

HYDROLOGY OF SOUTHWESTERN ENCINAL OAK ECOSYSTEMS: A REVIEW AND MORE

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Information about the hydrology of oak ecosystems of the southwestern United States and northern Mexico is lacking (Lopes and Ffolliott 1992, Baker et al. 1995) even though the woodlands and savannas cover more than 31,000 square miles. These ecosystems generally are found between 4,000 and 7,300 feet in elevation. Precipitation occurs in the winter and summer and averages between 15 and 20 inches annually. Soils usually are shallow and rocky and many are classified as Mollisols, Alfisols, and Entisols. The lands are important for rangelands for livestock, tree products, wildlife habitats, and, increasingly, public recreation. Hydrologic information is also important to public and private land managers for planning and assessing the impacts of activities. This includes forest land management plans, landscape fire plans, and other NEPA activities. Water yield augmentation by vegetation manipulations is not feasible in most locations because of high evapotranspiration, but the impacts of past and present management on erosion and sedimentation are a major concern. Lopes and Ffolliott (1992) and Baker et al. (1995) reviewed the hydrology of oak woodlands and the Madrean Archipelago, respectively. While anecdotal information exists, formal research data are uncommon. However, hydrologic and ecological research has been initiated in the oak ecosystems of Arizona and New Mexico. The paper reviews recent published research on segments of the hydrologic cycle including

interception, oak water use, runoff, and sedimentation and provides some new hydrologic information from the Cascabel watershed study.

OAK WOODLAND AND SAVANNA STUDY AREAS

Much of the recent hydrologic research has been concentrated in the San Rafael Valley on the southern slopes of the Huachuca Mountains of southern Arizona and on the Cascabel Watersheds in the Peloncillo Mountains of southwestern New Mexico where scientists from Southwestern Borderlands Ecosystem Management Project of the U.S. Forest Service's Rocky Mountain Research Station and the School of Natural Resources of the University of Arizona are working. The San Rafael and Cascabel sites represent the range of conditions from relatively dense oak woodlands to open woodlands and savannas. The 1973 UNESCO Formation Classification indicates that a woodland contains dominant trees greater than 16 feet tall and a canopy cover of greater than 40 percent, an open woodland has a tree cover of 10 to 40 percent with a grass cover greater than 50 percent, and a savanna is a grassland with a tree cover of less than 10 percent (Barbour et al. 1980).

Differences in stand densities and understory plant characteristics suggest that woodlands and savannas should not be considered as one homogeneous type (Ffolliott and Gottfried 2005). The woodlands in and adjacent to the San Rafael Valley have a relatively homogeneous stocking of approximately 185 trees per acre. Emory oak (*Quercus emoryi*) is the dominant species making up about 89% of the trees and is associated with Arizona white oak (*Q. arizonica*), alligator juniper (*Juniperus deppeana*), and border pinyon (*Pinus discolor*). The elevation is about 5,740 feet. Density at Cascabel is about 90 trees per acre with

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Emory oak constituting 60% of the tree composition. The two areas have a similar mix of tree species. The densities of large trees (9.0 inches at d.r.c (diameter at root collar) and larger) and medium trees (5.0 to 8.9 inches d.r.c.) are greater in the San Rafael Valley than at Cascabel while the stands contain similar numbers of small trees (1.0 to 4.9 inches d.r.c.) (Ffolliott and Gottfried 2005). The elevations range from 5,380 to 5,590 feet.

Herbaceous species on the two areas are relatively similar (Ffolliott et al. 2006). Some of the common grasses are blue and sideoats grama (*Bouteloua gracilis* and *B. curtipendula*), bullgrass (*Muhlenbergia emersleyi*), and Texas bluestem (*Schizachyrium cirratum*). Forbs are a minor component on both sites. Beargrass (*Nolina microcarpa*) and common sotol (*Dasylirion wheeleri*) are common half-shrubs. Pointleaf manzanita (*Arctostaphylos pungens*) is a common shrub that is found scattered throughout the areas. There are two growing seasons in this region of the Southwest. Production of early-growers at Cascabel averaged (with standard error) 137 ± 6 pounds per acre for a three-year period; 69% were grasses. Late-growers averaged 208 ± 8 pound per acre; 76% were grasses. Common measurements for both areas are only available for 2005 when the San Rafael site produced 156 ± 24 pounds per acre of late-growing species while the Cascabel produced 265 ± 12 pounds per acre (Ffolliott et al. 2006).

THE HYDROLOGIC CYCLE

Precipitation

The oak ecosystems of the Southwest have two precipitation periods, winter and summer. Average annual precipitation ranges from 15 to 20 inches. Frontal winter storms pass through the region from November through April producing rain and occasional snow at the higher elevations. Snow commonly does not remain on the ground for a long period after a storm passes. Summer monsoon precipitation, which occurs from July through September, is related to convectional storms that originate in the Gulf of Mexico. These storms often result in high-intensity, short-duration rain events that have been linked to accelerated erosion and sedimentation. The proportion of winter to summer precipitation shifts from southeast to

northwest throughout the region. Areas in south-central New Mexico can receive as much as 70 percent of their annual precipitation during the summer (Martin 1975). Approximately 55 percent of the moisture at Cascabel in southwestern New Mexico falls during the summer. The summer rains coincide with the growing season for most encinal plant species. However, two successive favorable growing seasons with satisfactory precipitation, temperatures, and humidity are necessary to obtain high forage production (Martin 1975).

Interception

Gross precipitation can be partitioned into amounts falling directly on the soil surface and amounts that are intercepted by tree canopies and other vegetation. Water can be retained on the leaves and branches where it evaporates, become throughfall and drip from the leaves, or drain down the stem into the soil and litter below where it evaporates or moves into the soil where most is utilized by the vegetation. A study in the oak woodlands indicates that tree canopies alter the rainfall intensity on the ground and that 70 percent of late summer-early fall precipitation is intercepted (Haworth and McPherson 1991). Throughfall varied from 30 to 100 percent depending on storm and tree size. Rainfall was evenly distributed under a tree canopy for storms greater than 1 inch. Grasses, forbs, and shrubs are important components of the ecosystems and also intercept rainfall. Baker et al. (1995) cite research that reported that the intercepted storage capacity of grasses is proportional to the product of the average plant height and the percent of ground cover.

Transpiration

Water use by Emory oak has been studied in the San Rafael Valley using the heat pulse velocity technique (Ffolliott et al. 2003, Shipek et al. 2004). The study site contained an area harvested by a coppice method that retained both large mature trees (standards) and stump sprouts and a central unharvested stand. Daily water use by mature trees fluctuated with peak water use being related to maturation of leaves and to increased photosynthesis and soil moisture. Average daily water use by mature trees over an 18-month period

was 4.62 gallons. Water use by sprouts remained constant throughout the period and averaged 1.06 gal per day. Similar water use values have been measured for mature Emory oak trees in the savannas at Cascabel.

The individual tree data were extrapolated to a stand basis using the stand inventory. The harvested area contained 174 mature trees and 375 sprouts per acre while the uncut stand contained 183 mature trees and 11 sprouts per acre. The harvested stand used more than 837,000 gallons of water in a year compared to 502,000 gallons for the uncut stand. These values were equivalent to 80 and 45 percent of the annual precipitation, respectively. The numerous sprouts, although they did not individually use much water, were the main reason for the difference between the two areas.

An oak stump (or stool) usually has numerous sprouts. These are often thinned to increase tree growth and decrease the time until a wood product might be harvested. Shipek et al. (2004) studied the water use by 20-year-old sprouts on stumps that had been thinned to one, two, or three sprouts per stool and unthinned stumps that had about 4.5 sprouts per stool. Stumps with one sprout used an average of 1.98 gallons per day compared to the controls which used 9.33 gallons per day. This was equivalent to 34 and 80 percent of the annual precipitation when converted to a total stand basis, including mature trees.

Water use data for the understory herbaceous and shrub species are unavailable although this topic was studied at the Sierra Ancha Experimental Forest north of Globe (USDA Forest Service 1953). Although we do not have the actual data from these studies, graphs comparing water lost from bare soil and used by different plant species or groups of species are available. One finding was that perennial grasses, many of which are common in the oak woodlands, had highest water use in August and September and lowest use during the drought period of May through July. Evergreen shrubs, such as shrub-live oak (*Q. turbinella*), which is not common to the borderlands area, had highest water use in April and May and again in August and September. Relatively deep root systems allow the shrubs to survive extended drought periods. These shrubs used some water throughout the year. Snakeweed (*Gutierrezia* spp.),

a half-shrub, showed high water use in April through early June and in late July through mid-September. Bare soil lost less water to evaporation than plants lost to evapotranspiration but the differences were not large.

Surface Runoff

Runoff from side-slopes in burned and unburned oak woodlands have been studied in rainfall simulator experiments (Stone et al. 2006). Runoff characteristics on the oak sites were influenced by microtopography that consisted of mounds around trees and shrubs and interspaces with grass cover. The interspaces were continuous in a downslope direction and concentrated runoff that efficiently transported sediments from the site. Burned woodland sites had significantly more runoff and sediment movement after a fire than before but erosion rates appeared to approach pre-burn conditions after two years.

Streamflow

There are few gauged encinal oak covered watersheds in the Southwest. Most streams in the oak woodlands are intermittent and only flow after precipitation events. Surface runoff occurs when infiltration capacity of the soil is exceeded. Many woodlands are found on shallow upland soils that do not have much storage capacity and baseflow related to precipitation events appears limited. The potential for water yield augmentation is low because of high evapotranspiration demands. However, runoff from these lands is locally important to ranchers, the recreating public, and wildlife. Runoff from higher elevation coniferous forests passes through many oak woodlands. Watershed management activities are concerned with water quality issues by maintaining or improving watershed condition and reducing erosion. In this respect, peak runoff events are probably more important than the amount of streamflow.

A Water Balance for Oak Woodlands

Ffolliott (2004) developed a water balance for Emory oak woodland stands based on previous research conducted in the Southwest. Many of the results of this research have been reviewed above. Ffolliott (2004) extrapolated an average annual interception value of 10 percent for oak woodlands

based on the research by Haworth and McPherson (1991). He estimated long-term frequency of large and small storms in a year and assumed negligible interception by other plants or stemflow. Ffolliott estimated infiltration into the soil as 72 to 77 percent of the total annual rainfall. The resulting budget is presented in Figure 1. It indicates that between 4 and 10 percent of the annual precipitation becomes streamflow and that between 34 and 77 percent of the precipitation is lost through transpiration.

CASCABEL WATERSHED STUDY

The Cascabel Watersheds provide an excellent laboratory to learn more about the hydrology of the oak savanna and open woodland ecosystems. The study was started in 2000 to determine the effects of cool season (November-April) or warm season (May-October) prescribed burning on the hydrology, erosion, and sedimentation dynamics of oak savannas in the Southwestern Borderlands (Gottfried et al. 2000).

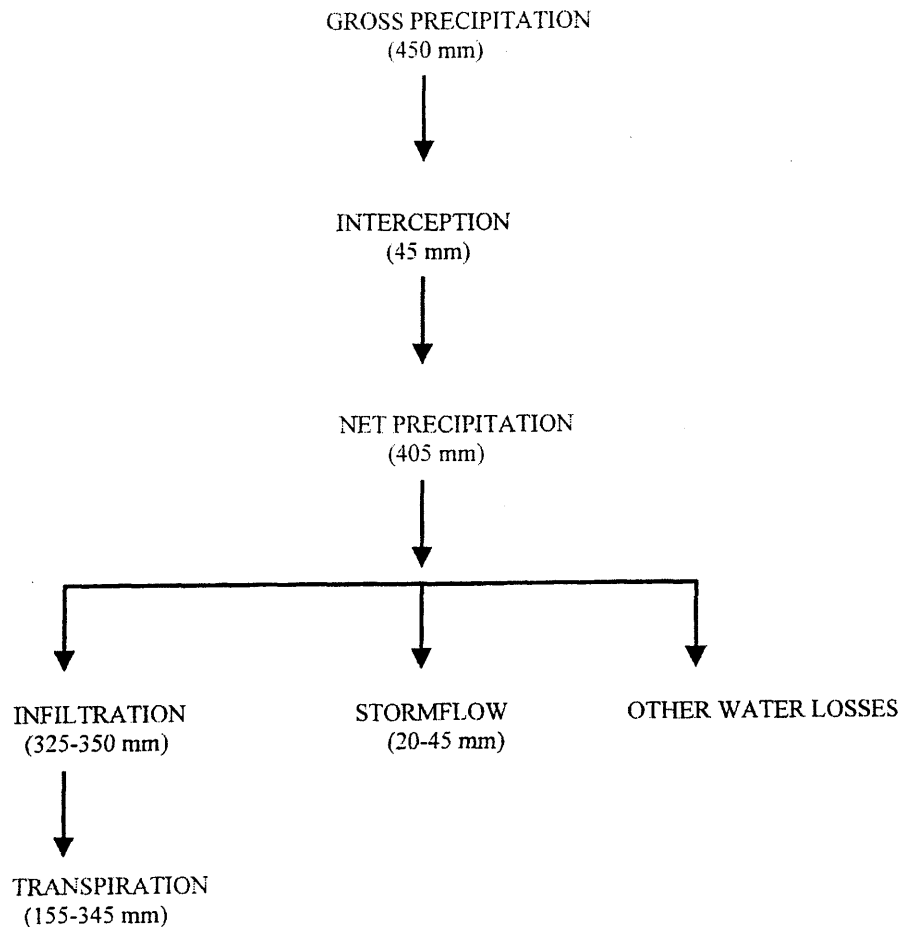


Figure 1. Annual water budget for selected management practices in the Emory oak woodlands of southeastern Arizona (Ffolliott 2004).

The effort was in response to questions raised during the preparation of the Peloncillo Programmatic Fire Plan by the Coronado National Forest and its partners. The main objective is to conduct an ecosystem study that examines the effects of burning season on as many resources as possible. A secondary objective is to learn more about the basic hydrology of this oak ecosystem since such information is lacking and has been requested by land managers (Gottfried et al. 2006, Gottfried et al. In Press). The Cascabel data set is relatively large and continues to be refined and analyzed.

Study Area

The 12 Cascabel Watersheds are located on the eastern side of the Peloncillo Mountains and west of the Animas Valley of southwestern New Mexico. They are within the Douglas Ranger District of the Coronado National Forest and adjacent to the Diamond A Ranch. The study area covers approximately 451 acres with individual watersheds ranging from about 19 to 59 acres. The watersheds being studied are located along an east-west ridge with six draining to the south into Whitmire Creek and six draining to the north into Walnut Creek (Figure 2).

Cascabel Watershed Boundaries

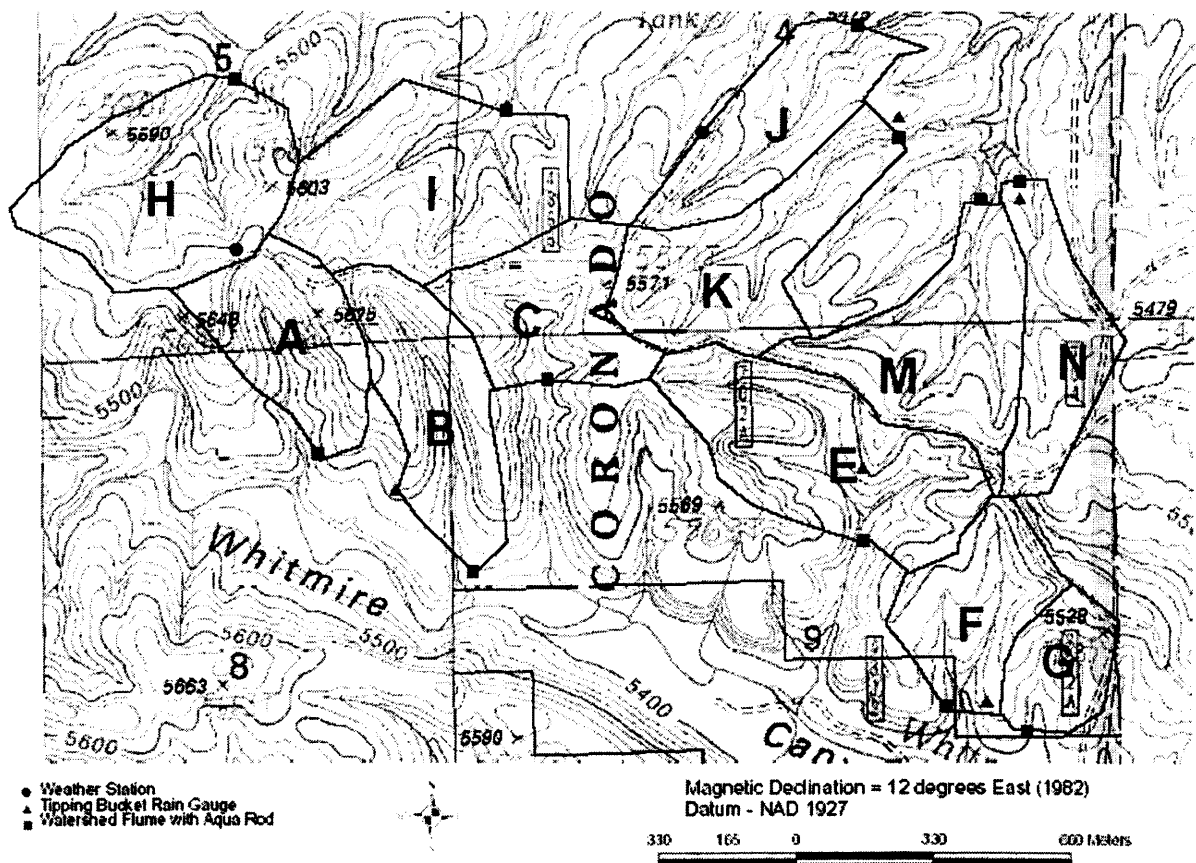


Figure 2. The watersheds are located along an east-west ridge with six (Watersheds A, B, C, E, F, and G) draining to the south into Whitmire Creek and six (Watersheds H, I, J, K, M, and N) draining to the north into Walnut Creek.

A cluster analysis of peak flow data was conducted to find similarities among watersheds. Aspect did not have a strong signature in the similarity pattern, so it was concluded that the relationship between aspect and peak flow was not strong. The watersheds were divided into four groups of three and potential treatments were assigned randomly; one watershed in each group will be burned in the cool season, one in the warm season, and one will remain unburned as a control. Annual precipitation at the Cascabel Ranch headquarters gauge from 1981 through 2004 averaged (with standard error) was 21.8 ± 1.2 inches, with about 53 percent occurring during the summer.

The geology and soils information for the watershed area has been described by Gottfried et al. (2000, 2006), Youberg and Ferguson (2001), and Robertson et al. (2002). The bedrock geology is described as Tertiary rhyolite lava overlain by Oligocene-Miocene conglomerates and sandstone. Rhyolite is more apparent on the three western watersheds. Soils on the watersheds have been classified as Lithic Argustolls, Lithic Haplustolls, or Lithic Ustorthents (Robertson et al. 2002). Soils generally are less than 20 inches deep to bedrock. Streams on the north side of the central ridge have longer, lower gradient channels than those on the south side. This difference might be related to the geomorphology of the two major creeks that border the study area, specifically, to their relative sizes, lithologic changes, and relative location with respect to the central ridge (Youberg and Ferguson 2001). Whitmire Creek to the south is closer to the ridge than Walnut Creek which is to the north of the study area.

METHODS

Streamflow and Precipitation

Each of the 12 watersheds contains a 9-inch Parshall flume with a capacity of 4.03 cubic feet per second (cfs) to measure common low flows and a larger 3-foot or 4-foot flume with capacities of either 42.7 or 57.5 cfs, respectively. These values assume that the flume is running at 90% of full depth. The flume size was determined from pre-installation calculations based on a 10-year return interval and a 2.8-inch rain event within 24 hours (Gottfried et al. 2000). The small flumes were converted to Replogle long-throated flumes

in 2005 to increase their accuracy to measure low flows. Pre-treatment calibration of the flumes began in 2001 and continues because the prolonged regional drought initially limited the number of flow events available to compare runoff peaks among watersheds. However, the minimum number of storms for analysis has been reached because of the relatively wet summers in 2005 and 2006 and the first fires will be ignited when conditions permit.

Two weather stations were established, one at the western edge of the area (Hcascab) and one on a north-facing side-ridge in the middle of the area (J2cascab). These stations measure several variables including precipitation, wind speed, humidity, and temperature. They are supplemented by six recording tipping bucket precipitation gauges located throughout the area.

Sediment

Sediment is measured at a sediment dam and basin on each watershed. The dam walls are about 2 to 3 feet in height and are tied into the channel walls. Every dam wall contains an opening to minimize streamflow retention. Each basin usually contains 11 surveying lines that are tied to a permanent benchmark. These are measured periodically using a surveyor's level and rod. Volumes and volume differences between periods are calculated using the WinXSPRO program (Hardy et al. 2005) and the average end area method (Dendy et al. 1979). Pebble counts have been made of surface deposits behind the sediment dams.

Side-slope erosion is measured at a series of three-pin groups located on five transects in each watershed that are orientated perpendicular to the main channels within each watershed. Erosion pins are measured in the spring and fall. Local bulk density measurements were used to convert measurements of average soil loss to erosion rates in terms of tons/acre (Kauffman et al. 2007). In addition, each watershed has a series of permanent channel cross-sections that are measured with a level and rod but these data are not reported here.

RESULTS

Precipitation

The J2 weather station is situated in the middle of the area. The record includes complete data for years 2002 through 2006 (Figure 3). Although the Southwest has been in an extended drought period for more than seven years, wet periods do occur. During the five-year period, the gauge measured an average of 15.99 ± 2.77 inches of precipitation, 8.57 ± 2.13 inches, or 54 percent of the total, occurred in the July through September growing season. Summer precipitation was about 43 percent of the total during the three driest years but was 53 and 75 percent during the two wettest years.

Summer precipitation is often characterized by short-duration, high-intensity rainstorm events. The storm of August 23, 2005 is such an example. It began at 12:00 hours and came from the northwest. The storm and some of its characteristics and resulting streamflow have been reported by Gottfried et al. (2006). Total 24-hour precipitation values ranged from 1.36 inches at the southeastern tipping bucket gauge on the border between Watersheds F and G to 2.99 inches at Watershed I. Rainfall intensities, expanded to an hour basis, ranged from 1.52 to 3.31 inches per hour. The two gauges at the eastern end of the study area recorded the least precipitation and the smallest rainfall intensities, and the storm started between 9 and 21 minutes later there.

Streamflow

The streamflow responses to storms are also variable. Differences can be attributed to storm characteristics, watershed size and characteristics, soil depth and textures, bedrock geology and geomorphology and location with respect to a storm track. This variability has been observed at Cascabel. Fifty-one peak runoff events have been recorded by at least one of the 12 watersheds since 2001 (Figure 4). Between 70 and 80 percent of the storms have been recorded on Watersheds C, and E on the south-facing slope and Watersheds I, and K on the north-facing slope. These four watersheds are all situated in the middle of the area and appear to be influenced by storms passing to the east and west of the area. The straight-line distance between the northwestern corner of Watershed A and the

northeastern corner of Watershed G is about 1.8 miles. Watersheds A and B at the southwestern end of the area and F and G at the southeastern side appear to flow less often and might not be influenced by as many storms, although this needs additional evaluations.

The cluster analysis indicated that aspect alone does not explain peak flow differences among watersheds. Highest average peaks were recorded on Watersheds E, I, and K. Watershed K had the largest average peak flow (with standard error) of 7.88 ± 2.35 cubic feet per second (cfs) based on 38 events since 2001. The smallest average peak flow of 2.92 ± 1.36 cfs was measured on Watershed N based on 30 events.

Runoff related to the large storm of August 23, 2005 has been discussed by Gottfried et al. (2006). The high-intensity storm produced larger peak flows than were anticipated in analyses conducted prior to flume construction. However, anecdotal evidence reported by local ranchers indicates that such storms are more common than expected. Antecedent soil water probably was relatively high before the storm; approximately 1.80 inches of rain occurred in July and about 5.58 inches of rain fell between August 3rd and 22nd. Streamflow on four of the watersheds overtopped the large flumes and had to be calculated from channel and slope characteristics. The highest peak streamflow was calculated at 77 cfs on Watershed H and the smallest, 32 cfs, was measured at Watershed F.

Data for the storm from Watersheds A and I also indicate the variable hydrologic responses within the oak savannas, even for two watersheds that are situated in close proximity. These two watersheds were studied more intensively by Gottfried et al. (2006) because of the quality of the record and the relative concentration of precipitation gauges. However, data from the two areas were not compared statistically. Watershed A, which drains to the south, covers 31.5 acres and is located at an average elevation of 5,550 feet. The channel is 1,378 feet long (Neary and Gottfried 2004) and has a slope of 5.6%. Side slopes, based on map measurements, average about 23%. The average peak flow is 4.39 ± 2.89 cfs based on 23 events. Watershed I, which drains to the north, covers 52.4 acres and has an average elevation of 5,530 feet. Channel length is 5,320

PRECIPITATION AT J2 CASCABEL WEATHER STATION

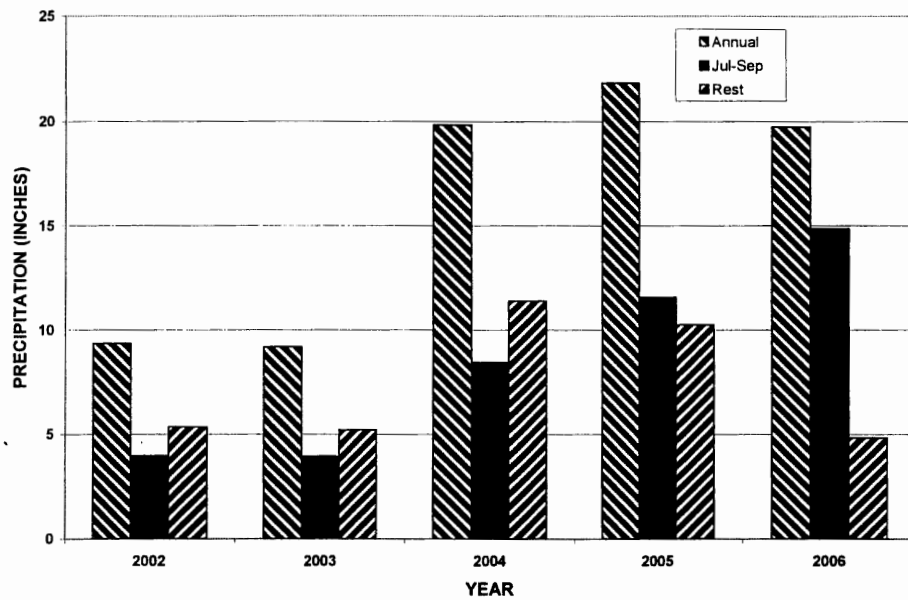


Figure 3. Annual and seasonal precipitation recorded at the J2 weather station at Cascabel in the Peloncillo Mountains of New Mexico.

PERCENT OF FIFTY-ONE PEAK FLOW EVENTS MEASURED ON EACH WATERSHED

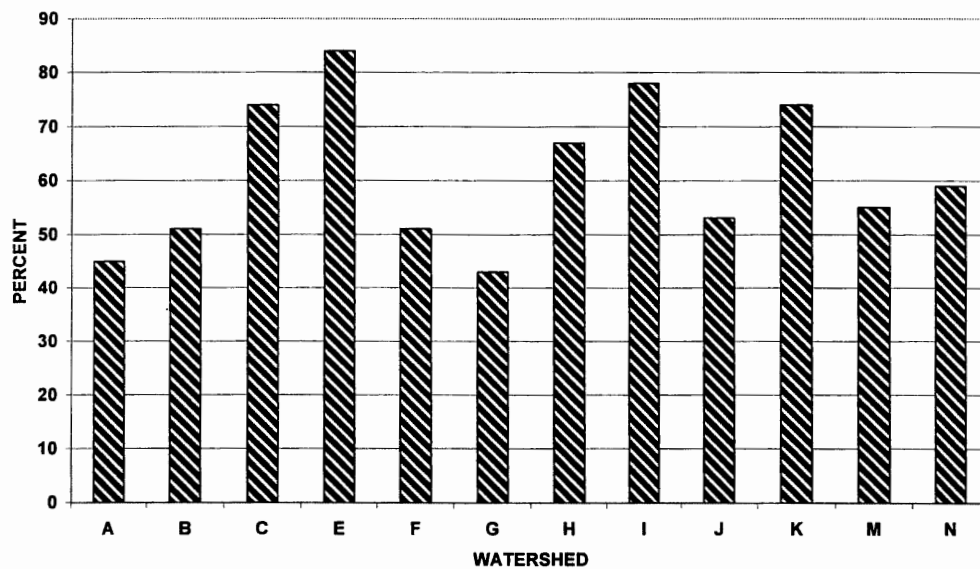


Figure 4. Percent of the 51 runoff events recorded at each of the Cascabel Watersheds from 2001 through 2006.

feet and channel slope is 3.8%. Side slopes average 17%. The average peak flow for the period of record is 7.12 ± 2.02 cfs based on 40 events. Watershed A recorded a peak flow of 67.2 cfs. The data for Watershed I were reanalyzed and now indicate a peak flow of 66.8 cfs.

Preliminary precipitation-runoff power regression curves from the two watersheds were developed for the entire record. They showed that Watershed I responds to relatively small storms of between 0.25 and 0.50 inches and that the hydrograph rises rapidly. Watershed I is one of the more responsive watersheds (Figure 4). Watershed A starts responding after 0.50 inch of precipitation and rises slowly but eventually produces a larger peak than Watershed I at precipitation amounts of between 2.20 and 2.25 inches. An indication of the different responses is the relative number of events recorded at each station (Figure 4). The slow response of Watershed A occurs even though it has a shorter channel length and greater channel slope than Watershed I.

There are several factors that might account for the differences. Differences in soil characteristics are one potential factor. The soils on Watershed I are Lithic Argiustolls that are well-drained and have an argillic layer that is between 2 to 15 inches thick (Robertson et al. 2002). The clay content in this horizon averages 38 percent. Watershed A contains a relatively large area of Lithic Ustorthent soils that are adjacent to the lower channel. This soil has a sandy-loam control section with an average clay content of 8 percent. Water infiltration into clay dominated horizons, such as those at Watershed I, is generally low and would provide for more rapid horizontal movement of water on top of the layer into the channels. Greater infiltration rates into and through the soil would delay the initiation of streamflow.

Geology, channel substrate, and vegetation are important factors influencing streamflow, base flow, and the availability of sediments for transportation. The channel in Watershed I contains 16 percent rock and 74 percent coarse alluvium (Neary and Gottfried 2004). The channel on Watershed A consists of 6 percent rock and 62 percent coarse alluvium. The greater amount of rock and impervious material in the channel would contribute to a more rapid streamflow response to

rain than from a more pervious channel where wetting and storage in the substrate is important. There also appears to be less surface rock cover on Watershed A (11.4 percent) than on Watershed I (16.0 percent) (Traphagen 2007). Vegetation differences, because of transpiration, affect soil water conditions and speed of soil water recharge. Robertson et al. (2002) report that the Lithic Ustorthents soils in the center of Watershed A apparently support a greater percent tree crown cover (20 percent) than the Lithic Argiustolls soil on Watershed I where tree cover is 11 percent. Other differences in percent rock, litter, and vegetation cover and understory production on the two watersheds have been determined by Robertson et al. (2002) and recent surveys by the University of Arizona. The differences in soils, geology, vegetation, and antecedent soil water contribute to streamflow characteristics but these remain to be studied further.

Erosion and Sedimentation

Erosion is the process of dislodging and moving soil particles from the soil surface by water or wind and sedimentation is the product of erosion. Data from watersheds A and I provide an insight into the processes in an oak savanna. Side-slope measurements were made after the winter of 2004-2005 and after the summer monsoons of 2005. Watershed A lost 20.7 tons per acre for the two periods while Watershed I lost 22.3 tons per acre (Gottfried et al. 2006). The two values appear similar, although they were not compared statistically. The difference between the two areas is related to the period when the losses occurred. Watershed A lost equal amounts in both periods while Watershed I lost 79 percent during the winter of 2004-2005. This could reflect the larger winter flows that occurred on Watershed I and the possibility that less detachable and transportable soil remained when the summer storms occurred. Sediment measurements behind the dams for the period from 2003 through 2006 indicate accumulations of 347.4 cubic feet for Watershed A and 190.3 cubic feet for Watershed I (Gottfried et al. 2006). Most of the material measured at the surface of the sediment accumulations behind the dams was sand and gravel but gravels were almost twice as common on Watershed I (62 percent) than

on Watershed A (33 percent). The reverse is true for sand accumulations. These differences reflect different soil and geological conditions and could represent differences in vegetation and local rainfall distribution. A recent herbaceous understory inventory showed that Watershed A contained 66 pounds per acre of understory biomass while Watershed I had 91 pounds per acre, but this is probably not enough to affect erosion.

SUMMARY

There has been little information about the hydrology, erosion, and sedimentation characteristics of oak savanna ecosystems that cover wide areas in the southwestern United States and northern Mexico. This paper reviews recent literature about the hydrologic cycle for these dryland woodlands and savannas. Much of the recent information is about interception by tree canopies and water use by mature oak tree and post-harvest tree sprouts. Ffolliott (2004) integrates the information and extrapolated that streamflow is between 4 and 10 percent and transpiration is between 34 and 77 percent of the average annual precipitation.

Research at the Cascabel Watersheds is providing comprehensive data sets about precipitation, streamflow, erosion and sedimentation in a typical oak savanna ecosystem. Other ecosystem information about vegetation, wildlife populations, and soil nutrient dynamics is being collected as well. Streamflow and precipitation data reflect the inherent variability within these lands. Even watersheds that are in the same locality may react differently to a precipitation event. Variability occurs both yearly and seasonally and is influenced by storm patterns and characteristics and by watershed features including watershed geology, geomorphology, soil, and vegetation characteristics. The high-intensity storm of August 23, 2005 was an extreme event but could have been more common than anticipated. The information from Cascabel about common long-term average and extreme events should be applicable to similar watersheds throughout the region and could be used, with caution, when planning and evaluating management activities.

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