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WATERSHEDS IN TRANSITION

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USE OF WATER BY A RIPARIAN MESQUITE COMMUNITY[1]

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ABSTRACT. In the semiarid regions of the Southwest where water resources may limit the development of industry and agriculture, an assessment of the water resources and future plans for water use is necessary. The objective of the study was to determine the amount of water lost by evapotranspiration from mesquite on an alluvial pocket aquifer which performed as a lysimeter. Water loss was determined by measuring fluctuations in the groundwater table and partitioning into two major categories: subsurface outflow, and evapotranspiration. The amount of water lost was 0.11 cm/day/unit area for March and increasing to 1.18 cm/day/unit area in June. Assuming 0.11 cm/day/unit area to be attributable to subsurface seepage, values for evapotranspiration were calculated at 0.01 cm/day/unit area for the first of April to 1.07 cm/day/unit area for the first half of June. A relationship between transpiration rates and air temperature was manifest as three nights of below freezing temperatures caused a lag in transpiration rates. (KEY WORDS: mesquite; evapotranspiration; water use)

INTRODUCTION

In semiarid regions of the Southwest where water resources may limit the development of industry and agriculture, an estimation of the water disposition from watersheds is necessary for assessing the present and future water resources.

During the past several years, much attention has been given to determining water use by plants. When water is not limiting, consumption by vegetation is largely influenced by climatological factors such as radiation, temperature, relative humidity, and wind velocity (Rijtema, 1961). Most research on water consumption has been done with agricultural crops, as opposed to native vegetation.

Native riparian vegetation characteristically grows along the stream banks in the arid and semiarid regions, and often may affect the hydraulic characteristics of the stream channel. Following surface runoff events, this vegetation uses large amounts of water in evapotranspiration.

This study is concerned with water consumption by a native stand of mesquite trees *(Prosopis juliflora* var. *velutina)* on the Walnut Gulch Experimental Watershed located in southeastern Arizona (Figure 1).

STUDY AREA

The study area is an alluvial pocket aquifer (Figure 2) overlying undulating granodiorite masses (Scheiffelin Granodiorite) and is occluded from the regional water table (Renard, et al., 1964). These pockets of alluvial material are generally recharged during the summer rainy season from surface flows in the overlying intermittent stream.

Figure 3 shows the general vegetation characteristics of the study area. Mesquite is the dominant overstory vegetation along a section of the stream channel. Understory herbaceous vegetation may become lush along the channel during and following the summer rainy season.

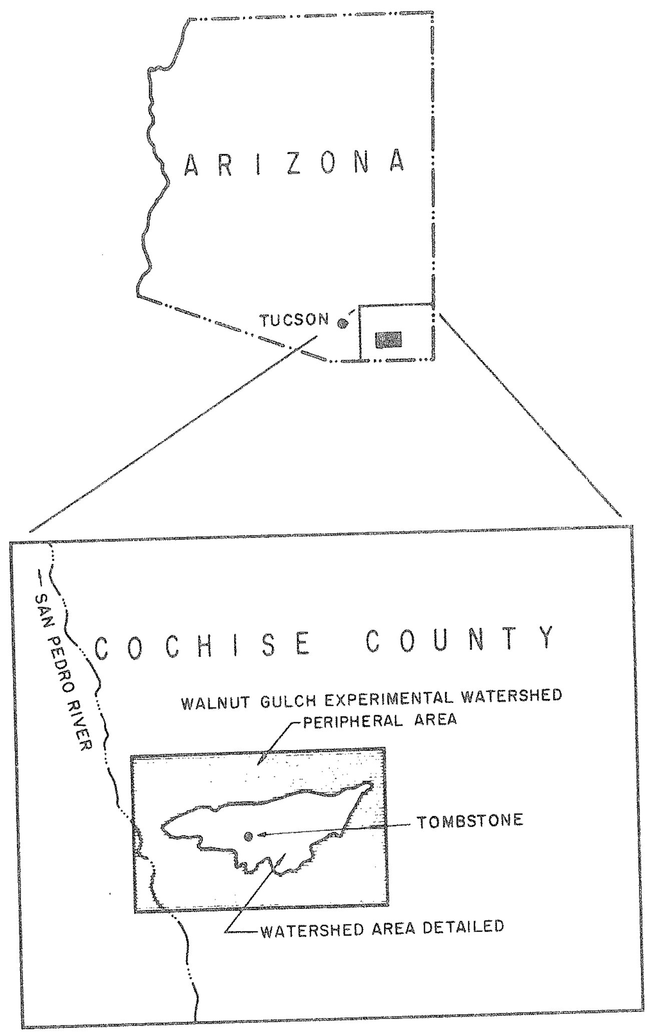

Figure 1, Walnut Gulch Watershed

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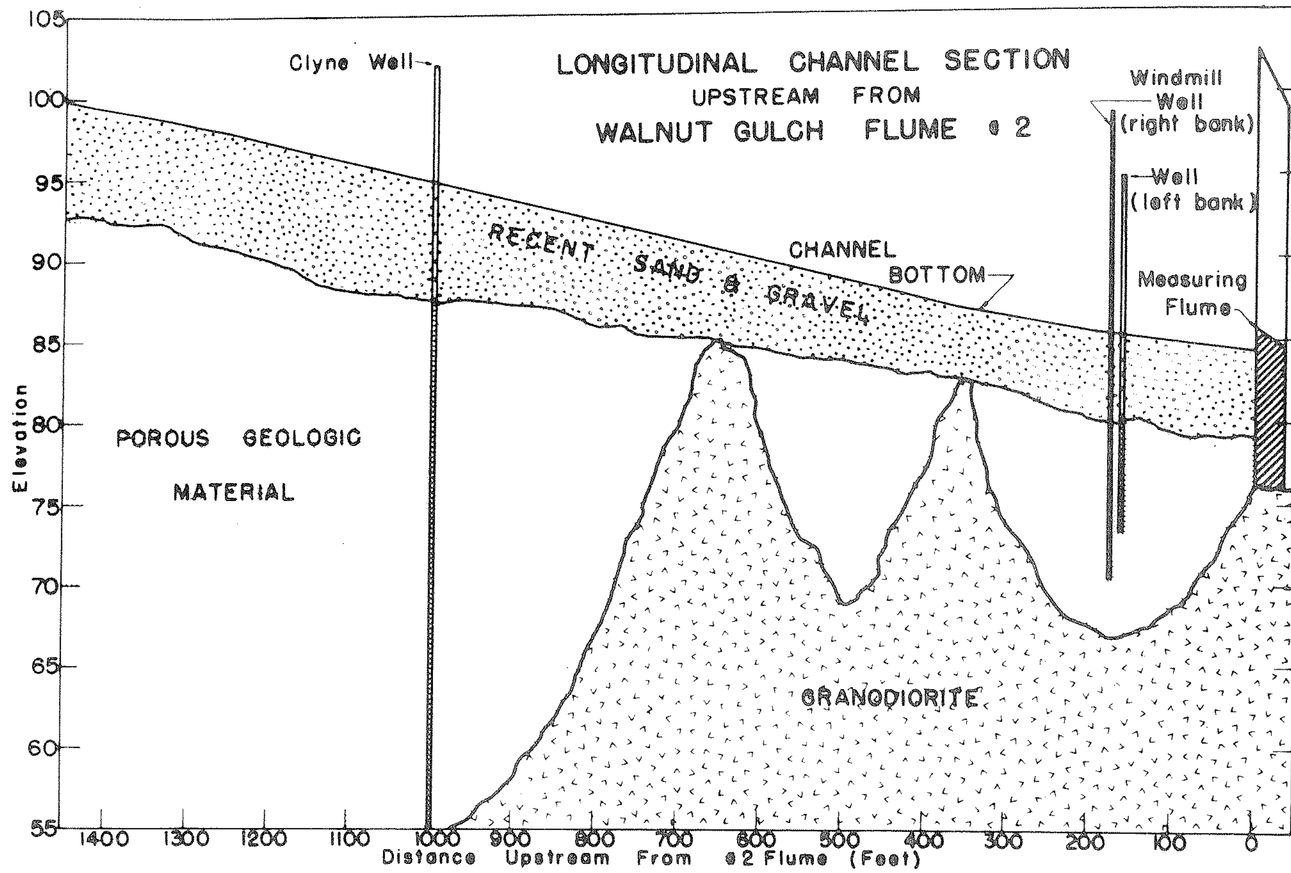

Figure 2, Schematic Longitudinal Section Along Channel Center Line

All trees and shrubs in the study area are deciduous (Qashu and Evans, 1967).

METHODS

Groundwater elevations were recorded continuously at selected sites throughout the research area to determine change in storage. Water loss was partitioned into two major categories: subsurface outflow or seepage, and evapotranspiration. Subsurface outflow is defined herein as that water which is lost from the aquifer by seepage into the granodiorite baserock. Evapotranspiration is the sum of the water transpired by vegetation and evaporated from the adjacent soil material on a given area in any specified time. Hourly changes in storage were used to calculate the evapotranspiration component.

Subsurface outflow was determined from water table elevation data collected during the winter when transpiration from the deciduous vegetation and surface evaporation are assumed to be negligible, and when there usually is no measurable subsurface or surface water inflow. When the water table is deeper than one meter from the surface, which is normal during the winter, evaporation losses become negligible (Gardner, 1960). Therefore, changes in water stored in the aquifer in the winter reflect the water lost from the perched aquifer by subsurface outflow. The approximate quantity of water lost from the perched aquifer in the spring and summer by subsurface outflow may be estimated by subtracting the water lost in the winter, assuming depth to water table is the same for the experimental time periods.

Water table elevations differed less than one foot for any date for the years of study. Thus, partitioning the water loss from the aquifer into various use categories is possible with additional calculations. Subtracting the subsurface outflow from the measured change in groundwater storage would give evapotranspiration component.

RESULTS

The average depth to the water table of this perched aquifer is about 3 meters, with fluctuations of 3 to 4 meters during a growing season. In March and early April, prior to any vegetative growth, the water table elevation drops slowly. As deciduous vegetation develops in April and May, the rate of water table decline increases. This decline results from an increase in transpiring area and an increase in radiant energy associated with the longer daylight hours. The high water use continues until the monsoon season begins about the middle of July.

Measurements of water table elevation beneath a mesquite stand were used to calculate daily transpiration for various periods. Vegetation, season, and weather affect the magnitude of the daily transpiration fluctuation (Todd, 1959). Maximum drawdown is produced on hot,

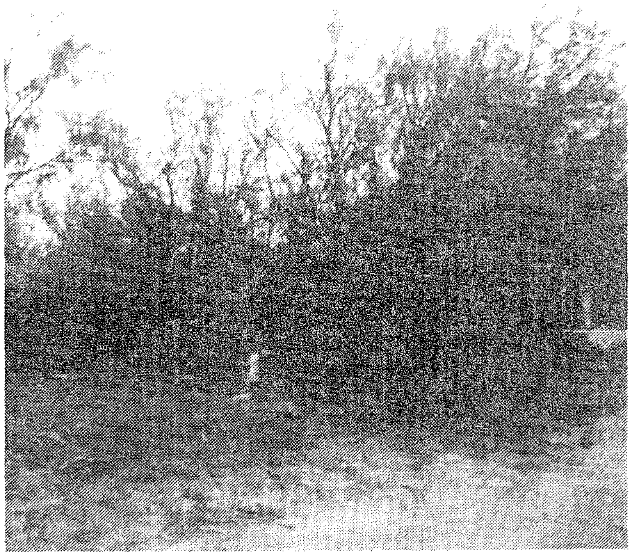

Figure 3, The General Vegetation Characteristics of the Study Area

windy days, while cool, cloudy days show only small variations. These fluctuations stop after killing frosts in the fall. Curve A in Figure 4 represents a period when plants were dormant and diurnal fluctuation was slight. As plant development increased, diurnal fluctuation in water table elevation became increasingly apparent as represented by curves B and C. The diurnal amplitude for a given area and for given climatic conditions related to: (a) stage of plant foliage development; (b) percent vegetal cover; (c) available water in the root zone; and (d) depth to water table.

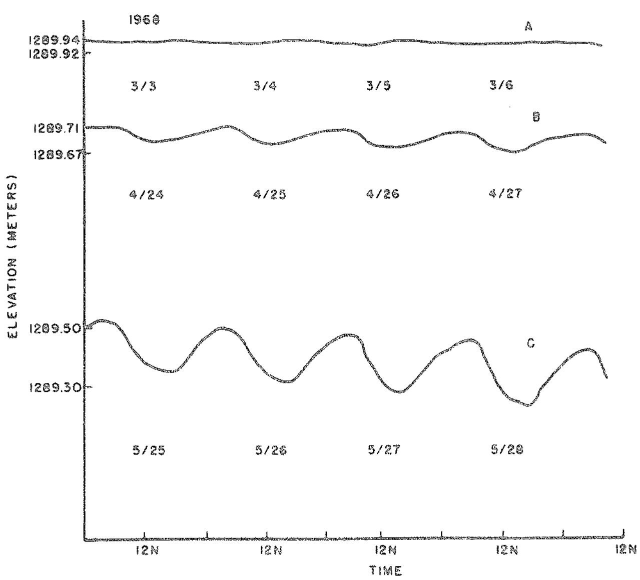

Figure 4, Fluctuations in Water Table Elevation Within the Research Area Surface Elevation was 1294.10 Meters

The vegetation canopy was 80 percent on the research area, as determined from low-level aerial photographs using a dotgrid system.

The water table level is highest in the morning and represents a quasi-equilibrium state between discharge (i.e., abstraction) and recharge from surrounding groundwater. During the day when evapotranspiration is greater than recharge, the water table level falls. Maximum discharge, associated with the steep slope of the drawdown curve, occurs when daily temperatures are highest. The evening minimum elevation represents another equilibrium point. The night-time recovery may be associated with water movement downward from the capillary zone or water movement from cleared or less densely vegetated areas to heavily vegetated areas.

Water loss increased through May and reached a maximum during June (Table 1). The loss was determined using Troxell's modification of the White method (Todd, 1959, p. 1570 from the change in water table elevation and the known porosity of the alluvium material. The loss of 0.11 cm of water by percolation and seepage through the granodiorite bedrock for each day estimated for the winter periods when the vegetation is dormant was then subtracted during other periods to determine the evapotranspiration.

Table 1, Water Loss and Average Evapotranspiration From a Perched Aquifer on Walnut Gulch Experimental Watershed

Date	Water Loss (cm/day)					Average ET (cm/day)
	1965*	1966	1967	Mean	Range	
3/07	---	0.12	0.10	0.11	0.02	---
4/01	---	0.13	0.10	0.12	0.03	0.01
4/17	0.05	0.17	0.16	0.13	0.12	0.02
5/01	0.26	0.25	0.21	0.24	0.05	0.13
5/17	0.51	0.30	0.55	0.45	0.25	0.34
6/01	0.94	0.70	0.90	0.85	0.24	0.73
6/20	---	1.16	1.20	1.18	0.04	1.07

* From Qashu and Evans (1967).

The value of 1.07 cm/day of evapotranspiration during June is of the same magnitude as values reported by Sebenik and Thames (1967) for saltcedar *(Tamarix pentandra)*. They computed evapotranspiration by salt-cedar on an areal basis from the number of shrubs on the area -- 895 shrubs per acre. Their average daily water use was computed to be 1.12 cm/day from July to September. The tent technique as described by Decker, et al., (1962) was used by Sebenik and Thames for obtaining transpiration values. The water table in their study was 2.5 meters below the surface, whereas at Walnut Gulch the depth to the water table was about 4 meters.

Qashu and Evans (1967) in examining water losses in the same study area using the water balance method showed that 0.94 cm/day of water would be lost by transpiration from mesquite during the last week of May and the first two weeks of June 1965 (Table 1). Similar transpiration values were calculated in our study for 1966 and 1967.

Adjusted water use values for mesquite in the Gila River Valley near Safford, Arizona as determined by Gatewood, et al., (1950) were 0.67 cm/day in June for a mesquite stand with 100% volume density. The White method of estimating water use was used in this study. Depth to the water table in the Gatewood study was 3.05 meters.

A relationship between transpiration rates and air temperature is reflected in Figure 5. In mid-April of 1965 the air temperature was below freezing for three nights, and transpiration rates were below the 1966 and 1967 rates for that period. Following the cold period, transpiration increased rapidly with the increasing temperature.

On April 20, 1966, the temperature low was 32°F. The daily transpiration rate decreased following this cold night for about 10 days and then increased as air temperature increased and the vegetation recovered.

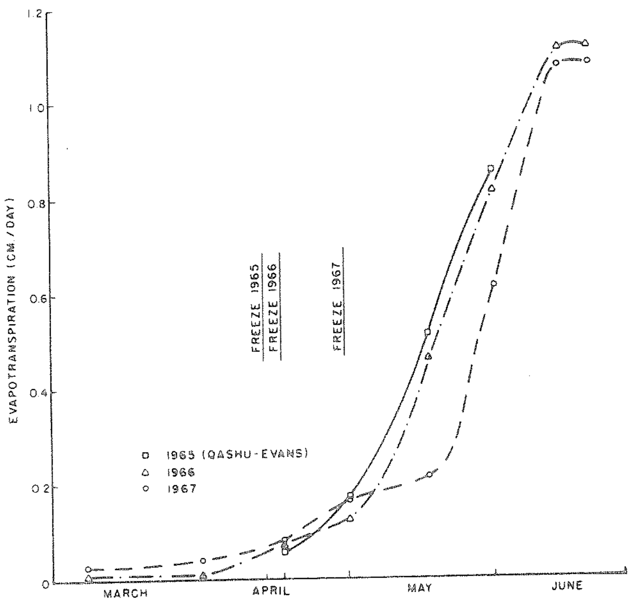

Figure 5, Comparison of Evapotranspiration Rates Showing Variability for Three Years of Study

The effect of low temperatures on transpiration was most apparent in 1967 when three days of freezing temperature occurred on April 30, May 1 and May 2. Effect of this low temperature is readily apparent from Figure 5. Transpiration had started increasing with the advent of warm weather approximately the first of April. But for approximately two weeks following the cold period, there was a definite leveling off of transpiration. This late freeze, which damaged the plant foliage, may account for the general lag in transpiration during 1967 as compared with 1965 and 1966.

Aquifers such as are described here are underground reservoirs of limited area recharged by runoff from the summer monsoon season. The critical period just before the runoff season begins -- when the aquifer supply is lowest and water use by vegetation is highest -- would be important because of its limiting the supply for local water users.

Although mesquite growth is fairly dense above the perched aquifer in the study area, caution should be exercised in extrapolating the water loss data to areas where much larger expanse of mesquite are found. The area surrounding the experimental site is covered by brush stands typical of southeastern Arizona. Thus the study site may have an increased energy input by advection from surrounding areas as opposed to a large area covered by a stand of uniform vegetation. These data are applicable only to mesquite trees having root growth in free water or in the capillary fringe.

SUMMARY

Water table elevations were measured in a riparian mesquite community to determine consumptive use of water.

Water loss per unit area gradually increased during the period of study. In the winter, before foliage development, water loss by deep seepage was estimated at 0.11 cm/day. Water losses from the aquifer gradually increased until they averaged 1.18 cm/day for the first half of June. Subtracting the seepage (0.11 cm/day) from the total water loss gives an estimate of the evapotranspiration. Daily evapotranspiration rates for the first half of June were thus calculated to be 1.07 cm/day.

The relationship between transpiration and freezing air temperature was apparent. The approximate 2-week lag in transpiration rates for 1967 behind those of 1965 and 1966 was apparently caused by the freeze that occurred the first of May.

Amounts of water used in evapotranspiration during maximum loss periods agree fairly closely with those determined by other investigators for Tamarix and for mesquite at other locations.

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