Appendix 8—Comparison of Meteorological Forcing at Three Riparian Sites

Three meteorological towers maintained by Fort Huachuca have been in operation since the fall of 2000 to monitor basic variables (air and soil temperature, relative humidity, wind speed, wind direction, air pressure, solar radiation, and precipitation) within the San Pedro Riparian National Conservation Area (SPRNCA). These towers are near the Palominas (elevation 1,290 m), Lewis Springs (elevation 1,240 m), and Charleston mesquite (elevation 1,200 m) biohydrology sites. The towers collect data to help understand how meteorological forcing, one of the primary drivers for the vegetation water use, varied within the SPRNCA. A previous model to determine SPRNCA water use (Goodrich, Scott, and others, 2000) assumed that the forcing measured at the Lewis Springs site as part of an earlier study could be used for the entire SPRNCA water-use calculations. A comparison, detailed in the following discussion, was carried out to determine if this was an accurate assumption.

Air temperatures were measured from 2001 through 2003 at 3 m above ground at the Charleston mesquite site and 2 m above the ground at the Palominas and Lewis Springs sites. Mean daily temperatures were quite similar across all sites, though the Charleston mesquite site was generally cooler than the higher elevation sites (fig. 8-A). Minimum daily temperatures at the Lewis Springs and Charleston mesquite sites were consistently lower than at the Palominas site, perhaps reflecting the increasing influence of nocturnal, cold air drainages further down the valley. The Palominas site usually experienced higher daytime maximum temperatures than the other sites. Likewise, the cumulative growing degree days from March 1–October 31, calculated by summing up the departures of mean daily temperature from 10°C, also reflect that the Charleston mesquite site was the coolest and the Palominas site was the warmest (table 8-A).

Although there were some significant differences in the temperatures, the different site characteristics probably had a microclimatic influence on these results. Charleston mesquite site temperatures were measured at 3-m height inside the mesquite woodland. Lewis Springs site temperatures were measured at 2-m height on a tower surrounded by a mesquite shrubland, and temperatures at the Palominas site were measured at 2-m height over an abandoned agricultural field. All the above site-temperature differences, except those for nighttime minimum temperature, could arguably be attributed to the differences in vegetation cover. Finally, the first freeze events of fall and the last freeze events of spring were remarkably similar across all sites (table 8-B). This likely was due to the influence of large-scale frontal air masses which are primarily responsible for the import of cold arctic air into the area. This final result probably is the most important result for riparian water use because the length of growing season almost entirely constrains the water use of the mesquite and, possibly, the water use of other important vegetation communities.

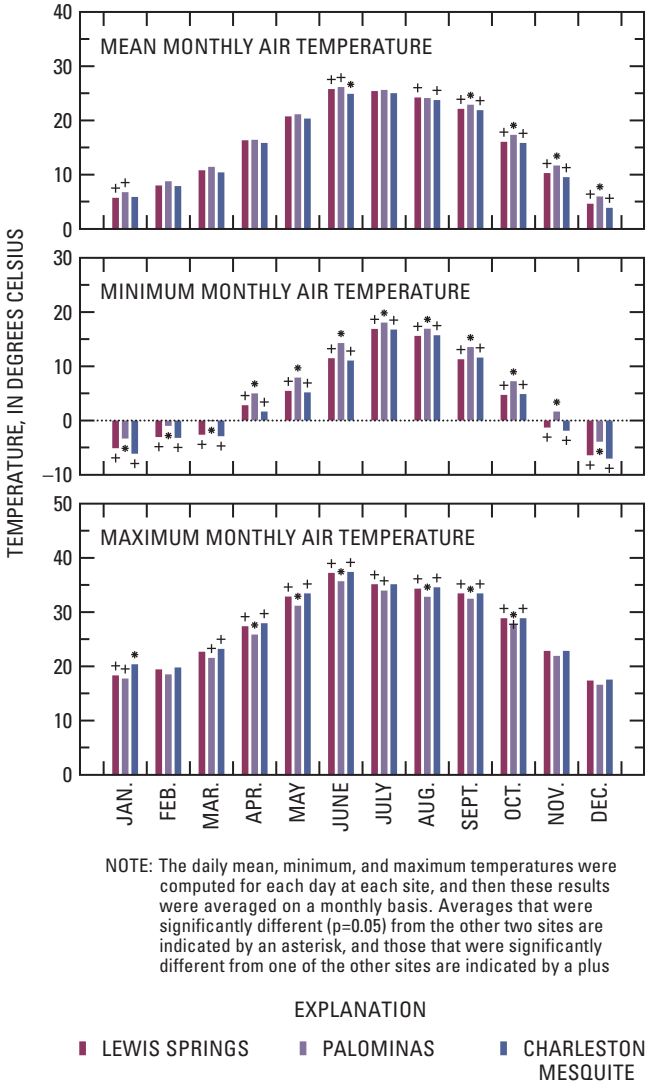

Figure 8-A. The 2000–2003 average monthly mean, minimum, and maximum daily air temperatures for the Lewis Springs, Palominas, and Charleston mesquite site meteorological stations, San Pedro Riparian National Conservation Area, Upper San Pedro Basin, Arizona.

Table 8-A. Growing degree days from March 1 to October 31, San Pedro Riparian National Conservation Area, Upper San Pedro Basin, Arizona

Year	Site		
	Lewis Springs	Palominas	Charleston mesquite
2001	2364	2439	2232
2002	2553	2650	2382
2003	2564	2718	2437

Table 8-B. Day of year of the last freeze of spring and first freeze of fall for all meteorological sites, San Pedro Riparian National Conservation Area, Upper San Pedro Basin, Arizona

[DOY, day of year]

Year	Site					
	Lewis Springs		Palominas		Charleston mesquite	
	Last freeze (DOY)	First freeze (DOY)	Last freeze (DOY)	First freeze (DOY)	Last freeze (DOY)	First freeze (DOY)
2001	126	286	125	288	126	286
2002	142	277	123	277	142	277
2003	132	299	108	300	131	300

Although there were small differences in air temperature within the SPRNCA, the greatest differences were found between the riparian area and the area outside of the riparian valley (fig. 8-B). For example, minimum daily temperatures at the Fort Huachuca meteorological support office (elevation of 1,422 m) were much warmer (more than 10°C during many months) than at the Lewis Springs site. This resulted in a higher mean temperature despite the higher elevation and the cooler maximum temperatures at Fort Huachuca. Future studies that employ ecohydrological models driven by meteorological forcing should use data collected within the riparian valley or use these data to build regression relationships with stations outside of the riparian valley.

Reference crop evapotranspiration (ET_o, Brown, 1989; http://ag.arizona.edu/azmet/et2.htm) was computed using the temperature, relative humidity, solar radiation, and wind speed to compare how atmospheric evaporation demand varied along the river. There were only slight differences between ET_o at the Lewis Springs and Charleston mesquite sites, but at the Palominas site, ET_o was considerably higher (fig. 8-C and table 8-C). Differences in wind speed between the sites (mean wind speeds were about 50 percent higher at the Palominas site) were primarily responsible for the differences in ET_o.

In conclusion, there were some small differences in the meteorological forcing between the sites. Mean daily temperatures differed between the sites with nighttime temperatures increasingly cooler down the river valley, but the last freeze of spring and the first freeze of fall differed little. Since these freeze events constrain much of the vegetation activity within the SPRNCA, the growing season length, which largely determines the total water use within a year, is similar for most of the ground-water-using plants within the riparian valley. This lends some support to this study's major assumption that the water use at the measurement sites was representative of the major vegetation communities within the SPRNCA. Yearly ET_o at the Palominas site was about 5 percent higher than at the other two sites owing to higher winds found at this less-sheltered site, but we do not believe that this difference was large enough to warrant the need for many additional monitoring sites nor the need to use a distributed modeling approach to estimate open-water evaporation.

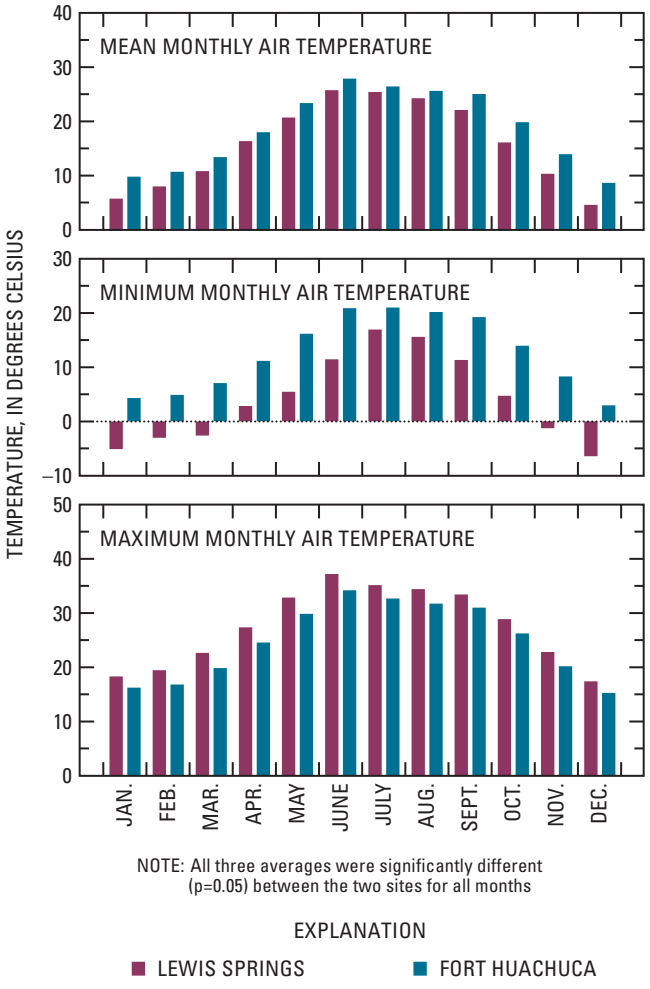

Figure 8-B. The 2001–2003 average monthly mean, minimum, and maximum daily air temperatures for the Lewis Springs site and Fort Huachuca meterological stations, San Pedro Riparian National Conservation Area, Upper San Pedro Basin, Arizona.

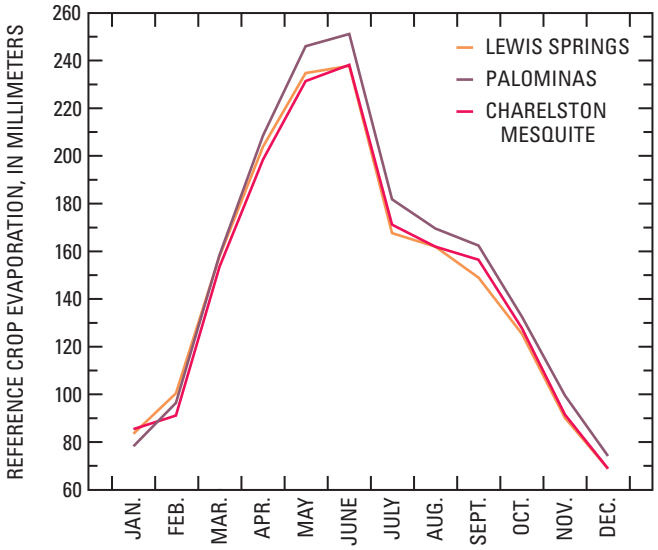

Figure 8-C. The 2001–2003 average total monthly reference crop evaporation (ET_o) computed using the Arizona Meteorological Network method for the Lewis Springs, Palominas, and Charleston mesquite sites, San Pedro Riparian National Conservation Area, Upper San Pedro Basin, Arizona.

Table 8-C. Average total monthly reference crop evapotranspiration (ET_o) for 2001–03 computed by using the Arizona Meteorological Network method, San Pedro Riparian National Conservation Area, Upper San Pedro Basin, Arizona

Month	Site		
	Lewis Springs (centimeters)	Palominas (centimeters)	Charleston mesquite (centimeters)
January	8.4	7.8	8.6
February	10.1	9.6	9.1
March	15.8	15.9	15.4
April	20.3	20.8	19.8
May	23.4	24.5	23.0
June	23.7	25.0	23.8
July	16.7	18.1	17.1
August	16.1	16.9	16.1
September	14.8	16.2	15.6
October	12.6	13.3	12.8
November	9.0	10.0	9.1
December	6.9	7.5	6.9
Total	177.8	185.6	177.4