Multiagency, Multinational Global Change Research Effort in the Upper San Pedro Basin

The Semi-Arid Land-Surface-Atmosphere Program ("SALSA") is a multi-agency, multi-national global-change research effort that seeks to evaluate the consequences of natural and human-induced changes in semi-arid environments. Current SALSA research is focused on the environmentally sensitive Upper San Pedro Basin of southeastern Arizona, USA, and northeastern Sonora, Mexico. SALSA science collaborators include the USDA Agricultural Research Service, Environmental Protection Agency, NASA, US Geological Survey, Los Alamos National Laboratory, University of Arizona, Southwest Center for Environmental Research & Policy, Harvard University, Instituto del Medio Ambiente y Desarrollo Sustentable del Estado de Sonora, Universidad de Sonora, Instituto Tecnológico de Sonora, Institut de Recherche pour le Développement (French), Centre d'Etudes Spatiales de la Biosphere (French), among many others.

The San Pedro Basin is considered to be an excellent "outdoor laboratory" for global change research, and has attracted scientists from a variety of disciplines to SALSA, including hydrologists, ecologists, remote sensing specialists, and social scientists. More than 40 scientists and 30 graduate students, from Mexico, France, USA, and elsewhere have participated in SALSA since it's initiation in 1996. SALSA scientists are conducting state-of-the-art research in the basin using the latest remote sensing and ground-based technologies for evaluating the basin water balance and ecological complexity.

In addition to answering basic questions about global change processes, SALSA collaborators work closely with local and regional agencies and institutions to address many of the immediate environmental problems in the San Pedro Basin, as well as in the US-Mexico borderlands. These cooperators include the Bureau of Land Management, Cochise County, City of Sierra Vista, Arizona Department of Water Resources, US Army, Secretaría del Medio Ambiente, Recursos Naturales y Pesca, and local ejidos, among many others. Community participation is an important component of SALSA, and an effort is made to keep the community involved in the field studies and informed of the research results.

Below is an extract from the final draft Commission for Environmental Cooperation (CEC) report, entitled "Sustaining and Enhancing Riparian Migratory Bird Habitat on the Upper San Pedro River," prepared by the San Pedro Expert Study Team. In addition to recommending a number of specific actions to reduce the water deficit in the basin and protect riparian habitat, the Expert Study Team proposed a "research agenda" to address many of the unknown factors influencing the hydrology and ecology of the Upper San Pedro Basin. These agenda items are listed below (original text in italics) along with comments indicating complementary SALSA research that is currently underway, planned, or needed to address these questions.

8.2 Research Agenda (from CEC Report)

We identified a number of helpful scenarios where the knowledge base is insufficient to answer the question of how helpful the actions might be. In these areas, we can only answer the pragmatic questions through more scientific investigations. It is useful to reiterate these areas for further fruitful study.

CEC Expert Team Recommendations	SALSA Research In-Progress, Planned, and Needed
1) The models of the San Pedro hydrology do not include the storm flow that happens on a short time frame and impacts the system. Models that include the entire hydrologic system, not simply the ground water system, need to be developed. These would answer the question of how storms impact the hydrology, especially the riparian corridor.	UA-Harvard-CERL† are updating the groundwater model for the Upper San Pedro Basin (USPB). ARS, EPA, and ASU, are modeling rainfall-runoff response of the watershed. SALSA collaborators need to integrate the groundwater and surface water models into an comprehensive model of basin hydrology.
2) One of the questions arising from the scenarios is how effective managing the recharge in retention basins near the mountains would be in increasing recharge. Where and how recharge currently occurs is not well understood. A better fundamental understanding of the recharge process would allow one to understand if it could be significantly increased by improved management retention basins, etc.	ARS and UA (with support from Cochise Co.) are studying ephemeral stream recharge on the ARS Walnut Gulch Experimental Watershed (WGEW). SALSA collaborators need to extend this research to other parts of the basin and to initiate research on "mountain-front recharge" processes in both the USA and Mexico portions of the USPB.
3) The evapotranspiration from the upland surface between the washes in the valley is not well understood. Hydrologists have an educated guess about the impact of changing vegetation, however, this is at best an educated guess. More needs to be understood about the fate of precipitation falling on the valley floor.	In 1997-98, IRD, IMADES, CESBIO, and others made intensive field measurements of upland evapotranspiration (ET) in the Mexico side of USPB. The results are currently being published. Since 1990, the ARS has been collecting ET data on grass- and shrub-land sites within the WGEW. SALSA collaborators need to extend this research to the USA portion of the watershed, and to test remote sensing techniques for estimating ET and precipitation over the basin.
4) The details of the valley fill geology are not fully understood. The fact that a clay layer seems to exist and could impact the recharge from the Sierra Vista sewage recharge site needs to be better explored.	USGS is completing a report on the hydrogeology of the USA part of the USPB (Sierra Vista sub-watershed). Results will be published in 1999. SALSA collaborators need to study the hydrogeology of Mexico side of USPB, of which little is known.
5) The details of evapotranspiration along the riparian corridor is the field site for the Semi-Arid Land-Atmosphere Program (SALSA). Studies in this area are providing a better understanding of moisture fluxes in region. These studies are providing valuable details in our fundamental understanding of the hydrologic cycle in this area.	ARS, UA, IRD, IMADES, LANL, JPL, and others conducted an intensive field campaign in 1997 to estimate ET from USPB riparian corridor. The results will be published in 2000. SALSA collaborators need to continue research into riparian ET and to validate remote sensing technologies for estimating ET along the entire riparian corridor. The ET model needs to be coupled with the groundwater and surface water models.
6) What are the impacts of introducing beavers in the area. At the moment the estimated impacts	SALSA collaborators are not currently monitoring the beaver activity on the USPB, although base-line

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appear to be educated guesses by the scientific community. Various individuals have opinions on what will happen; however, there appears to be little empirical data. The upper San Pedro valley affords an opportunity to observe in a highly instrumented and studied area the actual impact of beaver both on the hydrology and ecology of the area.	data collected by ASU, ARS, UA, EPA, and USGS will be helpful in evaluating changes to the hydrology and ecology caused by beaver dams. SALSA collaborators need to develop plans to monitor the effect of this new environmental stressor in the USPB.
7) There is almost no monitoring in Mexico, where there is a reasonably healthy riparian corridor. We need data in Mexico to manage the system effectively.	ARS and IMADES have established some experimental raingages and runoff flumes on small watersheds within the Mexico USPB. IMADES, USGS, and TNC propose establishing a surface flow monitoring network. SALSA collaborators need to work to setup hydrologic and ecological monitoring networks in Mexico.
8) Assessment and quantification of historical change in abundance of riparian vegetation and of specific riparian plant communities along the San Pedro River.	UA, ASU, EPA, and IMADES researchers are looking at various aspects of vegetation change within the USPB, using historical archives, ecological evidence, and remote sensing imagery. SALSA collaborators need to integrate these various land cover / land use data to determine trends in the riparian vegetation and plant communities.

† ARS = Agricultural Research Service, ASU = Arizona State University, CERL = US Army Corps of Engineers, Construction Engineering Research Laboratory, CESBIO = Centre d'Etudes Spatiales de la Biosphere (French space agency), EPA = Environmental Protection Agency, Harvard = Harvard University, IRD = Institut de Recherche pour le Développement (French research agency), IMADES = Instituto del Medio Ambiente y Desarrollo Sustentable del Estado de Sonora (Mexican research and development agency), JPL = Jet Propulsion Laboratory, LANL = Los Alamos National Laboratory, TNC = The Nature Conservancy, UA = University of Arizona, USGS = US Geological Survey,

As outlined by this table, SALSA collaborators are already addressing, to some degree, the research agenda proposed by the CEC Expert Study Team. Although SALSA collaborators have a good understanding of some basin processes, such as riparian evapotranspiration, there is insufficient understanding of less observable processes, like mountain-front recharge. Two things are needed to allow SALSA researchers to address the unknowns in the Upper San Pedro Basin: better integration of existing studies so as to maximize information output from research projects, and new studies to extend or initiate relevant research activities over all parts of the basin. Better integration could be achieved by the development of a centralized "knowledge-base" that would not only allow SALSA scientists to collaborate more effectively but would also facilitate the transfer of scientific results to resource managers and users within the basin. Both the knowledge-base and new studies are dependent upon funding being made available for these purposes.

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