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Texas A&M AgriLife Extension

What is the Fate of Your Rainfall?

Leader Guide

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What is the Fate of Your Rainfall?

The *What is the Fate of Your Rainfall?* program was designed to teach Texans about how their actions affect the path of water in the water cycle and the quality of that water once it leaves their property. The aim of the program is to help participants understand the hydrological process so they can adopt best-management practices that enhance and protect water resources.

Specifically, the program teaches:

- The movement of water through the water cycle
- The concept of a watershed
- The effects of land cover and management on the path of rainwater
- Practical implementation methods of rainwater harvesting for water storage in the soil, groundwater, and surface reservoirs
- The effect of increased impervious areas on water movement in the watershed
- Water and land management options to limit runoff and promote infiltration

The curriculum also aims to educate people about water resources management so they can make informed decisions about/future water quality, supply, and demand issues.

The *What is the Fate of Your Rainfall?* rainfall simulator, flip chart, and curriculum guide were created to demonstrate water movement through the water cycle. The activity can be part of a broader water-education program that includes *Current Events: How Streams and Rivers Flow*, a companion program that uses a stream trailer to teach about water movement through a watershed.

Using the rainfall simulator

The rainfall simulator consists of a frame that holds landscape trays, rain trays, and water collection containers. The landscape trays represent various landscapes in watersheds; the rain trays simulate rainfall on the landscape bins; and the water collection containers collect surface runoff and percolated groundwater, demonstrating the interaction between surface and groundwater.

To check out a rainfall simulator, contact the local county agent of the Texas A&M AgriLife Extension Service. The simulator will fit in the bed of a truck or in a large sport utility vehicle. The Extension agent can advise you on the size of vehicle needed for hauling.

Safety tips

Because the rainfall simulator is heavy, at least two people should load and unload it.

When using the simulator, make sure that no electrical cords or electronic devices are under or around it. Water often runs over or leaks from the demonstration, which could result in electrocution.

Have towels or a dry mop on hand to clean up any spilled water. Wet, slippery floors can cause falls.

When hauling the rainfall simulator, put the rain trays, catch containers, and buckets inside the vehicle or tie them down appropriately. They are very lightweight and can fly out of the back of a vehicle, endangering others on the road.

The amounts of water in the catch containers simulate rainfall runoff from various types of landscapes.

Initial setup

The landscape trays may be changed or altered to demonstrate specific types of landscapes. The lesson uses managed rangeland, over-grazed rangeland with bare soil exposed, turf-grass, and an impervious surface. Other landscape settings that could be used include a mulched shrub area or a rain garden.

The managed rangeland landscape tray.

Managed rangeland landscape tray

1. Add a 1-inch-deep layer of coarse gravel, with the gravel pieces ¼ to ¾ inch in diameter, to the tray. The layer of gravel allows for better drainage, water flow, and plant health.

2. Plant two or three grass plants such as little bluestem, sideoats grama, or Texas wintergrass. The plants should be between a softball and a volleyball in size. A wild onion or forb (broadleaf plant) may also be added to show diversity.

3. Place the plants at the desired level in the tray. You may need to remove soil from the bottom of the roots to get the plant deep enough in the tray.

4. Add enough potting soil or local soil containing organic matter to fill the tray.

5. Spread dead, decaying grass and leaves on the soil surface.

Overgrazed landscape tray

1. This landscape should represent a local site such as a horse lot, trap, or heavily overgrazed area. It simulates a site in which the soil has no organic matter and has been compacted by animal hoofs.

The overgrazed landscape tray.

2. Add a 1-inch-deep layer of coarse gravel to the tray. The layer of gravel allows for better drainage, water flow, and plant health.

3. Add soil that contains no roots or organic matter.

4. Plant one or two small, early-successional (shallow-rooted, quick maturing) grasses such as Texas grama, red grama, hairy grama, or threeawn.

5. Add a rock on top if rocks are common locally.

6. Water the tray thoroughly and pack down the soil and plants to remove air spaces.

The turfgrass landscape.

Turfgrass landscape tray

1. Add a 1-inch-deep layer of coarse gravel to the tray. The layer of gravel allows for better drainage, water flow, and plant health.

2. Fill the tray with soil to where the turf will be even with about 1/3 the way up the front spout.

3. Place a square of St. Augustine, bermudagrass, or other grass in the tray.

4. Fill in soil around the edge of the grass to keep water from running around the sides.

Impervious surface landscape tray

1. Add perlite, wood chips, or another light material to the tray, to a level near the bottom of the top spout.

The impervious surface landscape tray.

2. Cut out a piece of plastic or other material that will shed water, the size of the tray and lay it in.

3. Seal the edges of the tray with silicone to make it watertight.

Mulched plant landscape tray

1. Add a 1-inch-deep layer of coarse gravel to the tray. The layer of gravel allows for better drainage, water flow, and plant health.

2. Add a 1-gallon dwarf yaupon or other similar plant. Remove the soil from the bottom of the plant to bring down its level in the tray.

3. Add potting soil around the plant and wood chips as mulch on top.

The landscape trays are living demonstrations that need to be watered to maintain plant growth and given constant care in order to be used for demonstrations.

Rain garden landscape tray

1. Fill the tray about 1 inch deep with coarse gravel, with the pieces ¼ to ¾ inch in diameter. This allows for better drainage, water flow, and plant health.

2. Add the desired plants. Remove the soil from the bottom of the plants to bring them down to the level needed in the tray.

3. Add potting soil and create a berm (bank) in front of the runoff outlet. Pack the berm slightly. The berm will hold the runoff in the rain garden, helping it infiltrate the soil. The back portion will be dropped about 1 inch and level with the floor to provide a flat bottom to improve water infiltration.

4. Add mulch to the top of the rain garden area.

Care of the landscape tray

When assembled, the landscape trays are living demonstrations and will need constant care to be used for demonstrations. To maintain the landscape trays between uses:

- Water the plants in the trays at least once and preferably twice a week. The trays are shallow and cannot hold enough water to maintain plant growth without frequent watering.
- To reduce evaporation, place the trays that have plants in them in partial shade. This also extends the life of the plants and trays.

When conducting a demonstration, pour about 1 gallon of water in each rain tray to

simulate rainfall. During a continual display, add about a quart of water at a time to have a continual drip from the rain trays.

If the rainfall simulator demonstration will seldom be used, construct landscape trays for each event.

Demonstration checklist

These rainfall simulator components are needed for a successful training activity:

Item	Use
What is the Fate of Your Rainfall? flip chart	Introduces the lesson with learning objectives; shows actual situations being modeled by the rainfall simulator
Rainfall simulator frame	Holds the landscape trays, rain trays, and catch containers
Landscape trays	Hold the plants and demonstrate different land cover situations
Rain trays	Hold and distribute the water over the plant trays
Catch containers	Catch the simulated runoff and groundwater from plant trays
Buckets	Transport and hold the water needed to fill the rain trays
What is the Fate of Your Rainfall? fact sheet	Gives reference information to participants
Evaluation form	Allows participants to report knowledge gained during the training activity
Towels or mop	Dries up excess water spilled from the demonstration

The amounts of water in the catch containers simulate rainfall runoff from various types of landscape.

Rainfall simulator setup procedure

Set up the rainfall simulator on a level surface where the audience can clearly see the demonstration. The surface must be level to allow the water to fall straight down from the rain tray.

The site should have a surface that will not be damaged by water. Water is typically spilled on the ground or floor around the demonstration during the training event.

To assemble the simulator:

1. If indoors, place towels under the demonstration area.
2. Place the rainfall simulator frame where the demonstration will be conducted.
3. Set the rain trays and landscape trays in their places.
4. Place the catch containers under the landscape trays in their proper positions. The catch containers labeled Runoff go under the surface drains; those labeled Groundwater go under the bottom drains.
5. Fill each bucket with about 2 gallons of water.

Rainfall simulator disassembly procedure

After the training activity, disassemble the rainfall simulator:

1. Empty the excess water from the buckets and catch containers.
2. Clean up any spilled water.
3. Remove or tie down the landscape trays, rain trays, and catch containers from the frame for transportation.
4. Dry each component to prevent damage to the vehicles used to transport the demonstration.
5. Return the rainfall simulator to its storage location.

Lesson

Objectives

The participants will understand:

- The movement of water through the water cycle
- The concept of a watershed
- The effects of land cover and management on the path of rainwater
- Practical implementation measures of rainwater harvesting for water storage in the soil, groundwater, and surface reservoirs
- The effect that increased impervious areas have on water movement in the watershed
- Water and land management options that decrease runoff and promote infiltration

Materials

- Rainfall simulator frame
- 4 Landscape trays
- 4 Rain trays
- 8 Catch containers
- 2 Buckets for water
- Towels

Time

- 30 to 45 minutes

Rain trays

Landscape trays and catch containers

Presentation

DO

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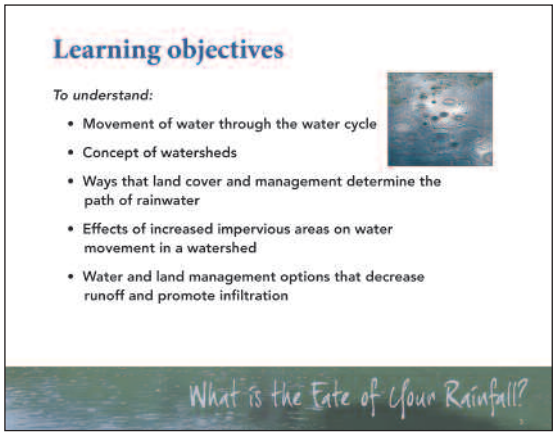

SAY

Today we will discuss how the cover and management of land—both large and small parcels—can affect the fate of rainfall.

We will look at how water moves through the water cycle and learn what a watershed is. We will discuss how the path of rainwater is affected by land cover and management.

Land cover, such as buildings and parking lots, can be impervious to water, or it can be permeable, such as plants, shrubs, and trees.

The lesson will also cover how to harvest rainwater so it can be stored in the soil, in groundwater, and in reservoirs. We'll look at how impervious areas affect the movement of water in a watershed.

And we will discuss some of the ways we can manage water and land to decrease runoff and promote water filtration into the soil.

DO

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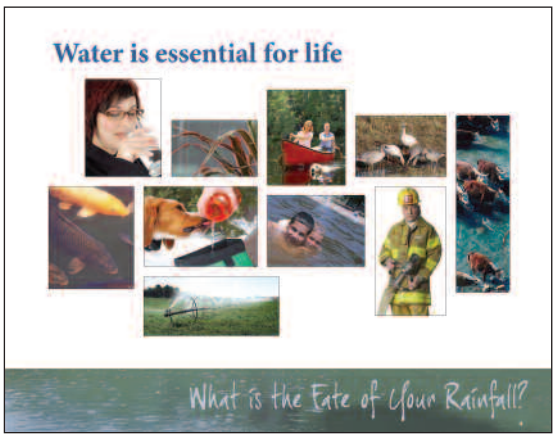

SAY

Water is essential to support life for many reasons. It is used for drinking water, food production, fire safety, and even recreation. How is water a part of your daily activities?

DO

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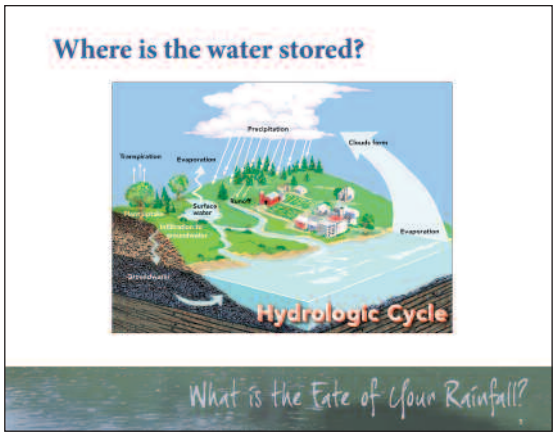

SAY

In the hydrologic cycle, water moves back and forth between the oceans, clouds, soil, groundwater, lakes and rivers, and oceans.

Where does rainfall go after it falls from the sky?

DO

Allow time for the participants to answer.

SAY

Rain falls onto the ground and seeps into the soil, replenishing the moisture levels there.

It may also percolate deeper through the soil to replenish the groundwater stored in aquifers. An aquifer is an underground layer of permeable rock or soil in which the pore spaces are filled with water. Wells are dug into aquifers to get water for human use.

Besides filtering into the ground, rainwater may run off the soil surface to streams, rivers, and lakes.

Plants use soil moisture and release it into the atmosphere as water vapor. The process of a plant's releasing water is called transpiration.

Water also evaporates from both soil and water surfaces. It returns to the atmosphere in a process called evaporation.

The water in the atmosphere forms clouds. Water vapor moves around in the clouds until it falls as rain at another location from where it entered the atmosphere. This completes the hydrologic cycle.

DO

Show flip chart page 6.

SAY

Many factors affect the fate of rainfall. These factors determine whether the water runs off your property or soaks into the soil.

One factor is the type of soil on the property. The type of soil affects how fast that water can filter into the soil and how much water it can hold.

Other factors are the type and amount of cover on the land—whether it is plants or impervious cover such as buildings. This cover helps determine the path that the rainwater takes.

Additional contributing factors are how hard and how long rain falls, how much moisture is in the soil at time of rainfall, and how steep the land is—its slope.

DO

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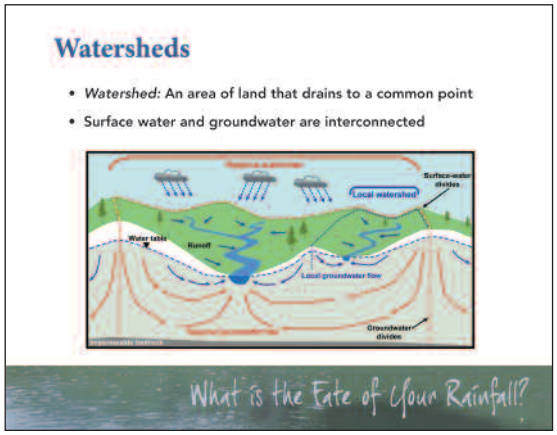

SAY

The slope divides the land into watersheds. A watershed is an area of land that drains to a common point. Everyone lives in a watershed. Actions at every point in the watershed affect the quality and quantity of water leaving the watershed.

Notice how this drawing shows the connections and interactions between surface and groundwater.

The water on the ground surface interacts with the water underground. In upland areas, the surface water filters down into the groundwater. In lower elevations, groundwater can seep upward into streams and rivers.

DO

Show flip chart page 8.

SAY

The goal of sustainable watershed management is to achieve the natural distribution of rainfall among the soil, the groundwater, and surface water. We can reach this natural balance by properly managing the land and the factors that affect it.

DO

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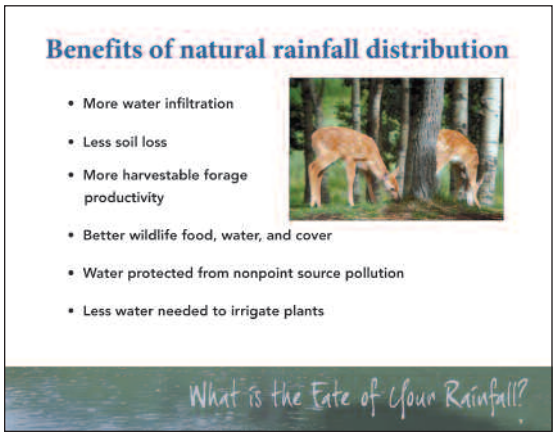

SAY

There are many benefits of maintaining the natural distribution of rainfall:

- More water filters into the soil.
- Less soil is lost to erosion.
- More grass grows that can be harvested and used for livestock.
- Wildlife has more food and water. The animals have more cover, which in this context is a place to hide or rest.
- Less water is polluted.
- Less water is needed to irrigate plants.

Keeping these benefits in mind, let's demonstrate what happens to rainfall on different types of landscapes.

DO

Pour about 1 inch of water into each rain tray.

SAY

We will simulate a 1-inch rainfall on each type of landscape depicted in the trays. Runoff water will flow through the surface drain into the catch container labeled *Runoff*.

The water that moves down into the soil profile will flow through the bottom drain. It will be collected in the catch container labeled *Groundwater*.

Let's allow the rainfall simulator to run while we continue our discussion. Later, we will come back to it.

People can alter the path of rainwater at a home or on a piece of land. What are ways that we can affect the way rain runs off our properties?

DO

Allow time for answers.

SAY

Although some factors cannot be changed, people can affect several other factors, including:

- The condition of the soil (the amount of organic matter in the soil and on the soil surface)
- The amount and type of vegetation growing there
- And the quantity and quality of the runoff water

You affect these factors by the way you manage the land. They are also affected by the amount of impervious surfaces on the land.

How well you manage these factors can make the difference between capturing rainfall in the soil for plant growth or seeing the soil erode.

DO

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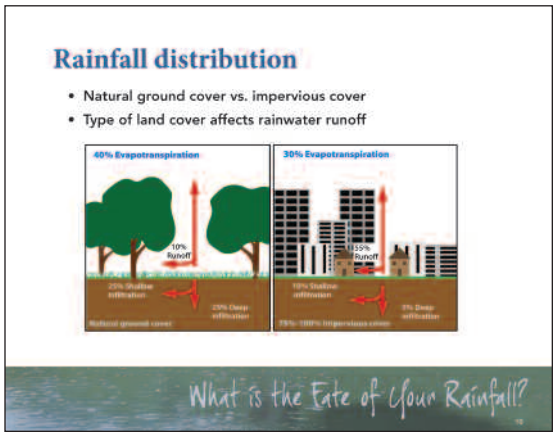

SAY

When land is developed and its uses are changed from crops, pasture, and rangeland, the amount of impervious cover also increases. Rainwater flows differently on natural areas than on developed areas with homes, streets, driveways, parking lots, and commercial buildings. These areas have impervious cover that changes the path of rainwater.

In an urban area or a poorly managed agricultural setting, rainwater that previously could infiltrate the soil leaves the site as runoff. More water runs off from a developed area than from a natural groundcover setting.

DO

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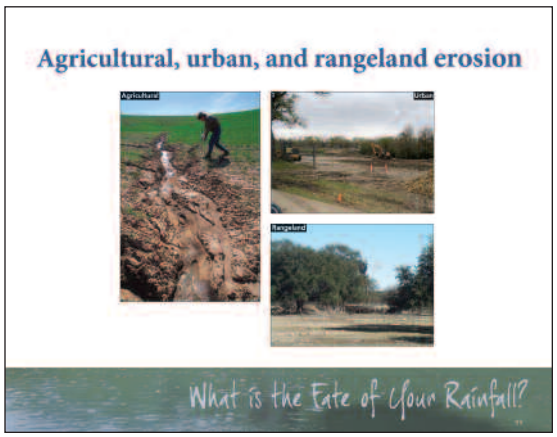

SAY

Vegetation helps filter the water, slow the water movement across the soil, and increase water movement into the soil. If an area has few plants or just bare ground, more water runs off, and water supplies decline.

But on land with more vegetation (such as deep-rooted bunch grasses), the plant roots and organic matter loosen the soil, providing a pathway for the water to seep into the soil. The water that infiltrates the soil profile is then available for helping the plants grow and for recharging, or replenishing, the aquifers below.

We need to help recharge the aquifers because they are major sources of water for both farmers and city dwellers.

DO

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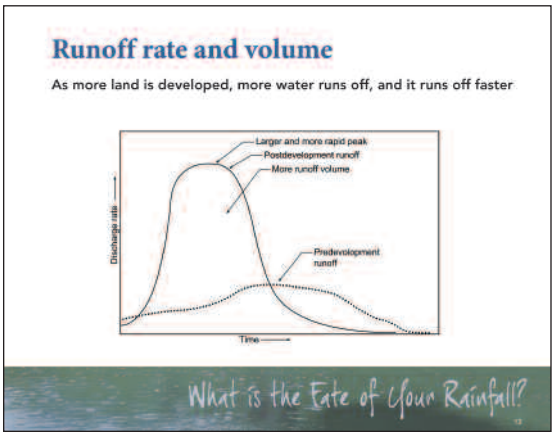

SAY

In areas where the land cover is impervious, large amounts of rainwater run off fast. Areas with just bare ground leave the soil exposed to the erosive forces of wind and water. Improper management can cause these problems in both agricultural and urban areas.

By contrast, areas with natural ground cover have less runoff, and the water that does run off flows much more slowly. Vegetative cover slows down the flow of runoff, decreasing its erosive power. Rainwater first filters into the soil; it does not run off until the soil is saturated or if the rain falls faster than the soil can take it in.

DO

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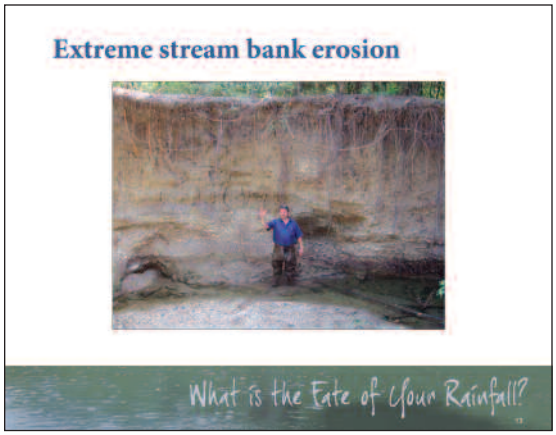

SAY

Another problem caused by large amounts of fast-moving runoff is that stream banks erode more. The energy of the fast-moving water removes the soil from along the beds and banks of streams. After an area is developed, a stream receives more water than before, which can cause extreme stream bank erosion.

Once the soil detaches from the bed and banks, it is carried by the flowing water until the water slows down. Then, the suspended soil particles fall out through a process called deposition. This process removes valuable soil from the upper areas of watersheds and deposits it downstream in lakes, rivers, and bays.

In addition to erosion, the increased runoff contributes to another problem: the transport of pollution downstream. Examples

of contaminants that can be transported are fertilizers, chemicals, bacteria, and oils.

Fertilizers, chemicals, and bacteria are generated from both urban and agricultural lands. Oils and other contaminants are commonly moved by runoff from roads, parking lots, and driveways. All of these contaminants flow with the water and soil to bodies of water downstream.

DO

Show flip chart page 14.

SAY

When too much water is removed or not enough water filters into the soil, the water supplies held in aquifers shrink.

Centuries ago, there were about 10,000 springs flowing in Texas. Today, only 60 percent of those springs still flow. The Texas Water Development Board has created a State Water Plan that estimates the decline of the water levels in the major Texas aquifers.

DO

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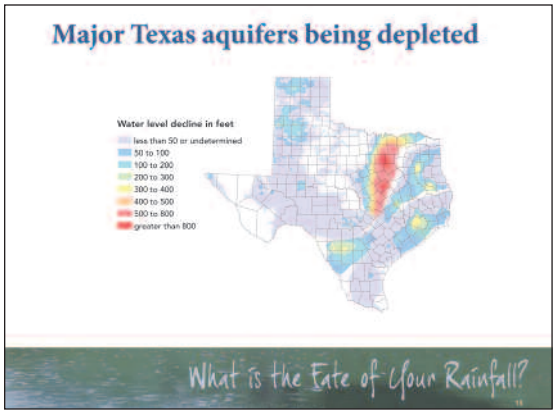

SAY

The colors on this map show estimates of how much the water level has dropped in the major aquifers of Texas from the pre-development times until about the year 2000.

The map shows that the most change has been in north-central Texas, where in some areas the water level has dropped more than 800 feet. However, water tables have dropped in all sections of the state.

DO

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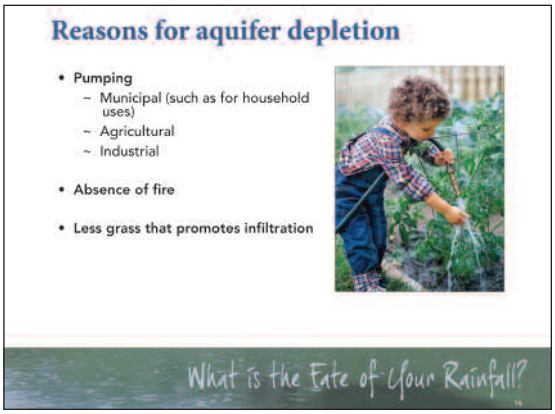

SAY

There are three main reasons for the decreased water in the aquifers that produced these springs. All of the reasons stem from watershed management techniques and practices over time.

The first main reason for the loss is that water has been pumped out of the ground for drinking, industrial, and agricultural purposes. As the population grows, more water from aquifers will be used. As more water wells are drilled and pumped, the water table will continue to drop unless we can increase the recharge and decrease the demand on the water sources.

The second reason is that fire is no longer used to control the growth of woody plants such as shrubs and trees. These plants remove large amounts of water from the soil.

In the year 1520, the Spanish explorer Cabeza de Vaca wrote an account suggesting that Indians in Texas routinely used fire as a management tool. In his diary, he wrote, "The Indians go about with a firebrand, setting fire to the plains and timber so as to chive off the mosquitoes, and also to get the lizard and similar things they eat, to come out of the soil."

This human activity, along with the fires started by lightning, caused the vegetation over vast areas of Texas to be dominated by mid-sized and tall grasses. In the Hill Country, the cedars, which were easily killed by fire, grew only in steep canyons. Live oaks were scattered as just a few large trees that survived the fires or resprouted after burns.

Other woody plants were restricted to areas in the canyons and along streams or in

clusters of sprouts in open grassland. As these woody plants increased, less water moved into the aquifers to supply springs.

The third reason for the loss of springs is the decrease in the amount of native bunch grasses that allow more water to infiltrate the soil. Livestock has heavily grazed the deep-rooted grasses that once dominated in Texas. Those grasses have been replaced by weeds, short grasses, woody plants, and bare ground.

Water filters into the ground best where the soil is covered with deep-rooted grasses such as little bluestem, big bluestem, Indian grass, switchgrass, and sideoats grama. As these plants are replaced, the rainwater more readily moves over the ground surface instead of moving into and through the soil.

Bare soil creates even more problems. Without vegetative cover, the soil can heat up to 30 to 50 degrees hotter than ground that is shaded. The bare ground and elevated temperatures can disrupt life in the soil. This promotes soil erosion during a rain shower.

When vegetative cover is destroyed by drought, fire, or excessive grazing, there is an increase of erosion and sedimentation in lakes and rivers. As more soil erodes, less water infiltrates the soil, which then decreases the number of animals that the land will support.

Let's look at the water levels in the different types of landscapes.

DO

Show the audience the water level in each of the catchment containers.

SAY

Why are the runoff and groundwater levels in the catch containers different for each situation?

DO

Allow time for the audience to answer.

Then point out the managed rangeland landscape tray.

SAY

This landscape tray contains tall bunch grasses. It simulates a well-managed rangeland. The roots of these grasses loosen the soil and provide a pathway for water to enter it.

The bunch grass roots live about 3 years and are constantly dying and being replaced. This process fills the soil with organic material from the dead roots, making the soil more able to accept water.

If more rain falls than the soil can take in, or if the soil becomes saturated, there will be runoff. But less water will run off, and it will flow more slowly. The dense vegetative cover protects the soil surface and slows the flow of runoff.

DO

Point out the overgrazed landscape tray.

SAY

This landscape tray simulates poor-quality or overgrazed pasture. Notice how much water ran off the surface and how little went to groundwater. Without vegetation and organic matter, the soil is easily packed down, making it difficult for water to filter into it.

Instead of entering the soil, the rainfall on overgrazed land runs off quickly, carrying soil with it. The soil surface is not protected, resulting in increased erosion and runoff.

DO

Point out the turfgrass landscape tray.

SAY

This landscape tray simulates turfgrass, such as that growing in someone's yard. It will get both groundwater and runoff water. The runoff rates from this type of landscape will vary, depending on the type of turf grass and the soil condition.

Turfgrass areas usually get more fertilizers and pesticides than any other type of land use. If too much fertilizer is applied, or if it is applied improperly, runoff can transport the chemicals and fertilizers downstream from the lawn. Water is an excellent transportation medium.

You can help prevent this chemical runoff by fertilizing your lawn properly. When you apply chemicals or fertilizers to your lawn, use only what you need, and apply products in accordance with the instructions on the product labels.

Also consider building rain gardens and bog gardens and reducing the amount of turf by adding xeriscaped areas with plants that demand less water and mulched to slow water runoff. Landscape to capture rainfall, and consider rainwater collection to capture runoff from your house's roof and use it to irrigate plants.

DO

Point out the impervious cover landscape tray.

SAY

This tray simulates an area with impervious cover. You see that all the water goes to runoff. None of the water could infiltrate into the soil to groundwater.

The water also ran off immediately. When the amount of impervious cover increases within a watershed, it can contribute to the flooding and increased stream erosion that we discussed earlier.

DO

Show flip chart page 17.

SAY

The solutions to the problems we've discussed today are as multifaceted as the problems themselves. But we can help solve the problems of soil erosion, water pollution, and dwindling water supplies. We can learn to use water and manage our watersheds wisely.

One step is to use less water by:

- Xeriscaping, a landscape technique that minimizes the use of water in landscapes
- Reducing waste and pesticide usage
- Reducing the size of the turf areas in landscapes and increasing natural or "wildscape" areas
- Using rainwater to irrigate landscapes

To start, determine whether your soil, plants, and water resources are being damaged now. Monitor the current conditions on your property, and note whether they change over time. Then make timely management decisions to protect your resources.

We can also protect the areas on residential or rangeland where water naturally filters into the soil. This will enable more water to recharge, or replenish, groundwater supplies.

Another technique is brush-sculpting, which restricts the growth of cedars and other woody plants. This strategy will help wildlife, especially endangered species. Brush-sculpting also increases the amount of forage grasses for livestock. And it helps reduce soil erosion by protecting riparian areas, which are the areas around streams, rivers, and lakes.

Ranchers can also help reduce erosion and increase and improve water supplies. One step

is to prevent overgrazing by reducing the number of livestock in an area, rotating livestock among pastures, and developing a good management plan.

When it comes to forage grasses—those grazed by livestock—a rule of thumb is to "graze half and leave half." Ranchers can also let areas rest for extended periods to allow plants enough time to mature and strengthen their roots.

We all can help decrease the amount of runoff and contaminated water. People in both urban and agricultural areas can adopt effective management practices that can minimize runoff and improve water quality.

We can xeriscape, reduce waste and pesticide usage, and add rain gardens and bog gardens. We can reduce the size of the turf areas in our landscape and increase the amount of natural or "wildscape" areas. And we can capture rainwater to use in our landscapes.

By managing land properly—whether it is a city lot, an agricultural field, or a sprawling ranch—we can protect natural resources and use rainwater for beneficial purposes. The actions we take can have long-lasting effects. For instance, it takes 500 years or more to rebuild 1 inch of soil. Saving that inch of soil can affect people, wildlife, and the environment for generations.

In addition to making changes on our own properties, everyone can teach others to be wise water-users and good stewards of natural resources.

Be a good steward of the land under your care so you can pass it on to the next generation in better shape than when you received it.

References and sources of more information

- *Increasing Bare Ground Indicates Poor Watershed Health*, by K. Brian Hayes, Barron S. Rector, and Larry D. White. Texas A&M AgriLife Extension Service, 2000.
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