Impact of Climate Change and Land Use
in the Southwestern United States

Climatic Variability

Evapotranspiration and Droughts

Ronald L. Hanson
U. S. Geological Survey

This paper is reproduced in its entirety from *Hanson, R.L., 1991, Evapotranspiration and Droughts,* ***in*** *Paulson, R.W., Chase, E.B., Roberts, R.S., and Moody, D.W., Compilers, National Water Summary 1988-89--Hydrologic Events and Floods and Droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 99-104..*

SIGNIFICANCE OF EVAPOTRANSPIRATION

Apart from precipitation, the most significant component of the hydrologic budget is evapotranspiration. Evapotranspiration varies regionally and seasonally; during a drought it varies according to weather and wind conditions. Because of these variabilities, water managers who are responsible for planning and adjudicating the distribution of water resources need to have a thorough understanding of the evapotranspiration process and knowledge about the spatial and temporal rates of evapotranspiration.

Estimates of average statewide evapotranspiration for the conterminous United States range from about 40 percent of the average annual precipitation in the Northwest and Northeast to about 100 percent in the Southwest. During a drought, the significance of evapotranspiration is magnified, because evapotranspiration continues to deplete the limited remaining water supplies in lakes and streams and the soil.

The lower 5 miles of the atmosphere transports an average of about 40,000 billion gallons of water vapor over the conterminous United States each day (U.S. Geological Survey, 1984). Slightly more than 10 percent of this moisture, however, is precipitated as rain, sleet, hail, or snow. The disposition of this precipitation in the conterminous United States is illustrated in **figure 1**. As shown, the greatest proportion, about 67 percent, returns to the atmosphere through evapotranspiration, about 29 percent is discharged from the conterminous United States as net surface-water outflow into the Pacific and Atlantic Oceans and across the borders into Canada and Mexico, about 2 percent is discharged as ground-water outflow, and about 2 percent is consumed by people, animals, plants, and industrial and commercial processes (U.S. Geological Survey, 1990). For most of the United States, evaporation returns less moisture to the atmosphere than does transpiration.

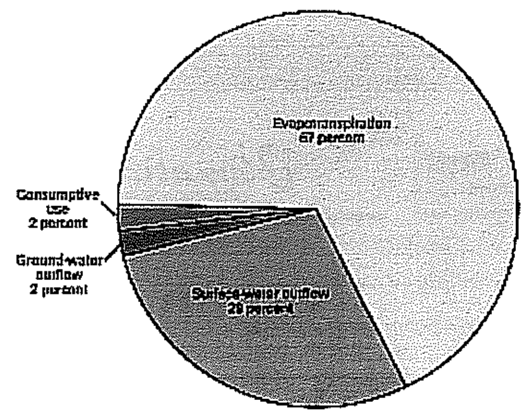


***Figure 1.** Average disposition of 4200 billion gallons per day of precipitation in the conterminous United States.* (source: Data from U.S. Geological Survey, 1990).

EVAPOTRANSPIRATION PROCESS

Evapotranspiration is the water lost to the atmosphere by two processes-evaporation and transpiration. Evaporation is the loss from open bodies of water, such as lakes and reservoirs, wetlands, bare soil, and snow cover; transpiration is the loss from living-plant surfaces. Several factors other than the physical characteristics of the water, soil, snow, and plant surface also affect the evapotranspiration process. The more important factors include net solar radiation, surface area of open bodies of water, wind speed, density and type of vegetative cover, availability of soil moisture, root depth, reflective land-surface characteristics, and season of year.

Assuming that moisture is available, evapotranspiration is dependent primarily on the solar energy available to vaporize the water. Because of the importance of solar energy, evapotranspiration also varies with latitude, season of year, time of day, and cloud cover. The distribution of mean daily solar radiation for the United States **(fig. 2)** shows a regional variation similar to that of mean annual lake evaporation **(fig. 3)** and mean annual air temperature. The areas that receive the maximum solar radiation and have the greatest lake evaporation in the conterminous United States are in the Southwest; the areas that receive the minimum solar radiation and have the least lake evaporation are in the Northeast and Northwest. According to the 1980 Bureau of Census data (U.S. Bureau of the Census, 1987, p. 181), the area of open-water bodies in the 48 conterminous States totals 38.4 million acres. Mean annual lake evaporation ranges from about 20 inches in parts of Maine, Oregon, and Washington to about 80 inches in parts of Arizona, California, and Nevada.

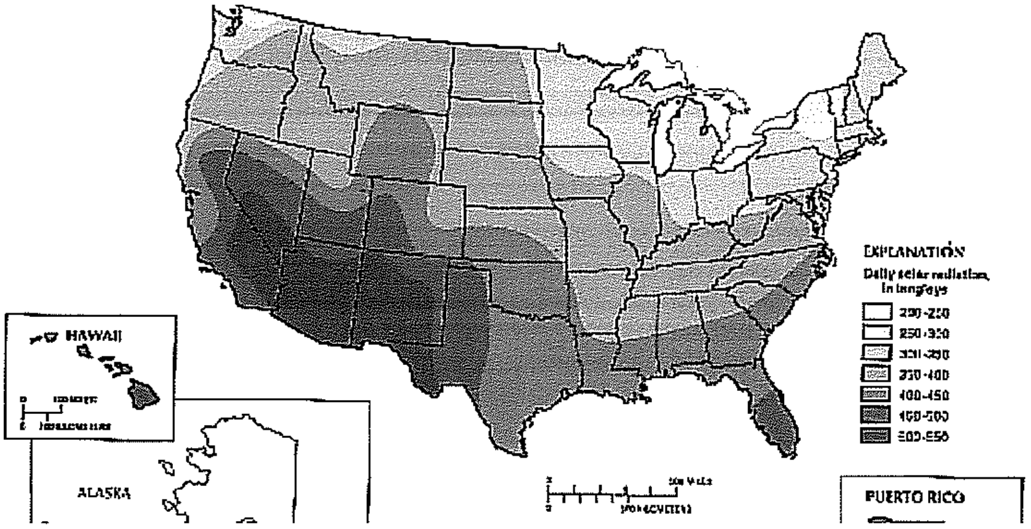


Figure 2. Mean daily solar radiation in the United States and Puerto Rico.(Source: Data from the U.S. Department of Commerce, 1968).

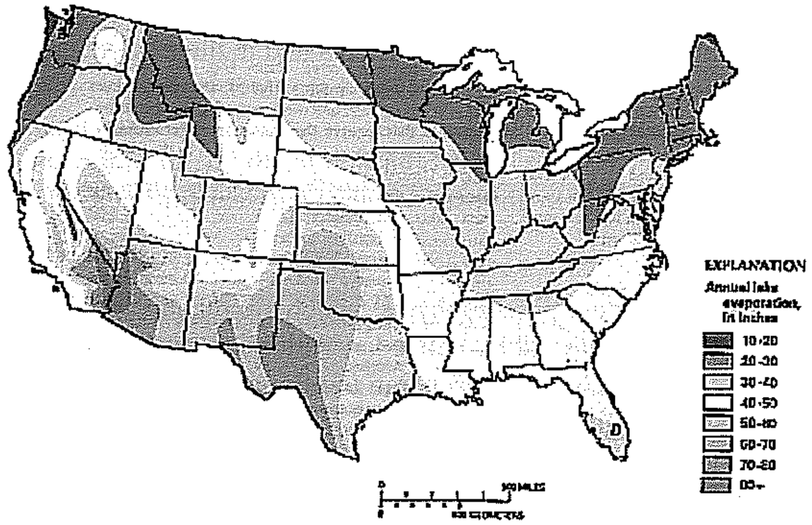


Figure 3. *Mean annual lake evaporation in the conterminous United States, 1946-55. Data not available for Alaska, Hawaii, and Puerto Rico.* (Source: Data from U.S. Department of Commerce, 1968).

Another important climatic factor that contributes to evapotranspiration is wind speed. Winds affect evapotranspiration by bringing heat energy into an area and removing the vaporized moisture. A 5-mile-per-hour wind will increase still-air evapotranspiration by 20 percent; a 15-mile-per-hour wind will increase still-air evapotranspiration by 50 percent (Chow, 1964, p. 6-20). Maximum mean annual wind velocities, averaging more than 14 miles per hour, are recorded in the central United States. Minimum mean annual wind velocities, averaging less than 8 miles per hour, are recorded along the West Coast and in the mountainous part of the east-central United States (Eagleman, 1976, p. 4).

The type of vegetative cover is not as important in the evapotranspiration process as is solar radiation if the vegetative cover is dense and sufficient soil moisture is available (Kozlowski, 1964, p. 147). Most plants that have a shallow root system, however, will experience moisture stress, which results in decreased transpiration during prolonged droughts.

The reflective characteristics of the land surface also have an effect on the magnitude of evapotranspiration. Coniferous forests and alfalfa fields reflect only about 25 percent of the solar energy, thus retaining substantial thermal energy to promote transpiration; in contrast, deserts reflect as much as 50 percent of the solar energy, depending on the density of vegetation (Rosenberg, 1986, p. 13).

The seasonal trend of evapotranspiration within a given climatic region follows the seasonal trend of solar radiation and air temperature. Minimum evapotranspiration rates generally occur during the coldest months of the year; maximum rates, which generally coincide with the summer season, when water may be in short supply, also depend on the availability of soil moisture and plant maturity. However, the seasonal maximum evapotranspiration actually may precede or follow the seasonal maximum solar radiation and air temperature by several weeks.

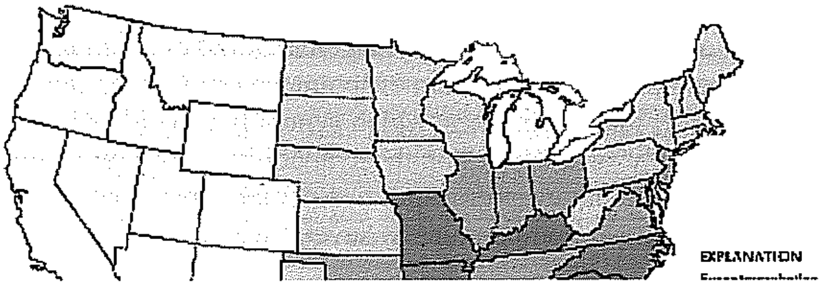
REGIONAL AND SEASONAL VARIABILITY OF EVAPOTRANSPIRATION

The United States is covered by a variety of vegetation due mostly to the variability in climate and soil types across the country. In the conterminous United States, two major forested areas exist: the eastern forests, which include large areas of conifers and hard- woods, extend from the East Coast to the eastern edge of the central Great Plains; the western forests, which are predominantly conifers that grow in mountainous areas separated by semiarid basins, extend from the West Coast to the western edge of the central Great Plains. The forests of the eastern United States cover 385 million acres; those of the western United States cover 353 million acres and include about 24 million acres in Alaska (U.S. Department of Agriculture, 1987, p. 475). Estimates of evapotranspiration for the eastern forests range from slightly less than 12 inches per year for spruce-fir forests to slightly more than 36 inches per year for pines and river-bottom hardwoods and for the western forests from about 6 inches per year for pinyon and juniper forests to almost 60 inches per year for Pacific Douglas-fir forests (Kittredge, 1948).

Some of the greatest users of water are phreatophytes, which are plants characterized by a deep root system that extends to or near the water table. Saltcedar, which is a particularly aggressive phreatophyte, is estimated to cover 16 million acres in the flood plains of the 17 Western States; it thrives in the arid regions south of the 37th parallel and below an altitude of 5,000 feet in the Southwestern States (Robinson, 1958, p. 75). Mean annual evapotranspiration by this phreatophyte was estimated to be about 56 inches for areas of dense cover along the flood plain of the Gila River in south-central Arizona (Culler and others, 1982).

In contrast to the two major forest areas, the central Great Plains are characterized by large regions of rangeland and cropland (irrigated and nonirrigated). The total rangeland in the conterminous United States and Alaska is about 817 million acres, and the total cropland is about 427 million acres (U.S. Department of Agriculture, 1987). Within these areas, irrigated grass or croplands occupy about 60 million acres (Irrigation Journal, 1985). The average annual evapotranspiration for irrigated lands varies greatly and, apart from the climatic controls, is dependent on the grass or crop type, quantity of water applied, and length of the growing season. During a drought, natural vegetation may experience moisture stress and wilting, whereas irrigated grasses and crops continue to grow and transpire at a normal rate (if water supplies are available for irrigation).

Most estimates of evapotranspiration are derived from studies of small areas (a few acres or less) where climate, available moisture, and plant cover are relatively uniform; thus, regional estimates are uncommon. However, the magnitude and distribution of mean annual evapotranspiration for regions of the United States have been estimated from hydrologic budgets given for each State in the 1987 *National Water Summary* (U.S. Geological Survey, 1990), as shown in **figure 4**. The estimated mean annual evapotranspiration for each State was determined from the mean annual statewide values of four principal components of the hydrologic budget-precipitation, surface-water inflow, surface-water outflow, and consumptive use. All four components were measured or estimated, and evapotranspiration was computed as a residual of these components.



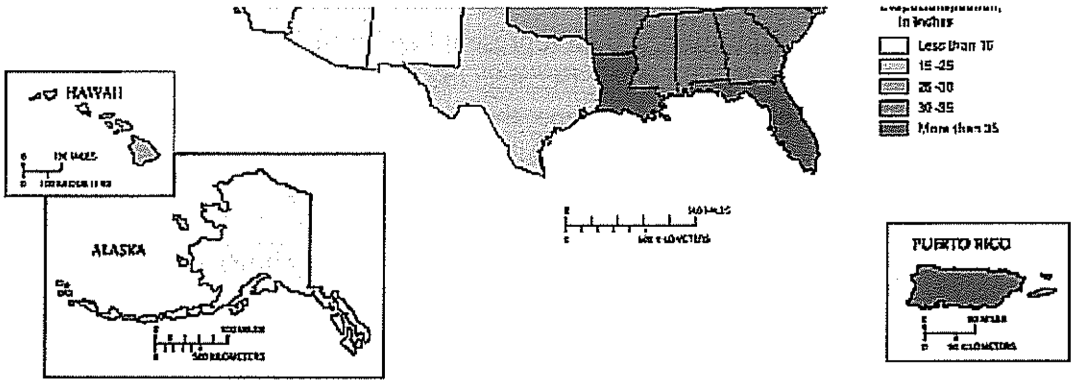


Figure 4. Estimated mean annual evapotranspiration in the United States and Puerto Rico. (Source:Data compiled from U.S. Geological Survey, 1990).

For the United States and Puerto Rico, the estimated mean annual evapotranspiration ranges from a maximum of 45 inches per year in Puerto Rico to a minimum of 7.6 inches per year in Alaska. Within the conterminous United States, the estimated mean annual evapotranspiration is greatest in the Southeast (about 35 inches per year or about 70 percent of the precipitation), which is an area of abundant precipitation, permeable soils, and substantial solar radiation; it is least in the semiarid region of the Southwest where precipitation is limited. For large areas of the Southwest, evapotranspiration is virtually equal to 100 percent of the precipitation, which is only about 10 inches per year. The ratio of estimated mean annual evapotranspiration to precipitation is least in the mountains of the Pacific Northwest and New England where evapotranspiration is about 40 percent of the precipitation.

The seasonal variability in evapotranspiration differs greatly throughout the United States and is similar to the seasonal trend in air temperature. In the northern part of the United States, measurable evapotranspiration, primarily transpiration by natural vegetation, usually begins in April, reaches a maximum in July, and decreases in October. In contrast, in the southern parts of the United States, evapotranspiration continues throughout the winter months, even though comparatively small, and generally is greatest in the early summer to midsummer months (June and July), when the leaf area of plants is fully developed.

Daily fluctuations in evapotranspiration also occur. On clear days, the rate of transpiration increases rapidly in the morning and reaches a maximum usually in early afternoon or midafternoon. The midday warmth can cause closure of plant stomata, which results in a decrease in transpiration (Kozlowski, 1964, p. 143).

Since the early 1970's, satellites orbiting the Earth have been used to monitor the vigor of vegetation. This information has been applied in the measurement of evapotranspiration, vegetative stress, and drought severity on a regional scale. In 1982, the National Oceanic and Atmospheric Administration (NOAA), by using data from polar orbiting satellites, began weekly production of global maps that show visible and near-infrared data for the surface of the Earth. The instrument used to record these data is an Advanced Very High Resolution Radiometer, which scans the surface of the Earth continuously at a ground resolution covering an area of about 0.36 square mile. These data provide a measure of the spectral reflectance of the chlorophyll pigment in plants in the visible and near-infrared bands of the electromagnetic spectrum.

Mathematical expressions have been developed that combine the visible and near-infrared reflectance to provide a normalized-difference vegetation index of plant vigor (Tarpley and others, 1984). A large index value corresponds to areas of substantial evapotranspiration rates, which represent dense vegetative cover, permeable soils, and substantial soil moisture. A small index value corresponds to areas having minimal evapotranspiration, which represent bare ground or little vegetation, relatively impermeable soils, and minimal soil moisture. Because the vegetation-index data characterize the emissive and reflective properties of the landscape, the data potentially are useful in monitoring vegetation conditions associated with the spatial and temporal persistence of droughts that affect large areas.

An image of these indices provided by the U.S. Geological Survey is shown in **figure 5**. The image represents the mean of 43 weekly images collected by the NOAA-9 satellite from February through November 1987. The map shows variations in "greenness" that relate directly to variations in density of vegetative cover, plant vigor, and the seasonal duration of vegetative growth. Large index values (0.26 and larger) are displayed for the densely forested areas throughout much of the eastern, south-central, and extreme western parts of the United States. Except for the West Coast, the densely forested areas in the western part of the United States display index values generally less than 0.26, which may be attributed to the short growing season.

Agricultural regions, such as the Corn Belt area of the Midwest, display smaller index values (0.21 to 0.25) than the native vegetation regions of the Eastern States because the agricultural growing season is shorter than that of the native vegetation. Thus, the seasonal potential for evapotranspiration in agricultural areas would be expected to be distinctly less than that of the native vegetation (K.P. Gallo, National Oceanic and Atmospheric Administration, written commun., 1988).

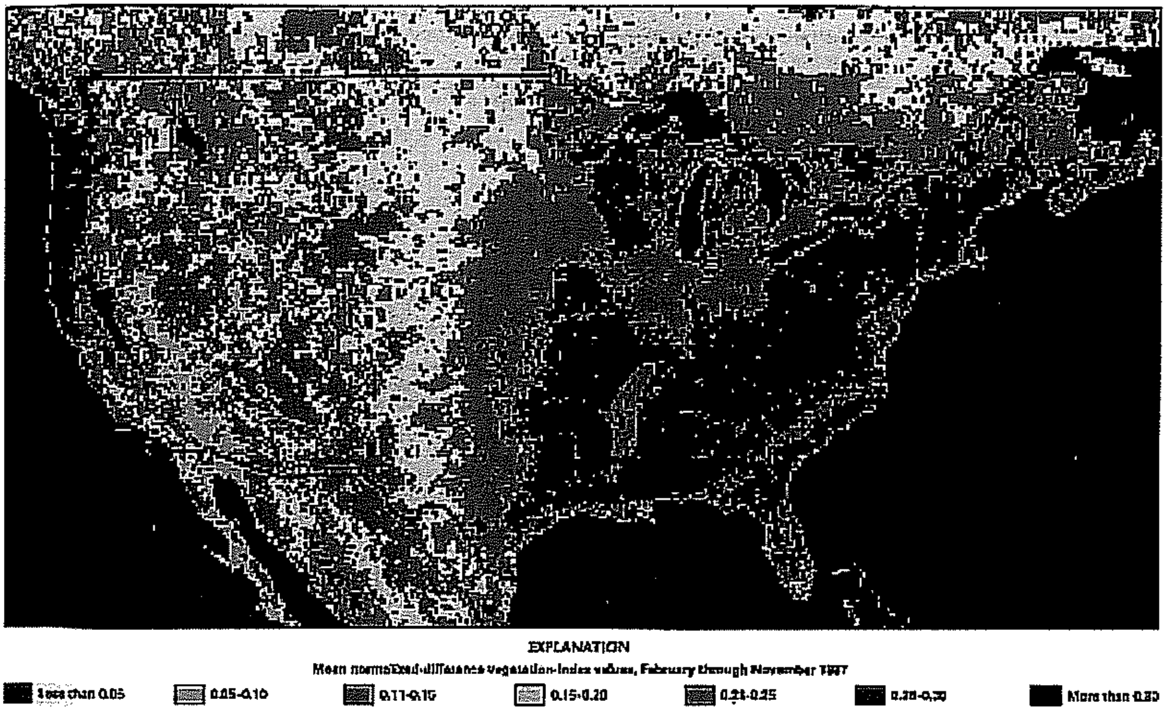


Figure 5. Mean normalized-difference vegetation-index values for the conterminous United States. Map produced from 43 weekly images acquired from February through November 1987 by the NOAA-9 polar-orbiting satellite using an Advanced Very High Resolution Radiometer. (Sources: Data from the National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite Data and Information Services; map from U.S. Geological Survey, Earth Resources Observation System Data Center).

CHANGE IN EVAPOTRANSPIRATION DURING A DROUGHT

Changes in evaporation and transpiration during a drought depend on the availability of moisture at the onset of a drought and the severity and duration of a drought. Also, weather conditions during a drought commonly include below-normal cloud cover and humidity and above-normal wind speed. These factors will increase the rate of evaporation from open bodies of water and from the soil surface, if soil moisture is available.

During a drought, transpiration by plants may decrease, as plants attempt to conserve water. The magnitude of the decrease in transpiration depends on the plant's root and leaf characteristics. The decrease in transpiration by phreatophytes, such as saltcedar, cottonwoods, bermuda grass, and alfalfa, typically is slight because they are deep rooted and obtain their water from near the water table rather than from the overlying soil zone. For example, alfalfa roots have been traced to a depth of 66 feet and also have been observed in a mine shaft at a depth of about 100 feet (Meinzer, 1927, p. 55). The decrease in transpiration by plants, such as cacti, in desert regions typically is slight because the plants have extensive root systems that obtain water from a large area and because their thick, fleshy leaves naturally transpire little water. In more humid areas having deciduous trees, some species of these trees decrease transpiration during droughts by leaf curling or leaf shedding (Kozlowski, 1964). The decrease in transpiration during droughts generally is greater in agricultural areas because crops die or their foliage (and, therefore, their ability to transpire water) is severely stunted during prolonged droughts.

SUMMARY

Apart from precipitation, evapotranspiration is the major component in the hydrologic budget. Evapotranspiration involves the process of evaporation from open bodies of water, wetlands, snow cover, and bare soil and the process of transpiration from vegetation. The principal climatic factors influencing evapotranspiration are solar radiation and wind speed. In the conterminous United States, evapotranspiration averages about 67 percent of the average annual precipitation and ranges from 40 percent of the precipitation in the Northwest and Northeast to about 100 percent of the precipitation in the Southwest.

Estimates of the mean annual evapotranspiration have been derived from hydrologic budgets for each State. These estimates indicate that statewide evapotranspiration within the conterminous United States ranges from about 10 inches per year in the semiarid Southwest to about 35 inches per year in the humid Southeast. However, in selected areas of the Southwest where moisture is available and solar radiation is high, evapotranspiration rates in saltcedar have been estimated to be about 56 inches per year.

Seasonal trends in evapotranspiration follow the seasonal trends in air temperature-maximum rates occur during the summer months, and minimum rates during the winter months. Advanced Very High Resolution Radiometer instruments installed on polar-orbiting satellites provide relative measurements of plant vigor, density of vegetation cover, and the seasonal duration of vegetation growth. These measurements also have been used to monitor the spatial and temporal persistence of drought for large areas.

Changes in evapotranspiration during a drought depend largely on the availability of moisture at the onset of a drought and the severity and duration of a drought. Evaporation from open bodies of water during a drought increases, but transpiration by plants, particularly shallow-rooted plants, generally decreases.

To effectively manage the Nation's water resources, water managers need to understand the significance of evapotranspiration in the hydrologic budget. Knowledge of the regional and seasonal variability of evapotranspiration and its change during a drought also is important.

REFERENCES CITED

Chow, V.T., ed., 1964, Handbook of applied hydrology: New York, McGraw-Hill, A Compendium of Water Resources Technology (29 sections).

Culler, R.C., Hanson, R.L., Myrick, R.M., Turner, R.M., and Kipple, F.P., 1982, Evapotranspiration before and after clearing phreatophytes, Gila River flood plain, Graham County, Arizona: U.S. Geological Survey Professional Paper 655-P, 67 p.

Eagleman, J.R., 1976, The visualization of climate: Lexington, Mass., Lexington Books, p. 1-29.

Irrigation Journal, 1985, 1984 irrigation survey: Irrigation Journal, v. 35, no. 1, 56 p.

Kittredge, Joseph, 1948, Forest influences: New York, McGraw-Hill, 394 p.

Kozlowski, T.T., 1964, Water metabolism in plants: New York, Harper and Row, Biological Monographs, 227 p.

Meinzer, O.E., 1927, Plants as indicators of ground water: U.S. Geological Survey Water-Supply Paper 577, 95 p.

Robinson, T.W., 1958, Phreatophytes: U.S. Geological Survey Water-Supply Paper 1423, 84 p.

Rosenberg, N.J., 1986, A primer on climatic change- Mechanisms, trends, and projections: Washington, D.C., Resources for the Future Paper RR86-04, 19 p.

Tarpley, J.D., Schneider, S.R., and Money, R.L., 1984, Global vegetation indices from the NOAA-7 meteorological satellite: Journal of Climate and Applied Meteorology, v. 23, no. 3, p. 491-494.

U.S. Bureau of the Census, 1987, Statistical abstracts of the United States (107th ed.): Washington, D.C., U.S. Government Printing Office, 960 p.

U.S. Department of Agriculture, 1987, Agricultural statistics: Washington, D.C., U.S. Government Printing Office, 541 p.

. U.S. Department of Commerce, 1968, Climate atlas of the United States: Washington, D.C., Environmental Science Services Administration, Environmental Data Services, 80 p.

U.S. Geological Survey, 1984, National water summary 1983-Hydrologic events and issues: U.S. Geological Survey Water-Supply Paper 2250, 243 p.

U.S. Geological Survey, 1990, National water summary 1987-Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

USGS

U.S. Department of the Interior, U.S. Geological Survey
This page is http://geochange.er.usgs.gov/sw/changes/natural/et/
Maintained by Randy Schumann

Last modified Tuesday, 25-Nov-2003 16:42:18 EST

Cooperative Extension

Turf Irrigation Management Series

No. 1

Basics of Evaporation and Evapotranspiration

INTRODUCTION

Local information on **evapotranspiration** (ET) is now readily available from on-site weather stations and/or public weather networks to assist turfgrass professionals with irrigation management decisions. Proper utilization of ET information can provide accurate estimates of daily water use and thus can assist irrigation managers with the all important decisions of when to apply water and how much water to apply. The concept of ET can be confusing and often is presented in a highly technical manner. The objective of this and subsequent bulletins in the *Turf Irrigation Management Series* is to simplify the subject of ET and thereby increase the effective utilization of ET in irrigation management. This bulletin provides some basic background on the related subjects of evaporation and **evapotranspiration**.

EVAPORATION

Water can exist in the natural environment in three different forms or states — solid (ice), liquid and gas. The process by which water changes from a liquid to a gas is known as evaporation. We are all familiar with liquid water as we drink, bath and irrigate with it daily. The gaseous form of water, known as water vapor, is less familiar since it exists as an invisible gas. However, we all have a feel for water vapor during the late summer months when it is called by the more common name of humidity. To the irrigation manager, the most important points about evaporation are 1) it is the process by which most of the liquid water we apply as irrigation leaves vegetation and 2) that evaporation requires energy (Fig. 1).

Two common household items — the clothes dryer and the evaporative cooler — clearly show the energy requirement of evaporation. In the case of the dryer, a gas burner or an electric heating element provides the heat energy required to evaporate water from the wet clothes. The evaporative cooler works in a somewhat opposite manner. Energy stored in the hot, dry, outside air is consumed by the evaporation process as the air passes through the wet pads. This energy consumption reduces the temperature of the air and allows us to use evaporative cooling as a means of air conditioning.

Water + Energy = Evaporation

Figure 1. Energy is required for evaporation.

Energy is also required for evaporation to proceed from vegetation. Meteorological conditions impact the amount of energy available in the natural world and therefore play a key role in regulating evaporation from vegetation. A more detailed discussion of the impact of meteorological conditions on evaporation is provided in the next section of this report.

EVAPOTRANSPIRATION (ET)

Evaporation from vegetation is generally given a more specific term — **evapotranspiration** or ET for short. By definition, ET is the loss of water from a vegetated surface through the combined processes of soil evaporation and plant transpiration (Fig. 2). The term evapotranspiration comes from combining the prefix "evapo"

12/2000 **AZ1194**

Turf Irrigation Management Series: I

The University of Arizona
College of Agriculture
Tucson, Arizona 85721

Paul Brown
Biometeorology Specialist

This information has been reviewed by university faculty.

ag.arizona.edu/pubs/water/az1194.pdf

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, James A. Christenson, Director, Cooperative Extension, College of Agriculture and Life Sciences, The University of Arizona.

Plant Transpiration

Well-watered, vigorous crops will usually transpire at nearly the rate demanded by the atmospheric conditions (PET), but as their water supply becomes limited, physical and biological controls begin to limit the rate of transpiration. The lower limit, of course, is near zero transpiration, which causes plant decay and death if it persists. The rate of transpiration, and thus soil water depletion, is reasonably clear and agreed upon at the wet and dry end points. What rates occur at the intermediate moisture contents is not clearly known and considerable differences exist among published results and contemporary scientists.

It is apparent that plant water use rates are a function of both atmospheric evaporative demand and plant available soil water. Plants have unique abilities to control water flow rates within their vascular system and through stomatal action. They make soil water available by root extension and by creating competitive water pressure within their membranes to cause gradients and water flow. However, with our lack of understanding and the complexity of soil water uptake and biological response, there is minimal detail which is currently warranted to represent the effects of crop water stress. Therefore, a simplified approach based on atmospheric demand and plant available water has been programmed, which represents a current general understanding.

The curves of Figure 7 provide a relationship between plant available soil water, defined by the range from wilting point to field capacity, and the ratio of actual transpiration to potential transpiration. Each curve represents a different level of total atmospheric demand, i.e., PET. The general shape of the curves are modifications of those derived by Denmead and Shaw (1960, 1962) in controlled pot studies of corn.

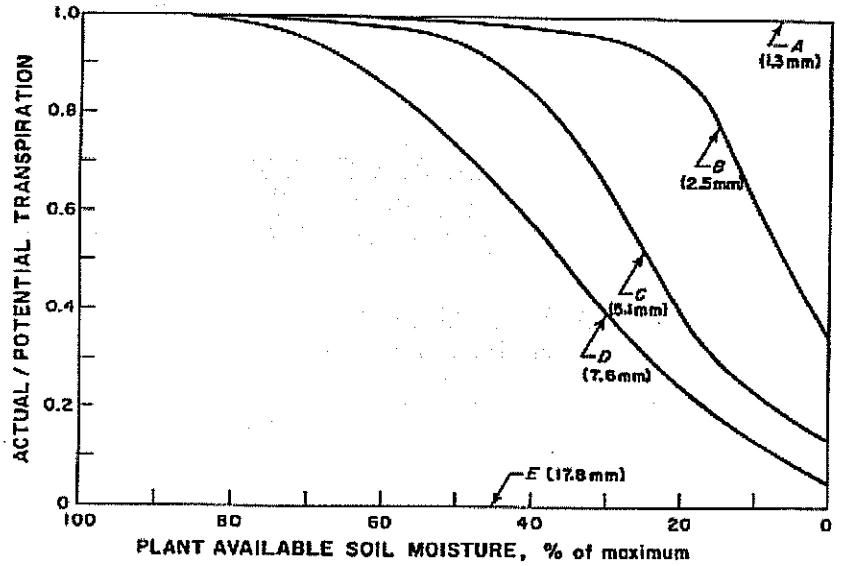


Figure 7: Actual over potential transpiration as a function of plant available water.

These curves of Figure 7 express the effect that actual plant transpiration will decrease from potential transpiration as plant available water is decreased in a quite non-linear pattern. The curves representing different levels of PET indicate that for a given level of plant available water, the plant will transpire a greater percentage of potential transpiration when PET is low than when PET is high.

This is readily observed when crops show significant wilting under a high PET day, but very little on a subsequent low PET day with very similar soil water conditions.

The exact shapes of these curves are not well defined by research results, particularly the soil water content at which transpiration reduction begins. It is particularly important to define what portion of the soil profile is used to assess the quantity of plant available water. Young plants have set roots only in the upper part of what will eventually be a full root penetration, yet some use the total "root zone" as the base for percent available water. The Denmead and Shaw results were from plants with limited root zone in which the entire pot likely had extensive root activity. In the SPAW model, the curves of Figure 7 are applied independently to each specified soil layer and the potential transpiration of that layer is a multiple expression of the PET, canopy, phenology and root density. The maximum possible available soil moisture for each layer is defined by field capacity minus the wilting point, as defined by the soil water holding characteristics specified for each layer.

The PET values assigned to each curve of Figure 7 are only approximately known, thus may require calibration for specific crop-soil-atmospheric conditions. Although experience has shown original values determined for corn were applicable to soybeans. Some modification was made for grass and dryland winter wheat, which indicates some calibration for crop may be desirable. Values for curves A to E for corn were 0.05, 0.10, 0.20, 0.30, and 0.70 inches; for grass, 0.05, 0.10, 0.25, 0.40 and 0.70 inches; and for wheat 0.0, 0.15, 0.40, 0.60 and 0.85 inches. These values provide the relative capability for plants to continue transpiration under water stress caused by a lack of available water, high atmospheric demand, or both. Generally these adjustments were not significant to the overall field hydrology and default values for those of corn are used. Currently the wilting point can be adjusted to accommodate crops with variable drought tolerance.

Plant transpiration is estimated as the combined effect of PET, root density distribution, and soil water content and distribution. The daily potential transpiration (PET minus interception times canopy) is allocated to soil layers according to the root mass of that layer, reduced according to the actual/potential transpiration curves of figure 7, and summed for the profile. Transpiration then becomes the third component of the daily actual ET. For well watered agricultural crops, transpiration can be 15-25 inches depending on crop characteristics, growth period and atmospheric demand. Crops with water stress often exhibit significantly less transpiration.

Field Hydrologic Processes | Precipitation | Infiltration | Potential ET
Interception | Soil Water Evaporation | Plant Water Stress
Root Water Uptake | ActualET | Soil Water Redistribution | Irrigation

Home | Manuals | Contents
Appendices: I: Runoff by Curve Number | IIa: Sample Crop Curves | IIb: Sample Field Input | IIIc: Sample Pond Input | III: Model Logic | IV: Keywords
References: Cited | Theory | Applications

Revised: Jul 15, 2002