

SUSTAINABILITY OF SEMI-ARID HYDROLOGY AND RIPARIAN AREAS SAHRA

HOW'S YOUR HYDROLOGIC LITERACY?

Semi-arid regions cover 1/3 of the terrestrial earth surface and contain the fastest growing populations in both the U.S. and around the world.

Water sources for these regions are regional groundwater and river systems, both primarily recharged by precipitation in high elevation areas, often far from urban and agricultural demand.

Changes in climate and land cover are affecting the amount and timing of renewable water resources as runoff and recharge.

Increased demand from growing populations and changes in supply require new management strategies.

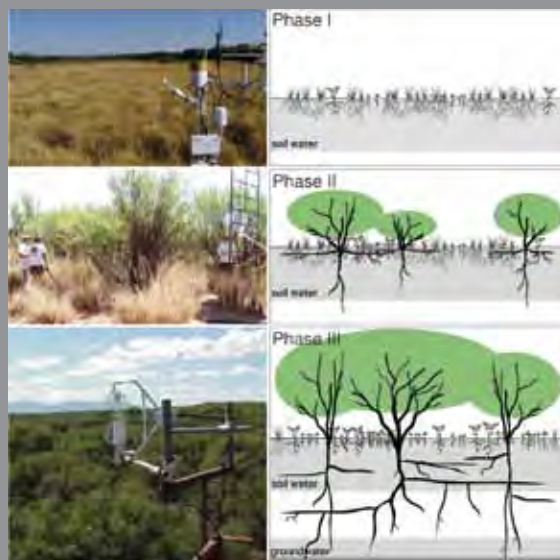
These are just some of the challenges faced by planners and stakeholders in the U.S. and around the globe when it comes to water resources. Improving the sustainability of these resources is a job that rests with elected officials, water managers, and policy experts at local, state, and national levels. Researchers and scientists must help inform these decision makers through focused research and dedicated efforts at knowledge transfer.

To address these needs, the Science and Technology Center for Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) set out in 2000 to promote sustainable management of water resources by conducting water resources-related science, education, and knowledge transfer in the context of critical water management issues of semiarid and arid regions.

The center, based at the University of Arizona, included the partnership of over 100 other institutions. Since inception, it has trained 222 graduate students, published over 450 peer reviewed papers and 27 books, developed novel hydrological models, and established unique capabilities in science-stakeholder engagement.



Collecting water samples in the Upper Rio Grande of Colorado for geochemical studies on water and salt sources.



SAHRA researchers have found that encroachment of shrubs into grasslands has increased water loss from the sub-surface.

At top: Landsat image of New Mexico. Photo: Image courtesy of USGS National Center for EROS and NASA Landsat Project Science Office, <http://eros.usgs.gov/Imagegallery/>

“The Center was unequivocally successful in meeting this mission with a legacy of research, education, knowledge transfer, and international activities that continues both at the University of Arizona and at numerous partner organizations,” notes SAHRA director Paul Brooks. “The center continues to address critical issues in hydrology and water resources, building on the successes during STC funding.”

“Sustainable” refers to the development and use of water resources in a manner that can be maintained in the long-term without causing unacceptable environmental, economic, or social consequences. As a university-centered effort, SAHRA research activities focus on the physical and behavioral sciences. However, the power to define unacceptable consequences and to improve sustainability of water resources properly rests with society through elected officials, resource managers, and stakeholders at local, state, and national levels. Beyond research, therefore, a major focus of SAHRA was, and continues to be, the development of effective mechanisms for synthesis, integration, education, and outreach, in support of better-informed decision-making.

Following the initial NSF award, SAHRA’s focus is shifting toward promoting and facilitating the development of cutting edge, stakeholder-relevant, water-related basic research projects, while relying on established institutional strengths in translating that knowledge into usable products for resource managers. Since 2009, SAHRA has served as the springboard for over \$15 million in current non-STC-funded research efforts including \$4.5 million for a Critical Zone Observatory (CZO), \$4.5 million for the COSMOS weather and climate program, and approximately \$3 million for the Biosphere 2 Landscape Evolution Observatory.

Research Focus

SAHRA researchers organize their research around three critical questions related to the hydrology and water resources of semi-arid regions:

- *What are the impacts of vegetation change on the basin-scale water balance?*
- *What are the costs and benefits of riparian restoration and preservation?*
- *Under what conditions are water markets or water banking feasible?*

These three integrating questions were designed to maximize coordination among researchers from various fields. By placing their research within the context of these overarching questions, researchers were able to more rapidly develop the multi-disciplinary understanding needed to address knowledge gaps in semi-arid hydrology.

Research also is organized within the context of river basins. Just as the three questions were developed to link scientific disciplines, the focus on river basins, where management decisions are typically made, facilitates the transition of results into practice. The center’s primary geographical focus is on: the Rio Grande/Rio Bravo, the Upper San Pedro River, and the Salt/Verde and lower Colorado River Basin. Human population centers, agricultural activities, and regional biodiversity all are concentrated along river systems, while river basins form natural management boundaries making a basin a fundamental study unit.

Decision Support Systems

Significant effort was placed in developing decision support tools that provided mechanisms to rapidly convey new findings to decisions makers and water managers. The Upper San Pedro Partnership brings together over 20 stakeholder organizations to use SAHRA decision support systems to help manage the region’s limited water supply to evaluate possible future scenarios for developing and sustaining the ecosystem.

A novel aspect of this work is linking ecosystem water stress to economics. Center researchers are developing new ways to evaluate the impact of population and water use on the regional hydrology, how in turn those changes will affect vegetation and bird diversity and abundance, and ultimately, how tourists and residents respond to those changes. A unique aspect of this project is that the valuation study is directly driven by the science.

Water Markets and Water Leasing

Increasingly, water markets and water banking are being considered in the Southwest as mechanisms for allocating water resources. The approach requires a detailed knowledge about factors that affect water supply and demand. Center researchers are developing new ways to improve estimates of precipitation and snow pack, and they are shedding light on the factors that affect residential and industrial demand for water. The results are being integrated into models that allow water resource managers to evaluate the potential of market-based mechanisms. Within the constraints of coupled physical, institutional, and behavioral models, SAHRA researchers developed a coupled model capable of evaluating economic and hydrologic impacts (including third-party effects) of water leasing on the middle Rio Grande and in the Mimbres river basin.

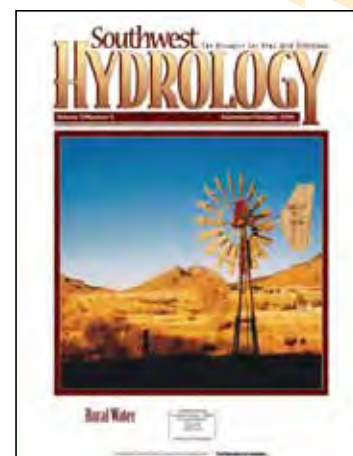
Integrated Environmental Observatories

As various earth science communities were exploring the need for integrated, multi-disciplinary observatories, SAHRA established a prototype observatory as part of its basin-scale water balance research theme. The research approach involves an integrated program of observation, modeling, and experimentation with targeted distributed data collection to assess the transferability of knowledge from individual sites to the region. These

efforts have greatly improved our understanding of ecohydrological interactions and biophysical processes at plant to regional scales, on topics such as atmospheric drivers of vegetation change, snow accumulation and melt, and how vegetation affects soil moisture supply. These efforts informed both SAHRA stakeholders and the recently funded Jemez-Santa Catalina Critical Zone Observatory funded by the National Science Foundation.

Traditional and Non-Traditional Education

Outreach and education are a major emphasis of SAHRA, with notable efforts in classroom learning from primary school through university and other publications for water professionals.



For example, *Southwest Hydrology* was a full-color, trade magazine published bimonthly and distributed free of charge to water professionals throughout the Southwest. The magazine promoted communication with a broad spectrum of water experts—ranging from university and federal researchers to regulators, consultants, policy-makers, and local water managers—to foster the sustainable management of water resources in the semi-arid Southwest. The publication received numerous awards over the years and was an extremely valuable resource to stakeholders and mechanism to rapidly transfer research to a broader audience. □