



Water Science School

Evapotranspiration and the Water Cycle

Evapotranspiration can be defined as the sum of all forms of evaporation plus transpiration, but here at the Water Science School, we'll be defining it as the sum of evaporation from the land surface plus transpiration from plants.

Note: This section of the Water Science School discusses the Earth's "natural" water cycle without human interference.

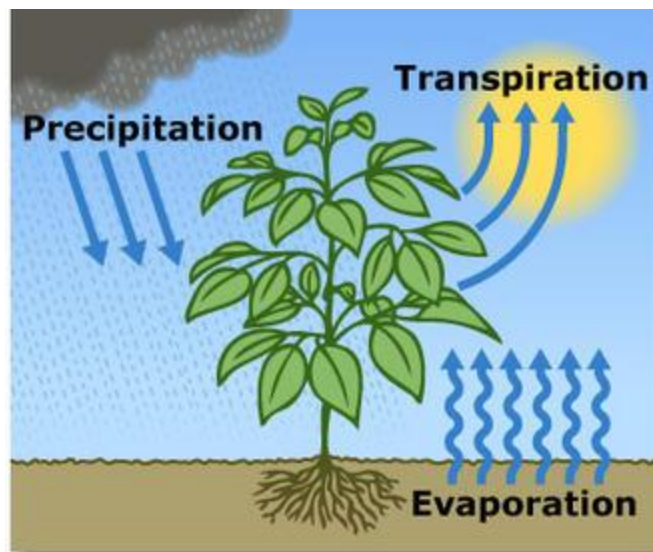
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What is evapotranspiration?

Evapotranspiration is the sum of **evaporation** from the land surface plus transpiration from plants.

If you search for the definition of evapotranspiration, you will find that it varies. In general, evapotranspiration is the sum of evaporation and transpiration. Some definitions include evaporation from **surface-water bodies**, even the **oceans**. But, since we have a Web page just about evaporation, our definition of evapotranspiration will not include evaporation from surface water. Here,



The typical plant, including any found in a landscape, absorbs water from the soil through its roots. That water is then used for metabolic and physiologic

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evapotranspiration is defined as the water lost to the **atmosphere** from the ground surface, evaporation from the capillary fringe of the **groundwater table**, and the transpiration of groundwater by plants whose roots tap the capillary fringe of the groundwater table. The banner at the top of this page offers an even more simple definition.

functions. The water eventually is released to the atmosphere as vapor via the plant's stomata — tiny, closeable, pore-like structures on the surfaces of leaves. Overall, this uptake of water at the roots, transport of water through plant tissues, and release of vapor by leaves is known as transpiration.

Water also evaporates directly into the atmosphere from soil in the vicinity of the plant. Any dew or droplets of water present on stems and leaves of the plant eventually evaporates as well. Scientists refer to the combination of evaporation and transpiration as evapotranspiration, abbreviated ET.

Credit: Salinity Management Organization

The transpiration aspect of evapotranspiration is essentially evaporation of water from plant leaves. Studies have revealed that transpiration accounts for about 10 percent of the moisture in the atmosphere, with oceans, seas, and other bodies of water (**lakes, rivers, streams**) providing nearly 90 percent, and a tiny amount coming from sublimation (ice changing into water vapor without first becoming liquid).

Transpiration: The release of water from plant leaves

Just as you release water vapor when you breathe, plants do, too – although the term "transpire" is more appropriate than "breathe." This picture shows water vapor transpired from plant leaves after a plastic bag has been tied around the stem for about an hour. If the bag had been wrapped around the soil below it, too, then even more water vapor would have been released, as water also evaporates from the soil.

Plants put down roots into the soil to draw water and nutrients up into the stems and leaves. Some of this water is returned to the air by transpiration. Transpiration rates vary widely depending on weather conditions, such as temperature, humidity, sunlight availability and intensity, precipitation, soil type and saturation, wind, and land slope. During dry periods, transpiration can contribute to the loss of moisture in the upper soil zone, which can have an effect on vegetation and food-crop fields.

How much water do plants transpire?

Plant transpiration is pretty much an invisible process. Since the water is evaporating from the leaf surfaces, you don't just go out and see the leaves "breathing". Just because you can't see



After a plastic bag is wrapped around part of a plant, the inside of the bag becomes misty with transpired water vapor.

Credit: Ming Kei College

40,000 gallons (151,000 liters) per year.

the water doesn't mean it is not being put into the air, though. One way to visualize transpiration is to put a plastic bag around some plant leaves. As this picture shows, transpired water will condense on the inside of the bag. During a growing season, a leaf will transpire many times more water than its own weight. An acre of corn gives off about 3,000-4,000 gallons (11,400-15,100 liters) of water each day, and a large oak tree can transpire

Atmospheric factors affecting transpiration

The amount of water that plants transpire varies greatly geographically and over time. There are a number of factors that determine transpiration rates:

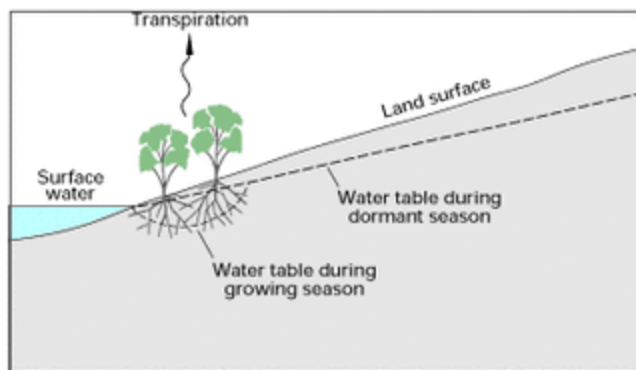
- **Temperature:** Transpiration rates go up as the temperature goes up, especially during the growing season, when the air is warmer due to stronger sunlight and warmer air masses. Higher temperatures cause the plant cells which control the openings (stoma) where water is released to the atmosphere to open, whereas colder temperatures cause the openings to close.
- **Relative humidity:** As the relative humidity of the air surrounding the plant rises the transpiration rate falls. It is easier for water to evaporate into dryer air than into more saturated air.
- **Wind and air movement:** Increased movement of the air around a plant will result in a higher transpiration rate. Wind will move the air around, with the result that the more saturated air close to the leaf is replaced by drier air.
- **Soil-moisture availability:** When moisture is lacking, plants can begin to senesce (premature aging, which can result in leaf loss) and transpire less water.
- **Type of plant:** Plants transpire water at different rates. Some plants which grow in arid regions, such as cacti and succulents, conserve precious water by transpiring less water than other plants.

Transpiration and groundwater

In many places, the top layer of the soil where plant roots are located is above the water table and thus is often wet to some extent, but is not totally saturated, as is soil below the water table. The soil above the water table gets wet when it rains as

water **infiltrates** into it from the surface, But, it

will dry out without additional precipitation. Since the water table is usually below the depth of the plant roots, the plants are dependent on water supplied by **precipitation**. As this diagram shows, in places where the water table is near the land surface, such as next to lakes and oceans, plant roots can penetrate into the saturated zone below the water table, allowing the plants to transpire water directly from the groundwater system. Here, transpiration of groundwater commonly results in a drawdown of the water table much like the effect of a pumped **well** (cone of depression—the dotted line surrounding the plant roots in the diagram).



Sources and more information

- [Evapotranspiration and Droughts](#), USGS, U.S. Global Change Research Program
- [The Water Cycle](#), NASA Earth Observatory

More topics and other components of the water cycle:



Date published: JULY 10, 2019

Status: Active

The Fundamentals of the Water Cycle

Earth's water is always in movement, and the natural water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Water is always changing states between liquid,

vapor, and ice, with these processes happening in the blink of an eye and over millions of years.

Contacts: [Ask USGS](#)



Date published: NOVEMBER 6, 2019

Status: Completed

The Water Cycle for Adults and Advanced Students

Earth's water is always in movement, and the natural water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Water is always changing states between liquid, vapor, and ice, with these processes happening in the blink of an eye and over millions of years.

Note: This section of the Water Science School...

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Date published: SEPTEMBER 8, 2019

Status: Completed

Precipitation and the Water Cycle

The air is full of water, even if you can't see it. Higher in the sky where it is colder than at the land surface, invisible water vapor condenses into tiny liquid water droplets—clouds. When the cloud droplets combine to form heavier cloud drops which can no longer "float" in the surrounding air, it can start to rain, snow, and hail... all forms of precipitation, the superhighway moving water...

Contacts: [Ask USGS](#)



Date published: JULY 16, 2019

Status: Completed

A Comprehensive Study of the Natural Water Cycle

Earth's water is always in movement, and the natural water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Water is always changing states between liquid, vapor, and ice, with these processes happening in the blink of an eye and over millions of years.

Note: This section of the Water Science School...

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Date published: JUNE 12, 2019

Status: Completed

Streamflow and the Water Cycle



What is streamflow? How do streams get their water? To learn about streamflow and its role in the water cycle, continue reading.

Note: This section of the Water Science School discusses the Earth's "natural" water cycle without human interference.

Contacts: [Ask USGS](#)



Date published: JUNE 12, 2019

Status: Completed

Snowmelt Runoff and the Water Cycle

Perhaps you've never seen snow. Or, perhaps you built a snowman this very afternoon and perhaps you saw your snowman begin to melt. Regardless of your experience with snow and associated snowmelt, runoff from snowmelt is a major component of the global movement of water, possibly even if you live where it never snows.

Note: This section of the Water Science School discusses the...

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Date published: JUNE 8, 2019

Status: Completed

Evaporation and the Water Cycle

For the water cycle to work, water has to get from the Earth's surface back up into the skies so it can rain back down and ruin your parade or water your crops or yard. It is the invisible process of evaporation that changes liquid and frozen water into water-vapor gas, which then floats up into the skies to become clouds.

Note: This section of the Water Science School discusses the...

Contacts: [Ask USGS](#)



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The Atmosphere and the Water Cycle

The atmosphere is the superhighway in the sky that moves water everywhere over the Earth. Water at the Earth's surface evaporates into water vapor which rises up into the sky to become part of a cloud which will float off with the winds, eventually releasing water back to Earth as precipitation.

Note: This section of the Water Science School discusses the Earth's "natural" water...

Contacts: [Ask USGS](#)



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Condensation and the Water Cycle

The air is full of water, as water vapor, even if you can't see it. Condensation is the process of water vapor turning back into liquid water, with the best example being those big, fluffy clouds floating over your head. And when the water droplets in clouds combine, they become heavy enough to form raindrops to rain down onto your head.

Note: This section of the Water Science...

Contacts: [Ask USGS](#)



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Infiltration and the Water Cycle

You can't see it, but a large portion of the world's freshwater lies underground. It may all start as precipitation, but through infiltration and seepage, water soaks into the ground in vast amounts. Water in the ground keeps all plant life alive and serves peoples' needs, too.

Note: This section of the Water Science School discusses the Earth's "natural" water cycle without human...

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Surface Runoff and the Water Cycle

Runoff is nothing more than water "running off" the land surface. Just as the water you wash your car with runs off down the driveway as you work, the rain that Mother Nature covers the landscape with runs off downhill, too (due to gravity). Runoff is an important component of the natural water cycle.

Note: This section of the Water Science School discusses the Earth's "natural"...

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Below are publications associated with the water cycle.
