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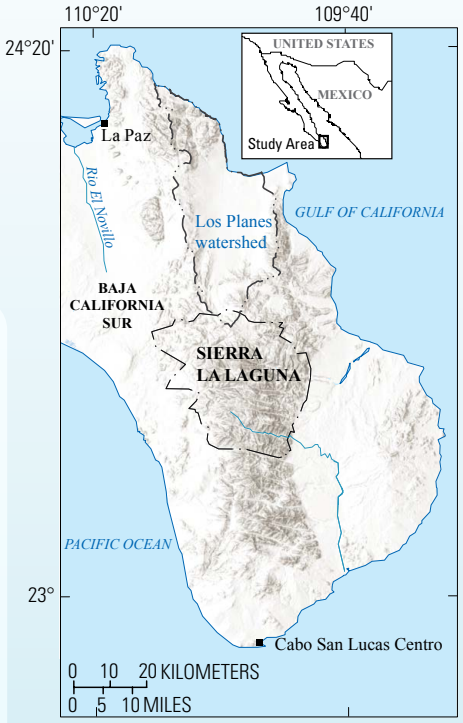
Preserving and Increasing Water Resources—Natural Infrastructure in Dryland Streams in Baja California Sur, Mexico

The Los Planes watershed of Baja California Sur, Mexico, and its underlying aquifer are experiencing groundwater decline owing to low average annual rainfall (28.1 centimeters per year) and rising water demand from population growth and agricultural activities. This decline in water availability can lead to desertification—a process that changes arable land to desert by degrading soil and vegetation—and can pose serious challenges to livelihoods that depend on the land.

To address these issues, a ranch in the Los Planes watershed has installed many natural infrastructures in dryland streams (NIDS) in channels for soil and water conservation. In 2022, the U.S. Geological Survey (USGS) began working with regional researchers and land managers to investigate the effects of NIDS on natural biological, geochemical, and physical processes and determine the efficacy of NIDS for water augmentation in the Los Planes watershed. The USGS also worked with local academic institutions and nonprofit organizations to create public educational opportunities focused on the area's hydrogeology. These and other collaborative efforts with the U.S. Water Partnership and Innovaciones Alumbra aim at enhancing water resources in the Baja California Sur region and promoting water security and safeguarding community well-being.



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Universal Transverse Mercator, zone 12 north
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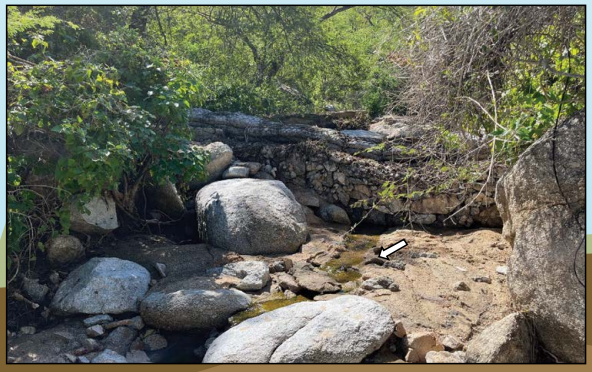
Map of southern Baja California Sur, Mexico, showing study area in the Los Planes watershed.



Sandbags and rock gabions are used as natural infrastructures in dryland streams (commonly referred to as NIDS). White arrows show direction of flow.

Natural Infrastructures in Dryland Streams: Adaptation and Mitigation to Deteriorating Landscapes

The USGS has extensively documented the ecosystem services of NIDS across the southwestern United States and northern Mexico. Natural infrastructures in dryland streams are natural or anthropogenic (human made) structures that use earthen material to slow down rapid water runoff, which then allows water to infiltrate into the land and create thick rich soils that sequester atmospheric carbon and promote the longevity and area of green growth. Improved vegetation health and increased water availability lower air and surface temperatures by providing shade relief and facilitating water evaporation from soil, surface water, and plants into the atmosphere through evapotranspiration. Vegetation also stabilizes hillsides and reduces erosion and the movement of sediment. NIDS are effective low-cost and low-technology nature-based solutions that aid in aquifer recharge and reverse degradation and desertification of landscapes.

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Groundwater well monitoring, done here by USGS staff, Jason Sorenson, and Innovaciones Alumbra staff, Carlos Lim, helps set the parameters of a water budget.

Study Overview

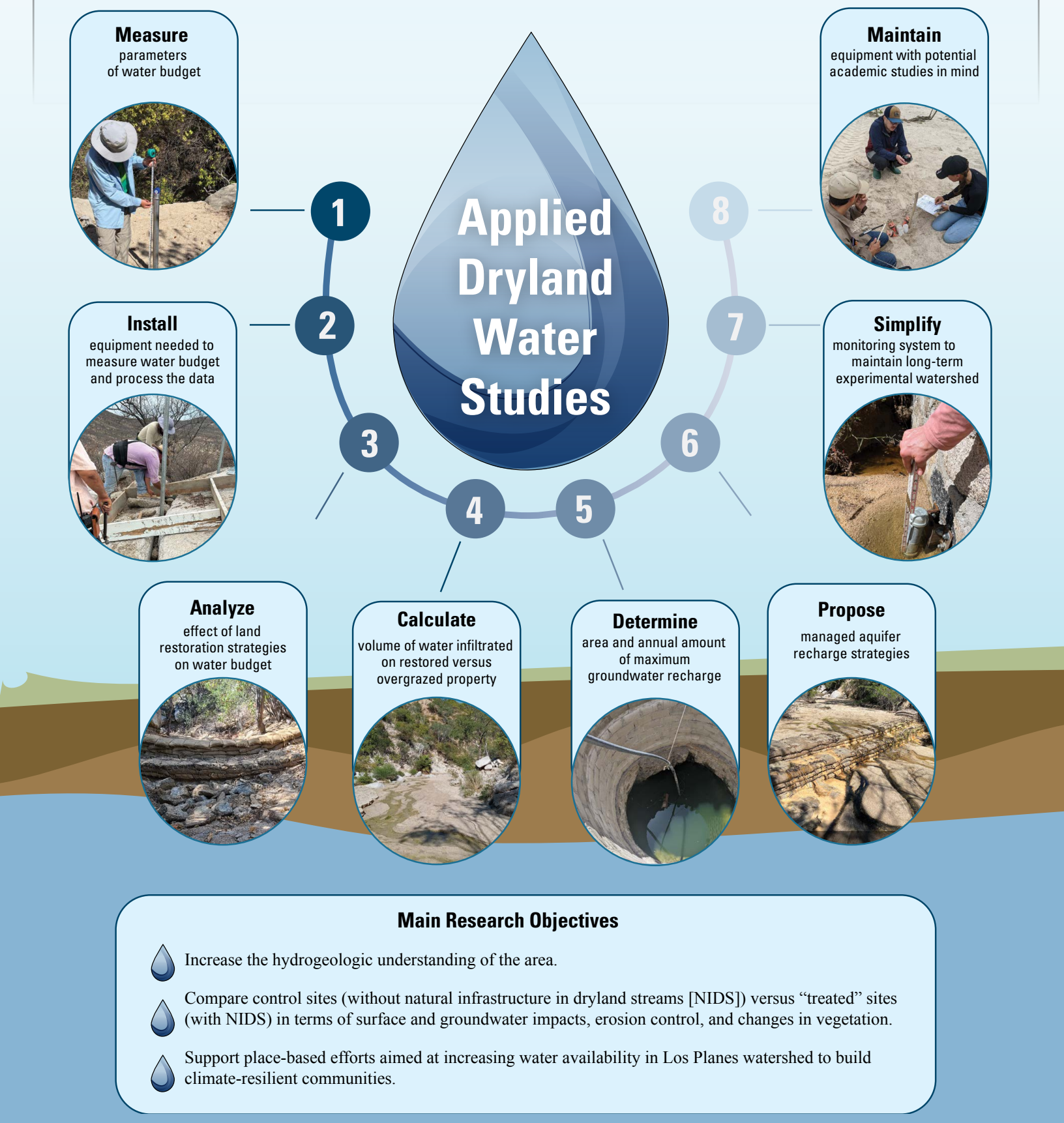
A paired-watershed approach, which consists of comparing similar watersheds to evaluate the impact of land management practices on the phenomenon of interest such as potential groundwater recharge, erosion and runoff control, or changes in vegetation was implemented. Smaller watersheds within the Los Planes watershed were selected to serve as control or treatment areas. This selection allows researchers to understand baseline conditions without the installation of NIDS and compare to areas where NIDS are present by monitoring and analyzing the effect of NIDS on the landscape, water supplies, and overall water availability (water budget).

The USGS and local scientists have installed meteorological stations and hydrologic monitoring instrumentation that record continuous climate data, including precipitation, groundwater and surface water levels, and surface water discharge. Groundwater wells in the ranch of the Los Planes watershed were instrumented to develop an understanding of water level changes in response to effects of precipitation, water availability, and NIDS. The depth to bedrock was mapped using ground-penetrating radar to improve the understanding of aquifer properties that influence the movement of water into bedrock fractures. Remote sensing techniques and field observations are being used to develop a land-use and land-cover map, evapotranspiration estimates, and document changes in vegetation. Resulting products and monitoring data are used to develop and calibrate surface water and groundwater models to improve estimation of the water budget and how NIDS are affecting watershed responses to rainfall. The infrastructure for continuous weather and hydrologic monitoring, along with a better understanding of the region's water systems, help improve water resource and environmental management. This, in turn, supports communities in their efforts to be water secure and climate resilient.

Photograph of researchers developing shared monitoring protocol, from left to right: Carlos Lim (Innovaciones Alumbra), Blanca R. Lopez (CIBNOR), Natalie R. Wilson (USGS), and Florence Cassassuce (Innovaciones Alumbra).

Broader Implications

The documentation of NIDS and their efficacy can help support their widespread application as a sustainable land management practice that can be replicated at strategic locations. Locations include those with the greatest recharge potential, and (or) in areas in need of erosion control. Study activities are grouped into 8 tasks that are scheduled to converge in the development of the Center of Applied Dryland Water Studies. Such an institute could provide the scientific communities of the Baja California Sur region with a platform that translates to the larger and growing global interest in desert and dryland restoration.



Main Research Objectives

- Increase the hydrogeologic understanding of the area.
- Compare control sites (without natural infrastructure in dryland streams [NIDS]) versus “treated” sites (with NIDS) in terms of surface and groundwater impacts, erosion control, and changes in vegetation.
- Support place-based efforts aimed at increasing water availability in Los Planes watershed to build climate-resilient communities.

Community Outreach

The USGS has hosted several public educational workshops in different communities for adults and youth community members. On March 2024, the USGS worked with Kumutú STEAM https://sites.google.com/view/steam-la-paz-bcs, a program of the Ándale La Paz AC organization, Center for Renewable Energy and Environmental Quality https://cerca.org.mx, Agua Viva BCS https://aguavivainternational.org, and Pronatura https://pronatura.org.mx), to organize the Caminos del Agua Water Festival with help from the Bachelor of Science program in Water Management and Sciences at the Autonomous University of Baja California Sur https://www.uabcs.mx/dact. The Caminos Del Agua Water Festival was hosted at Los Girasoles community center in El Sargento, Baja California Sur. Through talks, exhibitions, and interactive activities, awareness of local water-related challenges was heightened, and efforts to promote water stewardship were actively encouraged. One hundred and fifteen students and their teachers from the local middle and high school rotated through the various hands-on activities focused on the following subjects:

- Water quality
- Aquifer recharge
- Use of nature-based solutions, such as Natural Infrastructure in Dryland Streams (NIDS)
- Scientific methods
- Environmental health virtual reality
- Water awareness

These activities built on previous efforts to improve weather monitoring in the region, including "do it yourself" rain gauges with youth and the installation of new monitoring equipment. Students explored how water moves in a watershed, the effects of environmental pollution on ecosystems and human health, and water stewardship.

A student completes the water cycle puzzle after rotating through the different festival activities. Photograph by Alfredo Martinez, March 11, 2024.

This factsheet is also available in Spanish and can be found at https://doi.org/10.3133/fs20253042.

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For More Information

Research in the Los Planes watershed; water cycle augmentation—https://www.usgs.gov/index.php/centers/western-geographic-science-center/science/research-los-planes-watershed-water-cycle.

A review of rock detention structures in the Madrean Archipelago ecoregion—https://doi.org/10.1177/1178622120946337.

Natural infrastructure in dryland streams can establish regenerative wetland sinks that reverse desertification and strengthen climate resilience—https://doi.org/10.1016/j.scitotenv.2022.157738.

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