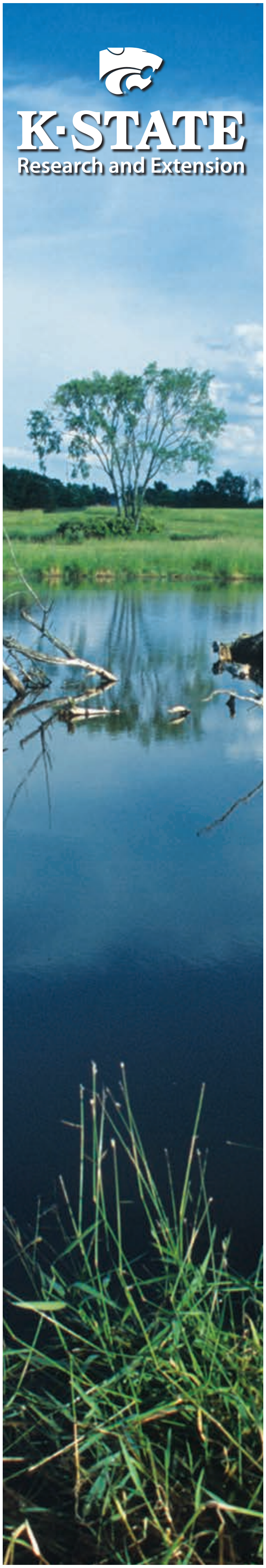

Water Primer: Part 2

The Hydrologic Cycle

Evaporation, Precipitation, and Runoff

The hydrologic cycle (Figure 1) is nature's amazing water purification system. Its three main components are evaporation, precipitation, and runoff. Their interaction results in a smooth continuation of the hydrologic cycle.

Evaporation is the natural source for all fresh water. The evaporation process involves transferring water molecules from any moist surface to the air. As the sun heats surface water, some water evaporates or moves from liquid to vapor as long as the air is not already saturated with water vapor. Most evaporation comes from large, non-flowing water bodies such as ponds, lakes, reservoirs, and oceans; but evaporation also occurs in small amounts from flowing water, wet surfaces, marshes, and wetlands. Continuous evaporation from oceans and other surface water is a never-ending process that produces a steady supply of clean water.

As water evaporates, it rises into the atmosphere then cools, condenses, and forms clouds. Some water eventually returns to Earth as precipitation (rain, hail, sleet, or snow) or condensation (dew or frost). As precipitation falls, some water evaporates into the atmosphere, some is intercepted by vegetation, and the rest reaches the ground, where it either infiltrates the soil or runs off to become surface water.

When precipitation exceeds the soil infiltration rate, it accumulates, filling surface depressions, and begins to flow over the soil, creating surface runoff. Runoff flows toward the greatest slope following the path of least resistance. The movement of surface water across land surface creates defined drainage channels because of erosion. Erosion is naturally occurring but can be damaging to unprotected soil surfaces where natural cover has been removed, such as construction sites or fire-damaged land. As erosion occurs, a small gully or rill may form. Rills connect together and flow down slope until enough water is collected to erode a small

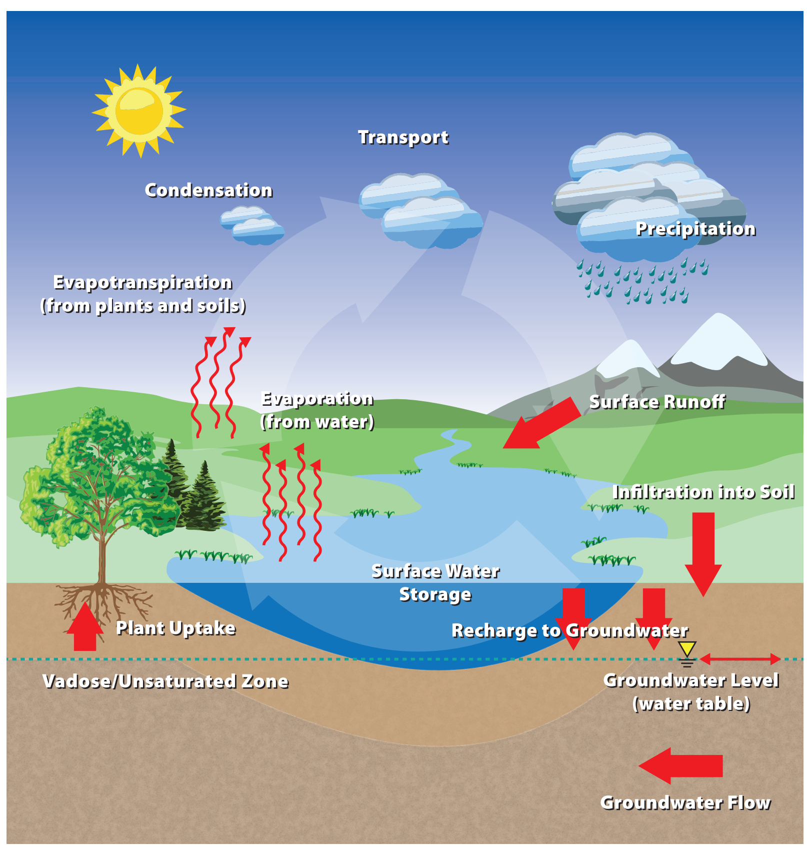

Figure 1. The hydrologic cycle.

channel. Water in these channels flows downstream, joining with other channels until they reach an intermittent stream. Intermittent streams continue downstream, joined by other streams until the valley is large enough and deep enough to allow groundwater to flow into the stream channel through springs or seeps.

When enough groundwater is available to supply a continual flow throughout the year, a perennial stream is formed. Perennial streams join other flows while gaining volume to become creeks or rivers, eventually reaching the ocean. Although water is in constant motion, much of the earth's water is stored in oceans, lakes, reservoirs, and underground aquifers. Surface water is the general name for water bodies visible from the earth's surface, while water in underground aquifers is known as groundwater.

Excess water in soil drains downward and, once below the root zone, eventually reaches groundwater. This process is called groundwater recharge. Groundwater recycles itself when it returns to the surface either as a seep, spring, direct flow to a stream, lake, or ocean, or is pumped. Some groundwater systems recycle the water in storage relatively quickly, but others move more slowly and take thousands of years to recycle water.

Evapotranspiration

Both evaporation and transpiration processes are driven by energy from solar radiation, air temperature, and wind. It is difficult to separate the water that moves through plants into the atmosphere as transpiration or the evaporation that occurs from the plant's canopy or the soil surface. The term evapotranspiration (ET), a combination of the words evaporation and transpiration, is used to describe this dual process.

Transpiration occurs when water vapor escapes from plant leaves through tiny pores (stomata) scattered over the leaf surface. It is different from evaporation because stomatal opening or closing occurs in response to a variety of environmental conditions instead of simply a result of the sun's heat. Water moves from moist soil into plant roots, through the plant, and out through leaf stomata into the atmosphere, thus completing transpiration. The loss of water to the atmosphere is an integral and essential part of plant physiology because the process moves nutrients from the soil into the plant and helps moderate the plant's temperature.

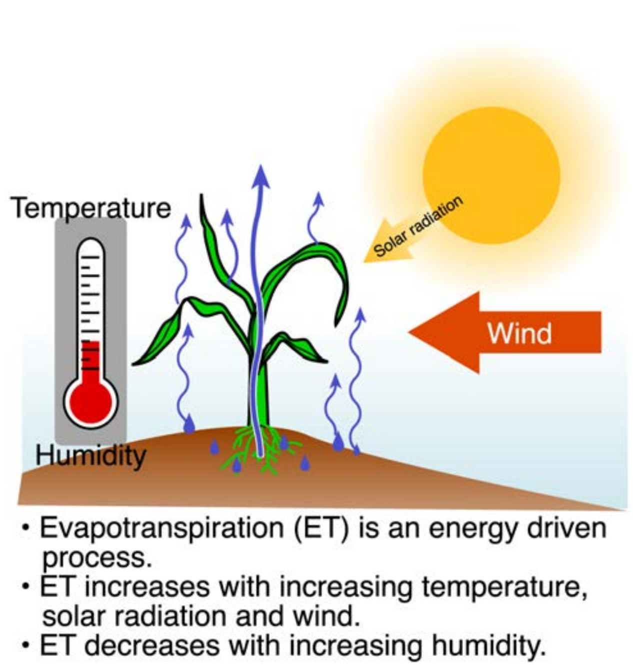

Figure 2. Illustration of the evapotranspiration (ET) process.
Source: KSU publication MF2389

The evapotranspiration process is illustrated in Figure 2. More ET occurs on a hot, sunny, windy day then on a cool, cloudy, calm day. The amount of ET can be measured indirectly by observing changes in soil water or directly in research plots using large weighing lysimeters. A lysimeter is a measuring device used to detect the actual amount

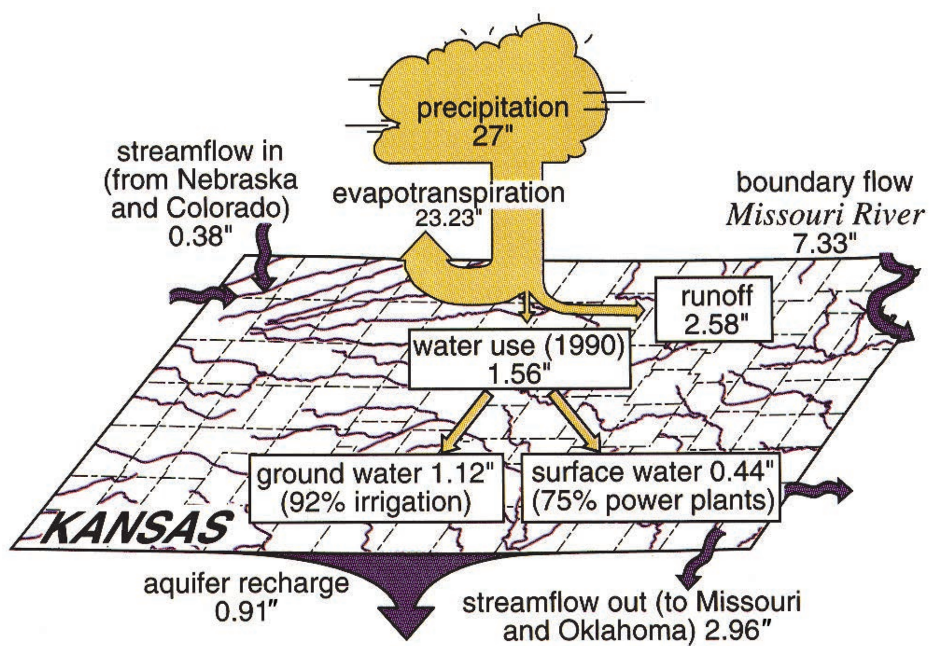

Figure 3. Water budget components for Kansas.
Source: Kansas Geological Survey

of evapotranspiration released by plants. Lysimeter studies were used to develop equations to calculate ET, and these equations provide a convenient and accurate estimate. Climatic data, such as solar radiation, air temperature, relative humidity, and wind are used in these equations.

Kansas Climate and Precipitation

Kansas serves as a unique point of transition between the wet and humid eastern United States and the dry and semiarid western United States. With an average annual precipitation of 27 inches, Kansas ties with Oregon for precipitation among the 17 western states behind Oklahoma, Texas, and Washington. Except for Minnesota, all states east of Kansas have more annual precipitation.

Precipitation throughout the state ranges from an annual average of 15 inches in extreme western Kansas to more than 40 inches per year in the southeastern region. Traveling east across the state, annual precipitation typically increases 1.5 to 2 inches for the distance of each county width, as shown in Figure 4. Approximately 70 percent to 80 percent of the precipitation occurs during the April to October growing season, which is ideal for crops, lawns, trees, and grasslands.

As illustrated in Figure 3, the largest water supply in the state is precipitation, which is mostly consumed by plants as evapotranspiration from crops, pastures, lawns, and parks. Surface water flows into and out of Kansas. Both surface water and groundwater are withdrawn for use for various activities, including irrigation, energy production, municipal, industrial, and for removing contaminants from the water.

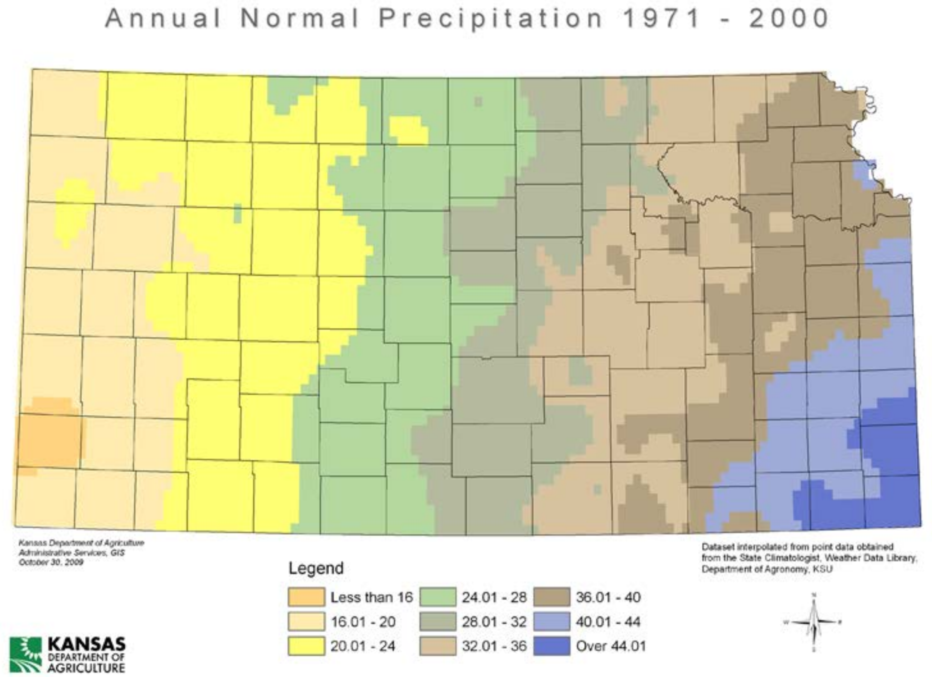

Figure 4. Average precipitation.

Source: Kansas Department of Agriculture

Because Kansas is in the center of a large landmass, its weather and precipitation pattern is continental, meaning weather is dominated by large air masses. These air masses generally move from west to east.

During winter months, moisture originates over the Pacific Ocean and precipitates over the coast range and Rocky Mountains. Some moisture also moves toward the state from the northwest. By the time these

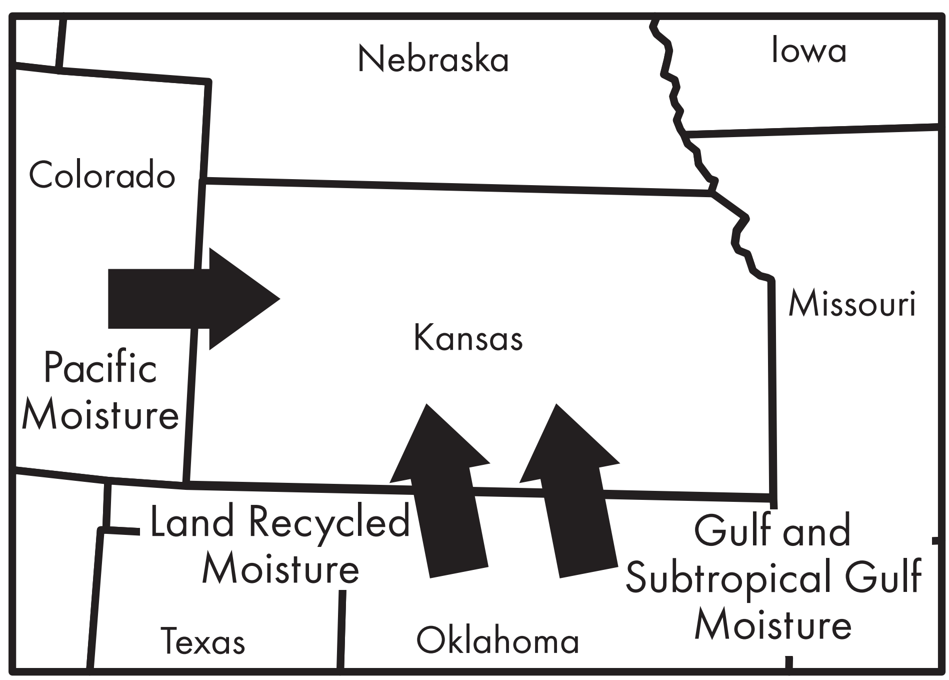

Figure 5. Principal sources and patterns of delivery of moisture into Kansas. Size of arrow implies relative contribution of moisture from source shown.

Source: adapted from Clement and Bark

air masses reach Kansas, they have crossed mountain ranges and, therefore, have lost much of their moisture, causing dry air and low winter precipitation.

During summer, southerly winds bring moisture into Kansas from the Gulf of Mexico. This southerly airflow includes land-recycled moisture, which is evaporation and transpiration from water surfaces and land areas. The nature of atmospheric moisture delivery to Kansas results in numerous severe floods and long, severe droughts. Figure 5 shows the relative direction and quality of moisture from the West and South that reaches Kansas.

References

Rogers, D. H. and M. Alam. 2007. *What is ET? An evapotranspiration primer.* Kansas State University Research and Extension. Irrigation Management Series, MF-2389 rev., *http://www.ksre.ksu.edu/library/ageng2/mf2389.aspx*

Clement, Ralph W., et al. *KANSAS -- Floods and Droughts*, Ralph W. Clement, U.S. Geological Survey, L. Dean Bark, Kansas State University, and Thomas C. Stiles, Kansas Water Office, U.S. Geological Survey National Water Summary Water Supply Paper 2375, *http://ks.water.usgs.gov/pubs/reports/wsp.2375.ks.html*

Authors:
Danny H. Rogers, professor, irrigation systems, biological and agricultural engineering
G. Morgan Powell, retired professor, biological and agricultural engineering
Kerri Ebert, extension assistant, biological and agricultural engineering

Publications from Kansas State University are available at: ***www.ksre.ksu.edu***

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF3021 **March 2012**

K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and United States Department of Agriculture Cooperating, Gary Pierzynski, Interim Director.