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# AN OVERVIEW OF THE 1997 ACTIVITIES OF THE SEMI-ARID LAND-SURFACE-ATMOSPHERE (SALSA) PROGRAM

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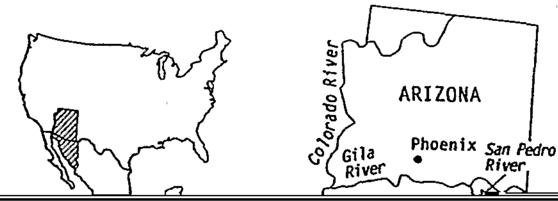
## 3. THE STUDY AREA




The Upper San Pedro Basin (USPB) was identified as the focal area for initial SALSA research during the 1995 workshop. The riparian system in the U.S. portion of the USPB is the first Congressionally designated National Riparian Conservation Area. The basin embodies a could be made of the value of integrating and assimilating both remotely sensed and *in-situ* observations (Toth et al., this issue).

Experimental surface observations were obtained from a variety of existing data collection networks. These include intensive monitoring at the 148 km$^2$ USDA-ARS Walnut Gulch Watershed (85 raingages, 30 runoff measurement sites, two sites with energy and CO2 flux, meteorology, vegetation and soil moisture measurements; Renard et al., 1993), meteorological data collection by the US Army at Ft. Huachuca, and five USGS stream gaging stations.

In addition, several new intensive research and data collection sites were established during 1997 in areas having sparse desert grass cover in Mexico at Morelos and Zapata (see Figure 1). A wide variety of *in-situ* and remotely sensed data are being collected at these sites to address ***objective two***. These measurements include meteorology, energy and CO2 fluxes, soil moisture, vegetation sampling, and surface reflectances

In addition to the continuous measurements, intensive synoptic in-situ and remote measurement campaigns of 32 to 56 hours were conducted in March, April, June, August, and October. This period spans the pre-green up and growing season to allow for characterization of the seasonal variations in evapotranspiration, and surface water - groundwater interactions. Measurements taken during the synoptic runs included hourly stream stage and water levels from five river sections and the piezometer network, stream discharge measurements determined by current metering, dye-dilution, and an in-stream flume for the June campaign (see summary by Maddock et al, this issue). Neutron probe measurements of soil moisture were made during synoptic runs and other periods of dynamic change. Treesap flow, water potential, stomatal conductance, and water sources using stable oxygen and hydrogen isotope ratios were determined for mesquite, cottonwood, and willow during each of the synoptic campaigns to capture variations in transpiration demand commensurate with the resolution of the RAMS mesoscale model. The period of these measurements and those described above are summarized in the following Activity/Data Collection Chart (Table 1).

flux in the riparian zone, but only if the regional fluxes are accurate. Toward this end several alternative surface parameterizations are being evaluated in RAMS, including the SiB2 scheme (Harlow et al., this issue). In the same measurements to estimate the evaporative water loss over the USPB riparian corridor. These evapotranspiration losses had a significant impact on both stream discharge and near stream groundwater levels (MacNish et al., this issue). Prior to green-up and inputs from storm flows, discharge at both Lewis Springs and the Charleston gage were very stable. After green-up of the cottonwoods and willows, stream discharge decreased and a distinct diurnal pattern in stream discharge was apparent.

Initial results also indicate that diurnal and seasonal variations in stomatal conductance and transpiration in cottonwood and willow were strongly influenced by radiation inputs and vapor pressure deficit (VPD). Transpiration fluxes at Lewis Springs were about 12% lower during the June observation period compared to that in August, which was proportional to differences in VPD. Water potential gradients between the rhizosphere and leaf during maximum transpiration, however, were higher in June than in August, suggesting that hydraulic conductivity of trees may have increased over the growing season. Stable isotope analysis revealed that cottonwood along the river at the perennial Lewis Springs site used only groundwater and did not take up surface water even following a large rain and flood event in August. Mesquite at this site likewise used mostly groundwater over the growing season, but shifted to predominantly surface water usage at an intermittent section of the stream (Boquillas site, Figure 1) following the monsoon rains (Williams et al., this issue). Further from the river (100-300 m) at Lewis, initial findings indicate that mesquite and sacaton did not use groundwater (Scott et al., this issue). These data, taken together, illustrate the complex nature of plant controls on ecosystem water fluxes within desert riparian ecosystems.

Initial results related to ***objective four*** indicate that sensible heat flux estimates from the 3-D sonics and scintillometer compare well over uniform terrain in both the U.S. and Mexico. Good comparisons were also obtained between the scintillometer and a weighted average sensible heat fluxes derived from the 3-D sonics over the mesquite-grass transect at Lewis Springs. In this case, this implies that a simple aggregation rule can provide good results (Chehbouni et al., this issue).

Results related to ***objective five*** indicated a 35% decrease in the grasslands, an 11% increase in desert shrubs, and a 50% increase in woodlands over a large area of the USPB in the 13- year span between 1974 and 1987. The grasslands also became much more fragmented with the number of grassland patches increasing 61% while the average patch size of the grasslands decreased 60%. These changes will have different implications for habitat suitability for various species due to differences in life history and scale requirements (i.e. patch size). However, for large grazing mammals such as the Mexican pronghorn the changes appear to be quite severe with an estimated 70% reduction in suitable habitat (Kepner, et al., 1995).

In conclusion it should also be noted that the SALSA Program activities have broken new ground in the approach to large-scale multidisciplinary science where challenges, of such complexity, as to require the joining of disciplinary forces to address them. Careful attention to fostering interdisciplinary communication built the foundation for trustful collaborations. This enabled unselfish sharing of numerous small grants and in-kind resources to accomplish a goal which is much greater than the sum of the disciplinary parts. An additional driving force behind the SALSA Program's success is the knowledge that the results of this research will directly aid land managers and decision makers in the near term.

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## 7. REFERENCES

Goodrich, D. C., 1994: SALSA-MEX: A Large Scale Semi-Arid Land-Surface-Atmospheric Mountain Experiment. Proc. 1994 Intern. Geoscience and Remote Sensing Sym. (IGARSS'94), Pasadena, CA, Vol. 1, Aug. 8-12, p. 190-193.

Kepner, W., K. Riitters, and J. Wiickham. 1995: A landscape approach to monitoring and assessing ecological condition of rangelands-San Pedro River case study. Proc. Symp. EMAP Science, Chapel Hill, NC, March 7-9, 1995. U.S.-EPA, Environ. Monitoring and Assessment Prog., Research Triangle Park, NC.

Renard, K. G., Lane, L. J., Simanton, J. R., Emmerich, W. E., Stone, J. J., Weltz, M. A., Goodrich, D. C., and Yakowitz, D. S., 1993: Agricultural impacts in an arid environment: Walnut Gulch case study. *Hydrological Science and Technology*, 9(1-4):145-190.

Wallace, J., 1995: Multidisciplinary Program Studies Land-Atmosphere Interactions in Semi-Arid Regions, *EOS, Transactions, American Geophysical Union*, 76(46), 465-469.

the southwestern United States. *Water Resources Research*, 29(4):1287-1295.

*7.1* *References in this Issue*

Arias, H.M., C. Watts, I. Parra, T. Maddock III, and R. MacNish, SALSA: An international integrated effort to aid in addressing socio-economic issues in the Upper San Pedro River Basin.

Bégué, A., D. Luquet, J. Dauzat, Y. Nouvellon, and H. Rey, Vegetation hemispherical fluxes calculated from 3d computerized vegetation canopies and ray tracing technique: application to a semi-arid grassland.

Chehbouni, A., O. Hartogensis, L. Hipps, J-P. Brunel, C. Watts, J. Rodriguez, G. Boulet, G. Dedieu, Y. Kerr, and H. De Bruin, (a) Sensible heat flux measurements using a large aperture scintillometer over heterogeneous surfaces.

Cooper, D.I., W. Eichinger and L. Hipps, Spatial properties of water vapor scalar and flux over a riparian corridor.

Harlow, C., J. Toth, and J. Shuttleworth Evaluation of the SIB2 surface scheme in a semi-arid region.

Hipps, L.E., D. Cooper, W. Eichinger, D. Williams, S. Schaeffer, K. Snyder, R. Scott, A. Chehbouni, C. Watts, O. Hartogensis, J-P. Lhomme, B. Monteny, J-P. Brunel, G. Boulet, J. Schieldge, H. De Bruin, J. Shuttleworth, and Y. Kerr, A summary of processes which are connected to evaporation of riparian and heterogeneous upland vegetation in arid regions.

MacNish, R., C. Peters, M. Schulte, D. Goodrich, D. Pool, T. Maddock, III, C. Unkrich, M. Whitaker, B. Goff, Quantification of groundwater - surface water interactions in a southwestern riparian system.

Maddock, T., III, R. MacNish, D. Goodrich, D. Williams, J. Shuttleworth, B. Goff, R. Scott, S. Moran, D. Cooper, L. Hipps, A. Chehbouni, An overview of atmospheric and surface water coupling to regional groundwater models in semi-arid basins.

Moran, S., D. Williams, D. Goodrich, A. Chehbouni, A. Bégué, G. Boulet, D. Cooper, R. Davis, G. Dedieu, W. Eichinger, J. Everitt, B. Goff, C. Harlow, M. Helfert, L. Hipps, C. Holifield, D. Hymer, A. Kahle, T. Keefer, Y. Kerr, R. Marsett, W. Ni, Y. Nouvellon, J. Qi, S. Schaeffer, J. Schieldge, R. Scott, K. Snyder, J. Toth, C. Watts, M. Whitaker, and I. Yucel, Overview of remote sensing of semi-arid ecosystem function in the upper San Pedro river basin, Arizona.

Moran, S. (b), D. Hymer, J. Qi, E. Sano, R. Marsett, M. Helfert, and E. Sano, Soil moisture evaluation using Synthetic Aperture Radar (SAR) and optical remote sensing in semi-arid rangeland.

Nouvellon, Y., S. Rambal, A. Bégué, S. Moran, J-P. Lhomme, J. Qi, A. Chehbouni, D. Lo Seen, An ecophysiological model for semi-arid grasslands.

Scott, R., J. Shuttleworth and D. Goodrich, Water use of two dominant riparian vegetation communities in southeastern Arizona.

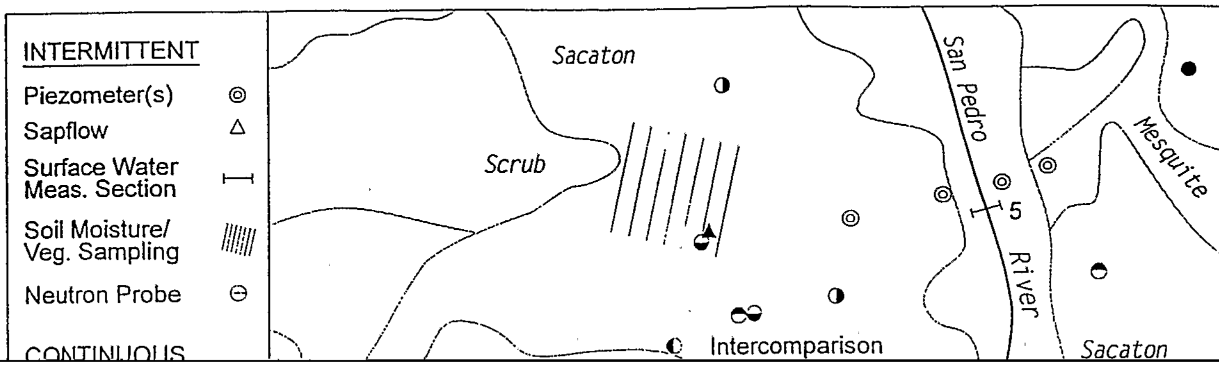
Shao, X. M., R.C. Carlos, M.W. Kirkland, Observations of precipitable water vapor in the planetary boundary layer via microwave interferometry.

Toth, J.J., D.C. Goodrich, M.S. Moran, R. Scott, D. Hymer, J. Shuttleworth, I. Yucel, J. Garatuza-Payan, C. Harlow, A. Chehbouni, G. Boulet, D. Cooper, M. Kirkland, C.J. Watts, R. Avissar, R. Pinker, and L. Hipps, An overview of spatially distributed surface fluxes of heat and moisture across the semi-arid San Pedro basin

Whitaker, M.P.L., T. Maddock, B. MacNish, D. Goodrich and B. Goff, Monitoring bank storage in the San Pedro riparian national conservation area, Arizona.

Williams, D.G., J-P. Brunel, G. Lin, S. Schaeffer, and K. Snyder, Biotic control over the functioning of desert riparian ecosystems.

Yucel, I., J. Garatuza-Payan, J. Toth, J. Shuttleworth, and R. Pinker, Cloud screened surface radiation estimates with high resolution from GOES-9 data.

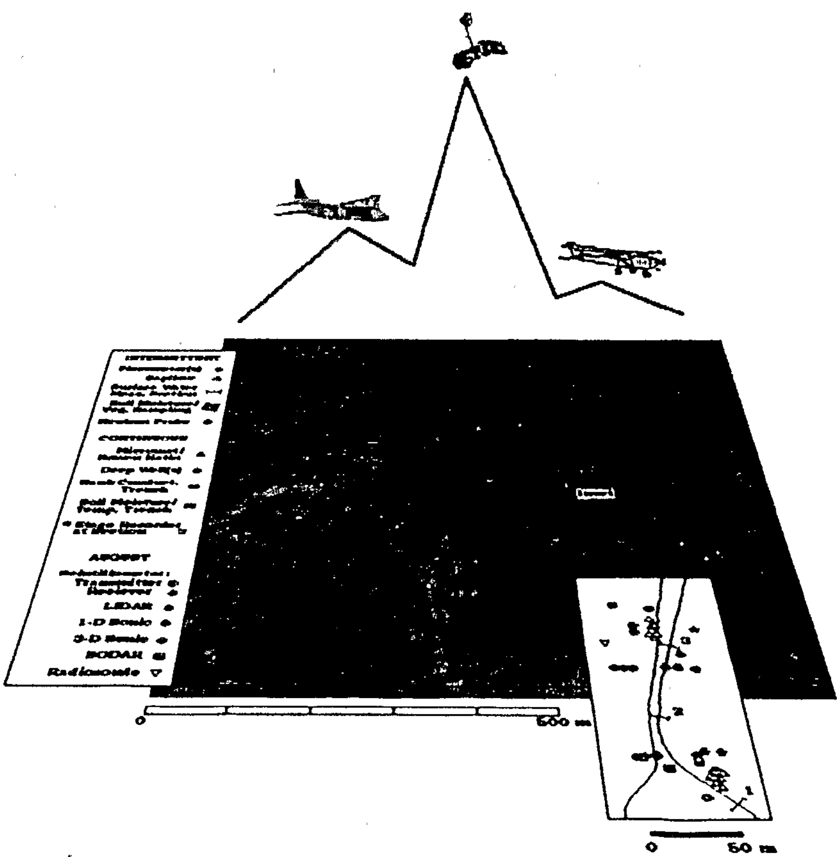


INTERMITTENT
Piezometer(s)
Sapflow
Surface Water Meas. Section
Soil Moisture/ Veg. Sampling
Neutron Probe
CONTINUOUS
Sacaton
Scrub
San Pedro River
Mesquite
5
Intercomparison
Sacaton

# Semi-Arid Land-Surface-Atmosphere (*SALSA*) Program

# Preliminary Results of 1997 Activities

Papers to be Presented at a Special Symposium on Hydrology, Session on Integrated Observations of Semi-Arid Land-Surface-Atmosphere Interactions
American Meteorological Society Meeting
Phoenix, Arizona 11-16 January 1998

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