evaporation, another major source from which moisture gets into the air is living plants. Moisture absorbed largely by plant roots from the soil, but also by other plant parts from the atmosphere, is released into the air during the plant's life. This diffusion of water vapor from plants is called transpiration. To see for yourself that plants transpire water, place an airtight, transparent plastic bag over a common potted house plant and tie it fairly tightly around the plant stem near the surface of the soil. Then, set the plant in the sunlight. Soon you will notice drops of water collecting on the inside of the plastic bag.

Different plants, of course, transpire greatly different amounts of water depending upon such factors as humidity, moisture availability, temperature, and wind. A large oak or other hardwood tree, for example, can transpire 500 gallons of water in a day. In dry country, where moisture for growing crops and for other purposes is badly needed, plants that are not considered useful but that transpire large quantities of water sometimes must be removed to conserve severely limited water.

Small amounts of water also are returned to the atmosphere as the result of chemical reactions. People, animals, and plants return some through the process of respiration, and the combustion or burning of fuels in cars and furnaces returns additional amounts.

Evaporation and Precipitation in Balance

The processes of evaporation and precipitation are the most significant ones in the endless water cycle that is always at work over the entire surface of the earth. The amount of moisture in circulation remains about the same throughout the ages. The 95,000 cubic miles of water in circulation in the water cycle today probably is about the same as it was when Pharaoh Cheops was building his Great Pyramid in Egypt.

To get some idea of the quantities of water involved in the cycle, pretend that an ordinary bathtub filled to the top represents all the water in the oceans. Compared with that, the amount of water circulation in the hydrologic cycle would fill an ordinary water glass about two-thirds full. To carry the comparison still further, the annual amount of precipitation on land throughout the world would be represented by the water in a juice glass only half-full. The small amount of water that actually flows from land areas and returns to the sea would be represented by a small hypodermic syringe half full of water.

As long as moisture is circulating about the earth in the atmosphere, there is little we can do with it, although scientists are now exploring new ideas to control the weather and increase the amount of rainfall at certain locations.

If all the precipitation on land areas throughout the world were evenly distributed, about 26 inches of moisture would fall annually on all land. Average annual precipitation in the U.S. is about 30 inches. But

precipitation is not evenly distributed. Some places get less than an inch and others more the 400 inches. if you live in the arid parts of the West, you see very little rain --- probably 4 to 8 inches in a year. Along the Cascade Range of mountains in Oregon and Washington, about 100 inches of rain and snow falls each year. Along the east coast, the average annual precipitation is about 35 inches.

In the time of Christopher Columbus, a family used 3 to 5 gallons of water a day for all its personal needs. In the U.S. today, each person uses about 1,900 gallons a day for bathing, watering domestic animals, air conditioning, food preparation, all manufacturing processes, irrigation for crop production, and all other purposes. You can understand why people now are much more concerned with water supply and use than they were even in your great grandparents' day, when the average use per person was about 95 gallons a day.

Infiltration

When the water in the hydrologic cycle reaches the earth as precipitation, it either soaks into the land or runs off over the surface. So that people can use it to satisfy their many wants and needs, the water that falls on the land has to be controlled. Control must begin where rain and snow first touch the earth. This means using and managing the land so that in most cases the maximum amount of moisture enters the soil. The entry of water into the soil is called infiltration, and the rate at which water penetrates the surface of the soil at any given time is the infiltration rate. We can help make it possible for water to enter the soil more readily by keeping plant cover on the ground, by slowing down runoff, by maintaining or increasing the organic matter in the soil, by maintaining good soil structure, and by using other conservation practices.

After water penetrates the surface of a soil that is already wet, it may continue moving downward through the soil by percolation. Percolation, the major means by which ground water supplies are replenished, is important, for many cities obtain all their water from wells. In many places, water for irrigating crops also is pumped from deep in the earth.

Water percolates through different soils at different rates; usually the larger the soil particles, the greater the percolation rate. To illustrate this, put sand in a small flowerpot that has a hole in the bottom. Pack

clay soil in an identical pot. Then pour water into each pot until it flows through the sand and clay and out the bottom. make sure that you record the length of time it takes for water to begin to trickle from the bottom of each pot.

In the natural world, there may be a layer of rock or of hard soil through which water passes slowly or not at all. If this layer is not far from the surface, it may keep water from percolating deep into the earth, and this means that there is limited space for water storage in the soil.

The percolation rate is important to people who need to know how fast water moves downward in the soil. For example, a septic tank system for the disposal of household wastes will not function if water cannot percolate through the soil rapidly enough. People who irrigate gardens and crops partially determine the amount of water they need on the basis of how quickly the water passes through the soil. Water that percolates through the soil might carry certain impurities, such as chemicals and bacteria, so those who get water from shallow wells need to know how fast and from what sources water percolated into the underground supply. Of course, not all of the water that enters the soil percolates through it. Some becomes part of the soil itself through chemical and physical action as it soaks into clay and silt particles and the pieces of decayed and decaying organic matter we call humus.

Capillary Action

Another fundamental means of water movement in the soil is capillary action. In this process, water seems to defy the force of gravity by clinging to a surface much as it does to a rock that you've picked out of a stream. Capillary action can even make water move upward, as it does in a paper napkin when you dip one corner in the water. In soil, this action makes water move in all directions, clinging as a thin film on the soil particles.

Capillary water is what keeps the soil moist after rain has percolated through the soil. A thin film of water that clings to soil particles and remains in tiny soil pores helps dissolve plant nutrients so that plants can use them. It is the source from which the fine hairs on plant roots get most of the water for a plant

You can demonstrate the process of capillary action by pouring water in a flat pan,

containing an inch of water, a clay pot in which a common house plant is growing in soil that has been allowed to become quite dry. Within a few hours you will note that the surface of the soil in the pot is moist. By capillary action, water has risen through the soil in the pot. For all practical purposes, even under ideal conditions, capillary action will cause water to move upward in dry soil only about 3 feet, and this could take several weeks. Once dryness breaks the film of capillary moisture on soil particles, water cannot move by capillary action again until the moisture supply is renewed and the film reestablished. Since this takes time, capillary action might not move water available after a long dry period to the plant roots soon enough to save wilting plants.

Too much water in the soil can be as damaging to plants as too little. In some places, one of the most important water problems is moving water off the land so that it will not stay in one place long enough to waterlog the soil, thereby cutting off the air to plant roots and to small soil organisms that need oxygen. When the water table --- the level below which the soil is filled completely with water --- is only a few inches below the soil surface, the growth of plants' roots is restricted and many plants cannot be grown. Where the water table in the soil frequently rises to within a few feet of the surface, water can weep into basements; and when some soils become much wetter than usual, they slip and settle, cracking plaster and shifting the foundations of buildings.

Problems of Runoff

When erosion reduces the depth of the surface soil, runoff generally increases. When runoff increases, soil erodes more rapidly. Thus, the cycle accelerates. We must manage the runoff to keep it from damaging the land and to keep the water itself from being damaged by picking up soil and other pollutants as it runs off. As you have already discovered, plants help water get into the soil. They also protect the surface soil from the erosive action of water moving over it.

When we use, remove, or change the kind of plants on the land, we usually change the quantity and quality of runoff. For example, if trees and grass are cleared from an area in order to build houses, we know that more water will run off the land, the runoff will be muddy, and the water will run off quickly. After the houses are built, the streets are paved, and community facilities are erected, much of the soil on the area that was

cleared is covered with hard surfaces. Runoff from this built-up area can be as much as ten times greater and will occur much more quickly than when the land was in trees and grass.

Similarly, when range or pasture is grazed by cattle or sheep plant growth is stunted and some plants die, the amount and speed of runoff increase and erosion occurs much more readily than when grazing is managed so that grass and other plants remain healthy. Fire also can remove plant cover from the land and expose bare soil for a nearby city.

Plant cover is indeed important in controlling runoff, but in many instances it is not possible to keep plants growing on the land. Then the soil surface can be protected with a mulch. Nearly any organic material -- straw, sawdust, leaves --- can be spread on the soil surface as a mulch. Sometimes the surface of the land needs to be shaped to guide and control runoff. Small dams and other types of water-retarding surfaces often must be built to control runoff so that the land and the water are not damaged.

Runoff: The Source of Our Water

The runoff that collects in creeks and streams and eventually flows from rivers into lakes and reservoirs on its return to the ocean is the source of most of the water we use. It is also the source of nearly all water used by wildlife.

Rainfall determines the amount of stream-flow in most parts of our nation, except for the West, where the winter snows in mountainous regions are the great reservoirs of water that determine the volume of stream-flow. The water that comes from melting snow trickling into mountain streams that join to form rivers is vital to plants, people, and wildlife that live hundreds of miles away in dry country where little rain falls. Because people need a fairly constant supply of water for many different uses, dams and reservoirs are built to control and store for later use the water from the melting snows.

But, the same amount of snow does not fall in the mountains each year and the storage capacity of reservoirs is limited. So, if people are going to plan wisely for the stream-flow they can expect, they must know something about the quantity of snow on the mountains. This is the

purpose of snow surveys --- to measure the snowfall and from that and other factors, predict the stream-flow for the coming season.

You know that not all snow is alike --- sometimes it is heavy and wet while other times it is light and powdery. This difference is very important to people who depend on the water that comes from melting snow. Many years ago, a teacher who loved to explore new ideas recognized the great differences in snow he found while hiking in the Sierra Nevada in winter. He experimented until he found a good way of measuring the water content of snow. Today, his method of measurement, much improved and more accurate due to new scientific devices, is still used in making snow surveys. With the help of many people, the U.S. Department of Agriculture measures the snowpack in the mountains in the West several times each winter and spring. Teams of snow surveyors measure the depth of the snow and determine the snow's water content and the amount of moisture in the soil below the snow. All these things influence the amount of water the snow will release when it melts. By comparing this information about the current snowpack with previous years' records, water-supply forecasters can predict with reasonable accuracy the amount of water that will flow in streams and rivers during the next season.

Snow and Water Supply Forecasting

During a typical snow-survey season, from January to June, surveyors travel more than fifty thousand miles, mostly by snow machines, skis, and snowshoes. Some snow courses --- a series of marked places where measurements of the snow are made --- are "read" from the air by teams in planes and helicopters. A new method of getting snowpack information involves use of electronic equipment that weighs the snow on a fluid-filled, rubber pillow, and sends the information to a central station by radio. Called SNOTEL, for "snow telemetry" the new system relies on the billions of sand-sized meteorites that enter the atmosphere every day. As each particle heats up and burns 50 to 75 miles above the earth's surface, its disintegration creates a cigar-shaped trail of ionized gas. These trails last from only millisecond to a few seconds, but that is enough time to reflect VHF radio signals from earth. The radio signals are beamed from central stations in Idaho and Utah and bounce off the meteorite trails down to remote sites in the high mountain areas of the West. The signals trigger small radios at these sites, which then broadcast current snow-

survey data along the same route. The whole transmission takes only a fraction of a second.

Once people have some idea of the amount of water the melting snows will contribute to streams and rivers, they can plan for use and management of the water that will be available. Those who are responsible for reservoirs that store floodwaters can release enough water from the reservoirs early to make room for the water from rapidly melting snow upstream, and thus control a flood. When cities know they will have less water than usual, they can start cutting down on use early in the season and perhaps avoid harsh rationing of water later. As the water-supply forecasts are made and farmers learn they will have less water than normal, they can plan to plant fewer acres of crops that require a lot of water and thus avoid having crops on some acres die for lack of water. Knowing in advance they will have less water to run their turbines, operators of plants producing electricity from water power can plan to use other sources of power to produce electricity for their customers.

Forecasting the flow of rivers and streams is important in all parts of our country, for if they are to manage it, people need to know about how much water will be available, and when too much water may come and cause a flood. Where most of the stream-flow comes from rainfall, it is difficult to predict very far in advance the amount of water a stream will supply, because rain runs off the land soon after it falls, and we do not know how much rain will fall during one storm in specific areas. Still, rainfall, stream-flow, and ground water records accumulated over the years make it possible for experts to give people some advance idea of the flow that might be expected in larger streams and rivers. These records also help forecasters predict accurately the possibility of flood downstream caused by heavy and widespread rainfall many miles upstream.

WATER POLLUTION

As we explore soil and water conservation and its relationship to our own lives, we soon discover that pollution of water is one of the big conservation problems facing us today. We discovered, too, that there are many kinds of pollution. In general, polluted water is water that contains anything that makes it unfit for a specific purpose. All water, except for small quantities used in science laboratories, contains

dissolved substances and suspended materials, so we cannot correctly say that even the safe, clean water most people drink is absolutely pure. What we are concerned with in the study of water pollution is learning how the quality of water can be damaged by people (or in other ways) and how to avoid or remedy this damage.

Some of the materials in water are important to the life processes of aquatic plants and animals and even people; water is not considered polluted until the kind or quantity of material or energy added to it makes use of the water less healthful, efficient, or enjoyable. For example, water might look sparkling clean, but if it contains any bacteria that cause disease, it is considered seriously polluted as drinking water for humans. Yet, such water could be safely used for navigation. Water that we consider far too dirty for swimming might be perfectly suitable for irrigating crops. Water that is polluted so much by the addition of energy in the form of heat that fish cannot live in it could well be safe for birds to drink. We see, then, that part of the overall problem in water pollution is deciding how clean water must be or, in effect, how much pollution we will tolerate in water to be used for different purposes.

Careful Planning is Needed

We cannot expect to use water to satisfy our many needs and have all of it remain clean enough to drink. But, if we are to have water of suitable quality for various uses, we must do some careful planning, learn to use water resources intelligently while controlling pollution, and spend sizable sums of money to clean up the damage already done to many of our streams, rivers, lakes, and estuaries.

Broad-scale planning for use of water resources and pollution control is difficult because the rain that falls on a watershed might travel in streams and rivers or underground through several states and be used many times for different purposes. Unless each state, each city, each community, and each individual water-user takes the responsibility for returning water to the rivers in good condition and keeping pollutants out of it, the people farther down the river will have to spend a good deal of money to clean up the water for their use. For some uses, they might not be able to afford to clean it up, and, of course, plants and wildlife suffer from dirty water in the stream.

The problems of water use and pollution control are a major focus of river-basin planning. Progress is being made in developing water-quality standards that apply to waters flowing across state lines, but pollution control general is still a matter for action through local governments, for they make many of the laws that govern water use and sources of pollution.

The Federal Water Pollution Control Act amendments of 1972 established national goals for clean water. Section 208 of the act has generated an intense and comprehensive planning effort designed to meet two major objectives;: determining effluent limitations needed to meet water quality standards and developing state- and area-wide management plans for pollution abatement.

There are two basic sources of pollution ---point and non point. A point source is an identifiable location from which pollutants are coming. A non point source has no single identifiable source. Non point pollution usually is associated with agriculture and land undergoing the transition from agricultural use to other uses, such as housing developments and roads.

Sediment

Soil washed from its source and deposited where it is not wanted is called sediment. In terms of quantity, sediment is the principal pollutant of surface waters.

You have observed this type of pollution in muddy streams, rivers, lakes, reservoirs, and harbors. You have learned of the tremendous costs of dredging sediment from lakes and harbors and removing it from reservoirs and other places; you know sediment can seriously harm or kill fish, plants, and other aquatic life; you have discovered that sediment adds greatly to the cost of cleaning water for use by cities, industries, and businesses; and you have learned how sediment in streams and rivers can increase the frequency of floods. You also have learned that the source of sediment is eroding land in towns or cities and on farms or ranches.

It is estimated that about half of the soil that erodes each year in the U.S. reaches our rivers, streams, and lakes. About one billion tons of soil is delivered to the oceans by rivers. The Mississippi River alone dumps more than 400 million tons of sediment into the Gulf of Mexico during an

average year, and another 1/3 billion tons is trapped by reservoirs.

Much of the sediment in surface waters comes from erosion on poorly managed rural lands, but a good deal comes from unprotected areas in or near cities. For example, annual sediment yields from land under cultivation in a portion of the Anacostia River, a tributary to the Potomac River near Washington, D.C., ranged from 416 to 2,750 tons per square mile, compared to estimated yields from forest and grassland of from 19 to 138 tons per square mile. The highest sediment yields in this watershed were from urban construction sites, ranging from 4,500 to 64,000 tons per square mile. Yields from undisturbed urban lands were much lower --- about 2,400 tons per square mile --- most of which came from stream-channel erosion.

The solution to water pollution by sediment is control of erosion, which means practicing good soil and water conservation throughout the watershed, from the first tiny trickle of water at the head of the stream to the river's end at the ocean. In other sections, specific measures for controlling erosion are discussed. You can help in solving the problem of sediment pollution of water by applying conservation practices so that your own yard, school grounds, Scout camp, and other places do not erode and add to the silt load of streams.

Plant Nutrients

The main plant nutrients that cause pollution problems (because relatively large amounts of the nutrients get into surface waters) are nitrogen, phosphorus, and potassium. At present, probably the most damaging to water resources is phosphorus, which comes from city sewage, detergents in waste water, runoff from land where much phosphorus fertilizer has been applied to grow crops, and natural sources.

Whatever the source, phosphorus often causes a great increase in the rate of growth and the quantity of algae in ponds, lakes, and rivers. The masses of algae that sometimes grow in a body of water are known as algal blooms. The growth of these plants in enormous quantities crowds out other aquatic life, and as decomposing organisms go to work on dead algae, so much oxygen is used from the water that little else can live, and the pond, reservoir, or river becomes a stinking mass of rotting algae. Lake Erie is a well-known example of the damage done to water by algal

blooms. Like all plants, algae must have certain nutrients. In most waters, the main factor that limits their growth is a lack of phosphorus, so that when additional amounts of it become available, the blooms grow rapidly.

The solution to plant nutrient pollution of water is effective treatment of sewage --- which contains much phosphorus from detergents --- and proper use of soil conservation practices to reduce runoff and delivery of sediment to streams from fertilized fields and from livestock-feeding operations.

Infectious Agents

Microorganisms and bacteria known as pathogens are especially significant pollutants of water because they cause disease. Before scientist learned how diseases were carried from place to place, many people and animals got sick as a result of swimming in or drinking water polluted by disease-causing organisms. Among the serious disease people might get from drinking polluted water are cholera, typhoid, dysentery, hepatitis, leptospirosis, and amebiasis. Several of these also affect animals.

Human wastes and animal wastes, including those from birds and other wild creatures, are the source of pathogens that get into water. Runoff can carry pathogens as it flows over the land to a stream. Some disease-causing organisms can remain alive in the soil for a long time and can move through the soil to underground supplies for shallow wells. Periodic tests should be made of all water for human use to make sure it is free of pathogens. Have you noticed that the water in your city swimming pool is treated with chlorine? This is done to kill disease-causing organisms. The effluent from sewage treatment plants also may be treated with chlorine to kill pathogens, and most cities treat their water supplies with chlorine before piping it to homes and businesses.

Another way pathogens in water can be killed is by heat. Generally, water must boil 20 minutes to kill pathogens effectively.

Organic Chemicals

These include a wide variety of materials that pollute water, such as pesticides and herbicides used to get rid of undesirable animals and plants; synthetic detergents; and petroleum derivatives. Many of these

products are new and create difficult problems.

Pesticides, herbicides, insecticides, fungicides, and other chemicals get into the water by being washed off the land. They usually move with soil particles carried by runoff --- another important reason for controlling erosion and runoff. Accidents or careless discharges of some materials have resulted in oil or deadly poisons getting into water and causing great damage to fish and wildlife along seashores, on inland lakes, and in streams and rivers. Because some chemical pollutants such as pesticides are stored in animal fat, some pollutants can undergo what is called biological magnification. This means simply that the lowest link in a food chain might contain only a very small amount of the pesticide, but each successive link will contain higher concentrations as animals, birds, or fish eat the things that have the chemicals in them.

It is vital that everything possible be done to keep organic chemical pollutants out of streams, rivers, and lakes through very careful use of the proper chemicals for a specific purpose, and by devising ways of preventing "accidents" through which the chemicals get into water. These new types of pollutants have led to many experiments with waste-water treatment to find means of removing them. Some industrial plants are setting up new waste-disposal and -treatment facilities that will take all chemical pollutants out of waste water.

Sewage and Organic Wastes

Sewage and organic wastes are highly significant pollutants because of the large amounts of them in the environment and the close connection between them and other categories of pollutants. In addition to the wastes that are carried by water from homes, great quantities of organic wastes result from food-processing operations and some industrial operations. Such wastes contain disease germs and large amounts of plant nutrients. Untreated or inadequately treated sewage and organic wastes often cause a stream to have a bad odor; they help upset the natural biological balance of a river or lake.

Under conditions of natural biological balance in a river or lake, aquatic plants fish, insects, and billions of different kinds of microorganisms work in harmony to maintain a cycle of life that helps keep the water clean. The green plants add to the oxygen in the water and a certain amount of oxygen is picked up by the water from the air. A turbulent

stream will pick up more oxygen from the air than a smooth-flowing, quiet one. Oxygen is vital to most life in water. Fish need it to live, and it is required in the decomposition of the natural wastes of the river such as dead plants, fish, and other organic matter.

We call the amount of oxygen required to decompose the organic matter present in water biochemical oxygen demand, or BOD. Sewage and organic matter added to water reduce its quality largely through their high BOD. A stream, river, or lake can handle a small amount of these pollutants; natural processes break them down over time and the water remains clean.

Decomposition of wastes and sewage requires great amounts of oxygen, and a stream can quickly become overloaded with wastes or short on oxygen because decomposition organisms (that also require oxygen to break down organic matter) multiply rapidly when there are large amounts of material for them to live on. Depending on temperature and other factors, fish and other forms of aquatic life will have enough oxygen when ten to twelve parts per million of dissolved oxygen is in the water. When the dissolved oxygen content drops below 3 to 5 parts per million for a long period, fish suffocate and the whole association of plants and animals in the river or lake usually changes.

When the number of people increased and they came to live in towns and to use water for industries, the amount of wastes dumped into rivers and lakes was far larger than the water could take care of by natural processes. The sewage and wastes polluted water so badly and upset the natural biological balance to such a degree that some streams became little more than open sewers. Fish could no longer live in them and people downstream had a difficult time cleaning up the water so they could use it. Today, some communities still dump raw sewage into streams and lakes.

Salts and Mineral Substances

Salts and mineral substances are troublesome pollutants in many places in the U.S. As water moves through the soil and over the land, especially in dry parts of the country, it picks up natural salts and minerals. Drainage from acid-mine waste is an example of this type of pollutant.

Salt in water is a major irrigation problem in the Southwest. Drainage

from irrigated lands can contain 25 tons of salt per acre-foot of water. Improved management of water used for irrigation can help ease this problem.

The runoff from acid-mine waste has caused severe damage to some streams and rivers. Coal and other minerals are frequently mined by using huge machines to strip away layers of soil and rock so that the minerals can be scooped up and hauled away. This is called strip mining. The waste materials from this type of mining contain chemicals such as sulfur, which, when combined with water from rain or snow, form strong acids. If enough of this acid water gets into a creek or river, no aquatic plants or animals can survive. The Surface Mining Control and Reclamation Act of 1977 regulates acid-mine wastes. It takes a little more time and money to use improved methods of strip mining, but with these methods the mined land can be made useful for other purposes, and pollution of streams by minerals and acid can be controlled.

Radioactive Substances

These are among the newest of water pollutants. It is the radiation from these substances and the process of their selective biological uptake that makes these pollutants dangerous to humans and other forms of life. The radioactivity of a substance decreases in time, and since we have no effective means of speeding up the rate of decay, holding or putting radioactive wastes in a safe place until they are no longer dangerous is the only waste-treatment method. As the number of plants producing power from nuclear energy increases and as the need for radioactive materials grows, disposal of these toxic radioactive wastes will become an even greater problem.

Liquid nuclear wastes range from low to high levels of radioactivity. Treatment of radioactive wastes can involve evaporating the water from them and fixing the solid wastes in clay, ceramics, or cement, which can then be buried deep in the earth or possibly the ocean.

Thermal Pollution

Raising the temperature of water so that it is damaged for other uses is a growing problem in the U.S. Many aquatic plants and animals cannot survive for long in lakes and streams where the water temperature is much higher than normal. Rainbow trout, for example, do not flourish when the water temperature exceeds 70 degrees Fahrenheit, although they

can survive water temperatures as high as 87 degrees Fahrenheit for short periods.

When large amounts of water are used for cooling purposes in industrial processes, air conditioning, producing electric power, and other ways, the temperature of a stream can be raised to the point where even plants cannot live. Even raising the water temperature a few degrees can make a big difference in the types of plants and animals that can grow in a stream, river, or lake.

To help reduce thermal pollution in surface waters, some industries are using cooling towers and other means of reducing the temperature of water so that it can be reused for cooling purposes. Many new industrial plants now have systems for recirculating water; this enables them to make use of water several times for different purposes. By installing facilities for cleaning up and using water over and over again, one chemical plant reduced its daily requirements for water from 130 million gallons to 4 million gallons --- and still cut down its costs for water.

While learning about the different kinds of pollutants that can get into water, you have probably noticed that each one is related to the use people make of water resources, and in many cases, the use they make of soil resources, too. You have probably decided that the problems of water pollution and its control are very complex. This is true. It is going to take much planning and hard work by many people to find ways to clean up dirty water, to control pollution, and to make wise decisions concerning water use. This means that if we are to have a prosperous and healthful country, we must all work together to see to it that our water and land are not damaged by the uses made of them. Action to manage water and wastes needs to make sense in terms of large natural land and water units, watersheds and river basins. Understanding the problems of water use and some of the processes of water treatment is important, for unless people understand the vital need for water-pollution control, they will not be willing to pay for it.

Sewage Treatment

Because we want to continue to use water to move sewage and organic wastes and still have relatively clean streams, rivers, and lakes, we must do something to our huge quantities of sewage and wastes so they will not pollute streams. This is the purpose of sewage-treatment plants. Cities

and towns usually construct and operate their own central sewage-treatment plants. IN addition to receiving the sewage from homes, hospitals, garages, hotels, and other businesses, the plants often also serve some industries. however, numerous industrial plants maintain their own facilities for treatment sewage before letting the water they've used get back into the environment.

Although new plants an additions to existing plants are being constructed, cities and towns generally are not building sewage-treatment plants fast enough to keep up with the need for them. Many cities and towns use sewage-treatment plants designed and built years ago, and these are overloaded as the cities and towns grow in size and people use more water. In many places, storm drains built to handle the runoff from city streets flow into the sewer system; when there is much rain, the great amount of runoff cannot be taken care of by the sewage-treatment plant, so some flows directly into a river or lake, carrying raw sewage along with it. ideally, storm-drainage systems and sewer systems should be completely separate, but this an expensive type of operation.

After sewage is collected in public sewers and brought to a central point, it might receive primary treatment or primary and secondary treatment. In a few instances, it might also receive tertiary treatment. There are general terms to describe the degree to which waste water is cleaned before it is put into a river or lake or used again. Each type of treatment is accomplished by different specific methods. The type of treatment used depends largely on the strength and quantity of the sewage in relation to the nature and volume of the water (river, stream, lake, reservoir) into which the treated waste water is discharged. Since not all sewage-treatment plants are alike, you might see different methods of treatment than those mentioned here if you visit the treatment plant in your community.

Primary Treatment

Primary treatment mainly involves removal of the solids from waste water. This type of treatment is the only kind many towns use; but there are different methods of accomplishing it. The first step in primary treatment is usually some type of screen to trap sticks, rags, and other large objects. Or, all the sewage might pass through a grinder that chops these large objects. In the next step, the sewage moves slowly through a grit chamber where stones, sand, and other heavy inorganic materials sink to the

bottom and then are removed from the chamber. Next, the waste water -- - also called effluent --- goes to a settling tank; it stays there long enough for organic matter and fine particles of other material to settle so that they can be collected, and to allow scum and grease to float to the surface, where they are skimmed off. Certain chemicals can be added to the settling tank to cause the fine particles to cling together and settle out faster.

In primary treatment, the effluent from the settling tank is discharged into a river or stream or allowed to soak into the land. Sometimes, as the effluent flows out of the settling tank, it is treated with chlorine to kill bacteria.

the collected solids --- called sludge --- from the bottom of the settling tank then go to a sludge chamber or digester where decomposing bacteria go to work on them. The digested sludge then goes to a drying bed. After it is dry, it can be burned or buried, or it can be put on land as solid conditioner --- fertilizer.

Secondary Treatment

Often, the effluent resulting from primary treatment is not clean enough, so secondary treatment must be practiced. In secondary treatment, the waste water goes through one of two processes for further organic decomposition of wastes. Both processes depend upon biological action and both require oxygen. The oxygen is supplied by spraying the effluent into the air or by pumping air into it (aeration).

In one of the processes, the effluent goes from primary settling tank to a trickling filter in which it passes slowly over stones or other material where biological growths decompose the waste still in the effluent. The purpose of the stones and other material in the trickling filter is not to filter out the solids but to provide as much surface area as possible where there is oxygen so that biological growths can live and do their work. In the other basic secondary process, effluent from primary settling tank goes into a sludge tank where activated sludge --- material that has various biological growths in it --- completes the process of decomposing organic materials. While the effluent remains in the sludge tank, it is continuously aerated.

The effluent from either the trickling filter or the activated sludge tank

then goes to a secondary settling tank to allow more waste materials to settle out. These materials go with the sludge from the primary settling tank to a sludge chamber or digester. As it flows from the secondary settling tank, the effluent is treatment with chlorine before being released into a stream, river, or lake, or being allowed to soak into the earth.

Tertiary Treatment

Even secondary treatment doesn't get waste water clean enough in some situations. Tertiary treatment is used after the waste water goes through primary and secondary treatment. After tertiary treatment, the waste water is actually clean enough to be run through a city's water-treatment process for water to be used in homes.

Very little waste water now receives tertiary treatment, and there is no typical tertiary treatment plant. The process used depends upon the specific need for further treatment of the effluent after it has received secondary treatment. Tertiary treatment consists of slow or rapid filtering of the effluent through sand to remove dissolved solids. This treatment could be aeration to foam out detergents. it could be the use of chemical precipitation to settle the solids. or, it could be superchlorination followed by dechlorination to ensure killing of harmful bacteria and disease-bearing organisms.

One important thing to remember is that waste water properly treated is no longer water wasted. it is good water and can be used again. Another important fact is that treatment of waste water helps prevent the great damage that sewage and organic wastes do when they get into streams, rivers, and lakes. As you traced the different methods of treating waste water, you might have observed that all sewage treatment is similar to nature's endless chemical and physical water-purifying processes. But, nature nature's processes take a long time, and they simply cannot take care of the huge amounts of waste people want to get rid of each day. Primary, secondary, and tertiary waste-water treatment does the same thing nature does, only faster and under controlled conditions. Why don't all cities and industries treat their waste water so they can use it again? It is primarily a matter of high costs.

HOW YOU CAN HELP

If you need help in getting started on a project, don't hesitate to ask

experts --- soil conservationist, foresters, fish and game managers, soil conservation district supervisors, teachers, park commissioners, county agricultural agents, city and regional planners, highway supervisors, or anyone else who works with natural resources and can help you with the planning.

The conservation task you select need not be a big one. Select a project that will give you a chance to apply some of the basic conservation ideas you have learned in working on this badge.

Plan First

Organize your thinking and indicate major details:

- A description of the project area
- The problem that needs attention
- An outline of steps to be taken and the necessary tools and material needed
- A sketch map showing how you propose to lay out the job
- Notes on any follow-up or maintenance requirements

Be realistic about what you can and cannot do. It is better to choose a small project that can be completed successfully than to get hopelessly involved in a large one that never gets started. For instance, you will ask yourself, What factors of slope, climate, and soils need to be dealt with? What will be the appropriate grasses, shrubs, trees, or vines to plant for the purposes you have in mind? Will the project harmonize with the soil and water needs of the surrounding area? What's the best timing for doing the work? What care is needed to keep the project in useful condition after completion?

You will also want to be sure your plan includes normal safety precautions for using tools, handling plant materials, and conducting yourself on hazardous terrain or in the vicinity of ponds and streams.

Protect a Stream Bank

Aim: Repair and protect embankments subject to flooding and erosion to reduce sedimentation and improve conditions for fish and stream-side wildlife.

Choose an area needing attention along a small brook or creek.

Protection for the banks of rivers is best left to engineers and other professionals. If the bank is steep and undercut, use hand tools to reslope it to a uniform, gentler grade. Secure suitable plant materials or seeds.

Several kinds of grass may be used for bank stabilization.

Plant Trees and Shrubs

Aim: Help hold the soil in place, provide shade, produce timber, provide shelter and food for wildlife, and beautify an area.

Control Trail Erosion

Aim: Protect footpaths in camp areas, hiking and nature trails, and primitive roads from damage due to erosion and from earth slides caused by heavy rains and melting snow.

Be careful not to remove the natural cover of vegetation near the side of the trail. You may use a water bar. Use wood chips.

Mulch Your Soil

Aim: Hold surface soil in place until newly seeded plants become established and shelter otherwise bare soil from water-erosion damage.

Planting Grasses and Other Ground Cover

Aim: Keep soil covered and hold it in place to control water and wind erosion and reduce flooding and siltation and beautify an area.

Build a Grass Waterway

Aim: Dispose of excess runoff safely, prevent soil loss and other water damage, and help keep sediment out of water.

Conservation Inventory

Aim: Discover conservation needs in a selected area within your community and direct the attention of people to them so conservation practices can be applied.

- Are the banks of rivers or smaller streams eroding?
- Can you see evidences of flooding? When did the last flood occur?
- What flood-control measures or devices does your community have? Where does your community or town get its water?
- What kind of treatment is being given sewage by your town?
- Are there little ditches along the sidewalks where grass once grew?
- What is the condition of slopes along highways?
- Did you see any litter baskets or barrels? Were they being used?
- Does your community have any shade trees? Are they healthy? who takes care of them?
- How many different kinds of birds and other wildlife live at various

- locations in your neighborhood? Why do they live there?
- What is happening to vacant lots?
 - Did you see any junkyards?
 - Does your school have a conservation project?

CONSERVING ENERGY

Agribusiness in America's largest consumer of petroleum products, using about 17 percent of the nation's supply. In the production of food and fiber, liquid fuel is used for tilling, harvesting, and other farming operations including the production and feeding of livestock. Crop drying uses liquefied petroleum gas (LPG), natural gas, and fuel oil. Petroleum energy also is used for irrigation, frost protection, and greenhouse culture.

Agricultural supplies such as fertilizers, herbicides, insecticides, and other chemicals use great amounts of energy for their manufacture. Other segments of the entire agribusiness industry, including transportation, processing, manufacturing, and packaging, consume vast amounts of energy. But the nation's 2.5 million farms and ranches consume only a small percentage of the total energy annually used in the country.

While soil and water conservation practices are not the only answers to reducing energy consumption, they do offer agriculturists the opportunity to reduce energy usage while maintaining the productive levels necessary to meet the food and fiber needs of this nation and millions of people around the world. Energy-intensive agriculture in the U.S. is so efficient that one farmer produces food and fiber of nearly sixty other persons.

The best potential for reducing fuel requirements in agriculture is the use of minimum or conservation tillage. Conservation tillage eliminates the use of the plow since the farmer plants directly into the residue of previous crops. This reduces the number of trips across the field preparing the land, planting, and cultivating, and saves time, labor and energy.

Studies have shown that conservation tillage cuts fuel costs 54 percent. Conservation tillage saves energy and provides excellent protection of the soil, since roughly tilled land with large amounts of residue is effective in controlling erosion and conserving moisture. Conservation tillage makes

use of crop residues to improve the soil structure, maintain organic matter, and provide good working conditions for soil bacteria. A growing number of farmers are using it.

The second greatest potential for energy savings in agriculture lies in improving efficiency of irrigation by trying to reduce the amount of water pumped per acre. Currently, 13 percent of all energy used in farm production is for pumping irrigation water. Better water-management practices could raise irrigation efficiency by as much as 10 percent with no additional cost to the farmer. Water application in the correct amounts and at the proper time would result in a savings of 75 to 80 million gallons of fuel annually.

Water, dripping slowly and directly at the base of individual plants, is the idea behind drip irrigation. Through a series of main and lateral lines that run parallel to rows of crops, water is piped from a central source to drip at a rate of 1 to 4 gallons per hour directly to the roots of individual plants. It's not for every crop or every farmer, but drip irrigation can provide great savings in energy and water. An estimated annual savings of 231.2 million gallons of fuel and 55.8 million acre-feet of water could be achieved by using this new irrigation method.

Other conservation practices that could reduce agriculture's consumption of energy include pasture management, increasing the use of animal waste as fertilizers, parallel terraces, and windbreaks. The total annual estimated energy savings for all these conservation practices would amount to more than 2 billion gallons of fuel each year by the year 2000.

Responding to the national need to become more self-sufficient in energy, agriculture research has been expanding in the area of alternate energy sources. Work is underway on the use of biomass or organic materials produced by plants and animals. Biomass is renewable and low in sulfur, which presents no problem with air pollution regulations. The residues of biomass benefit the land when returned to it. Although these positive factors make biomass seem attractive, there are disadvantages to its use. These are the cost of collecting and transporting the material, and the increase in soil erosion when material is removed from the land. In the future, though, use of biomass could make a major contribution to energy savings in rural communities and on farms. Solar and wind energy is also receiving great attention from agriculture researchers. Power derived

from the sun offers prospects of significantly reducing the amount of fossil fuel needed by agriculture for many tasks, including food processing, grain drying, crop drying, heating of livestock shelters, and heating and cooling of greenhouses. Other applications for both solar and wind energy include operation of irrigation pumps, supplemental energy for rural homes, and providing power to pump water.

The development of alternate sources of energy will increase in the next few years. As it does, new applications for solar, wind, and biomass will be discovered. Just as important, as new uses for these energy sources are found, costs for manufacturing and installing collection, storage, and delivery will be reduced, making the use of alternate sources of energy more attractive to farmers.