WRRC Water Webinar

Prioritizing Transboundary Aquifers in Arizona-Sonora Region

a Multicriteria Approach for Groundwater Assessment

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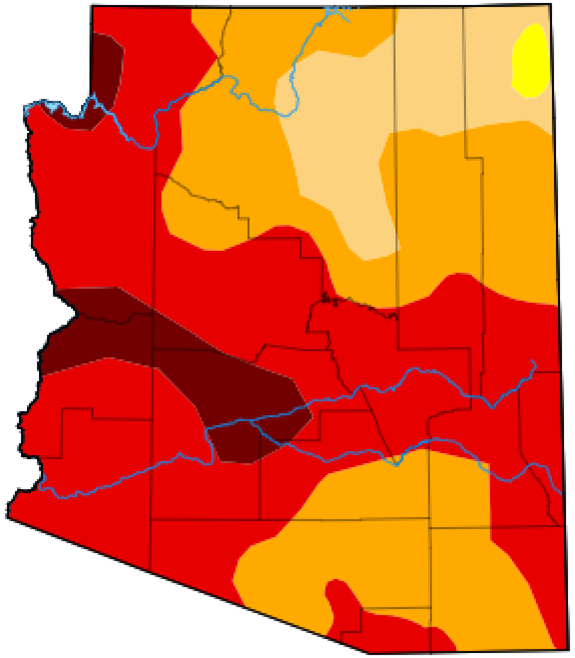
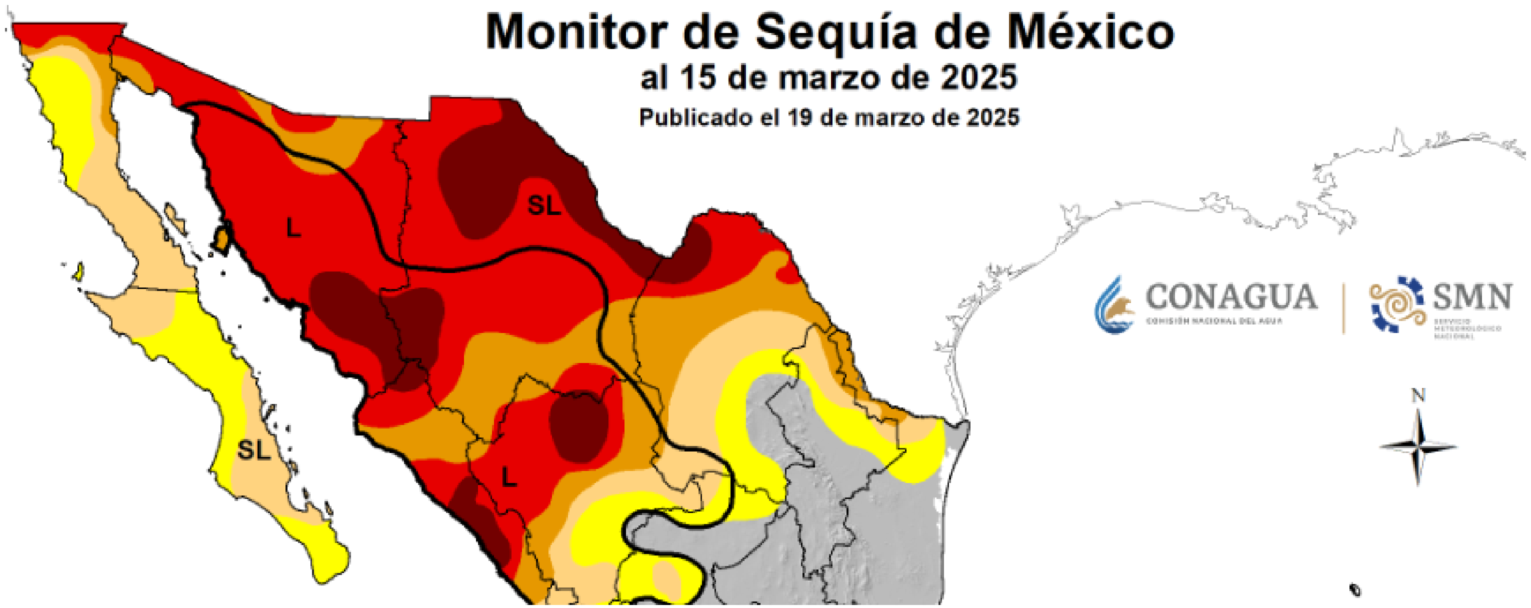
March 28, 2025

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
WATER RESOURCES RESEARCH CENTER

Introduction

- Groundwater is a key water source for U.S.–Mexico border cities.
- Persistent drought over the past 20+ years has undermined water security and development .
- Climate projections indicate reduced precipitation over the next 70 years, increasing risks of water shortages.





Map released: Thurs. March 27, 2025
Data valid: March 25, 2025 at 8 a.m. EDT

Intensity

- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)
- No Data

Authors

United States and Puerto Rico Author(s):
Brad Rippey, U.S. Department of Agriculture

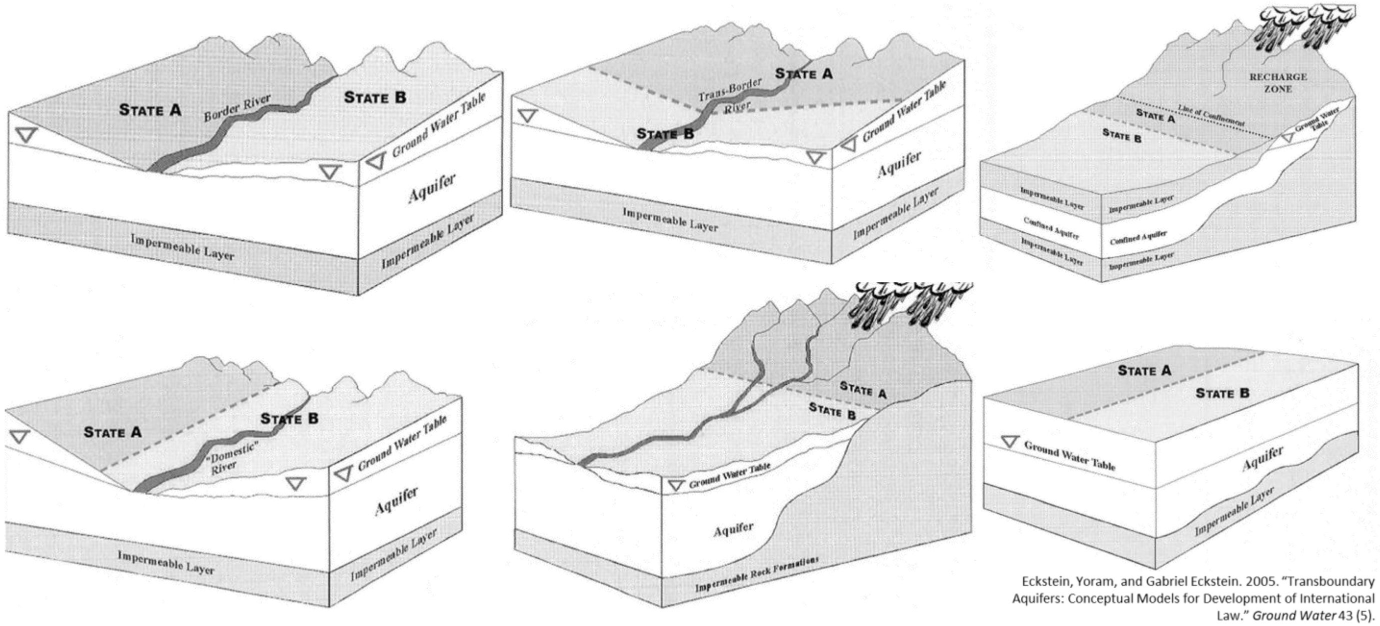
Pacific Islands and Virgin Islands Author(s):
Denise Gutzmer, National Drought Mitigation Center

Transboundary Aquifers

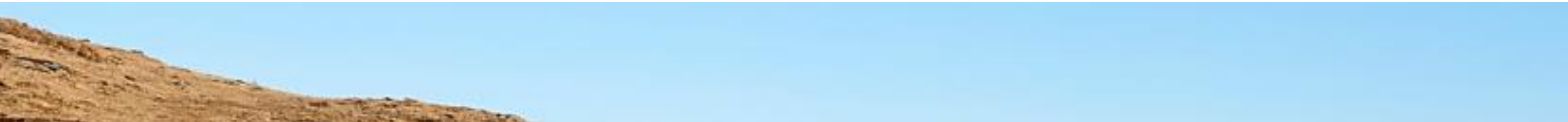
A transboundary aquifer is a groundwater system that spans two or more state boundaries (UN International Law Commission, Draft Articles).

An aquifer is a permeable water-bearing geological formation, underlain by a less permeable layer, with water in its saturated zone.

Groundwater is an invisible resource.



Eckstein, Yoram, and Gabriel Eckstein. 2005. "Transboundary Aquifers: Conceptual Models for Development of International Law." *Ground Water* 43 (5).



Groundwater Resources

- **Groundwater** knows no borders.

- There are approximately **600** transboundary aquifers around the world.

- Groundwater needs to be understood to be managed sustainably.

We still don´t know enough about the state of aquifers!

International Groundwater Resources Assessment Centre

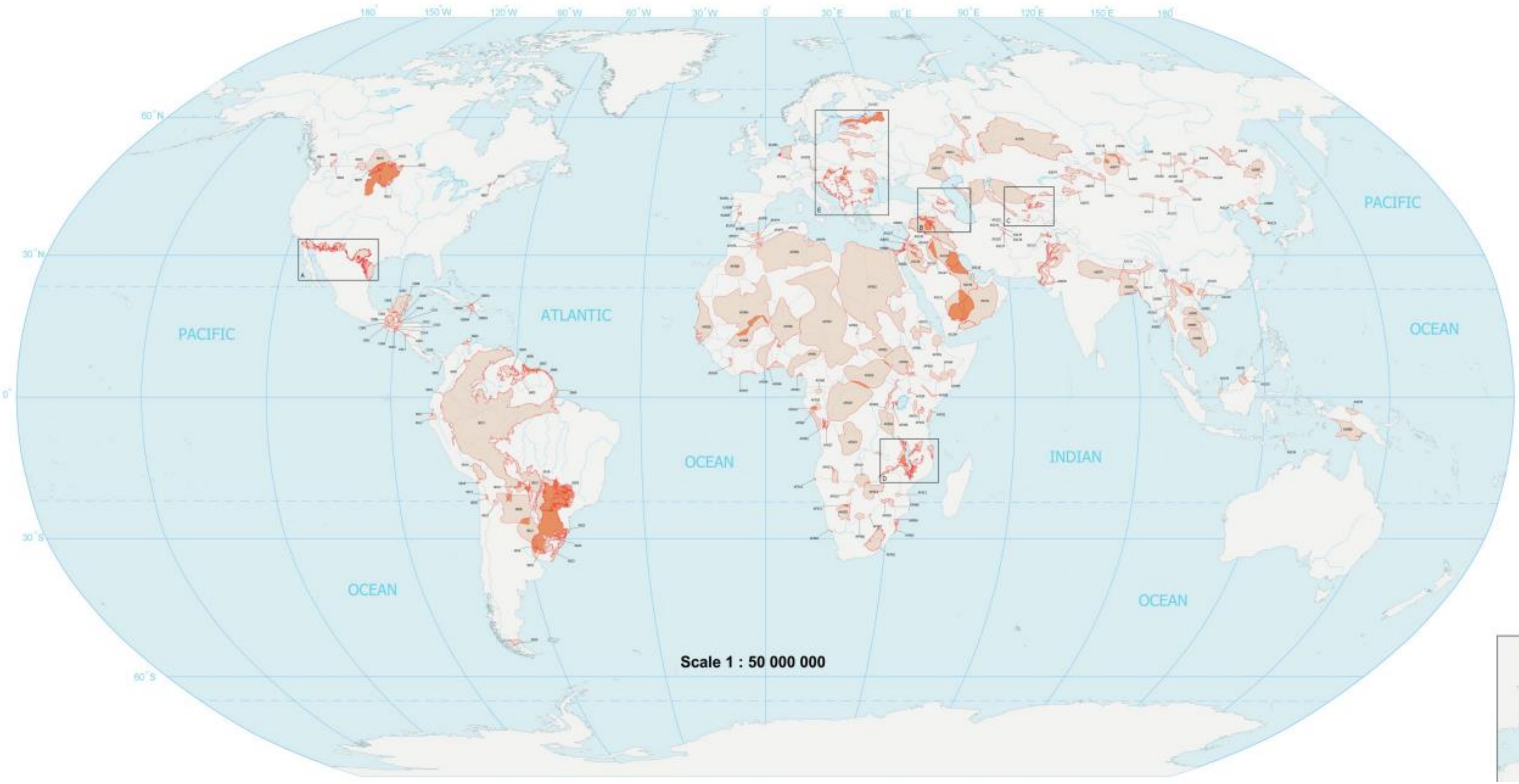
Transboundary Aquifers of the World

- Update 2021 -

unesco
Intergovernmental Hydrological Programme

World Meteorological Organization

Government of The Netherlands



Legend

Occurance and extent

- aquifer
- overlapping area

Type of TBA delineation

- confirmed boundary
- unconfirmed boundary

Geographic elements

- rivers
- lakes
- detailed maps

SC/HYD/2021/Map-1

Prepared by IGRAC

Base maps

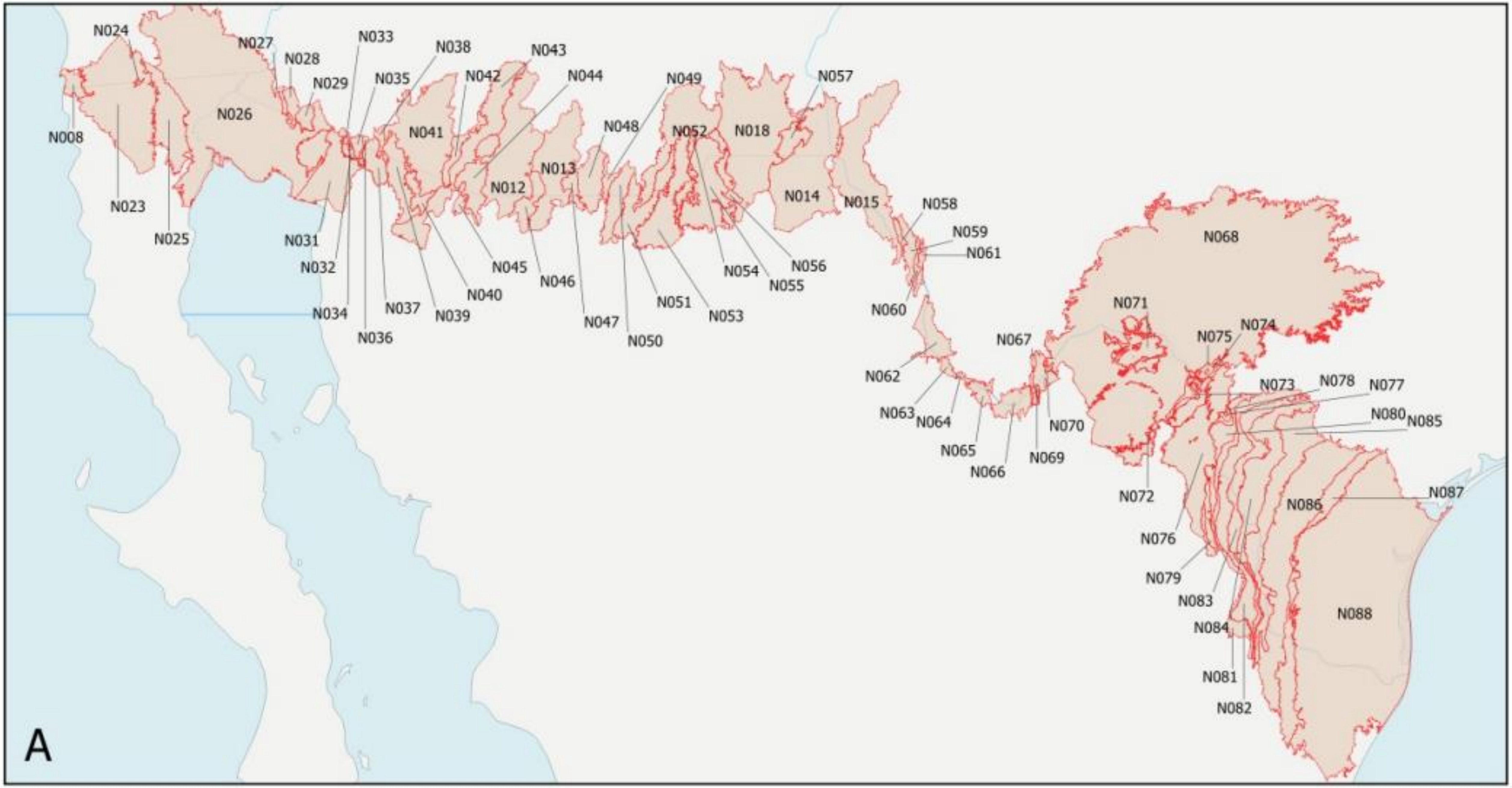
Country borders: The United Nations Clear Map (2018)
Rivers and lakes: ESRI (2018)

Map projection

Robinson projection, geographic coordinates, spheroid WGS84, longitude of central meridian 0º

Disclaimer

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.A full disclaimer is available on the back of this map.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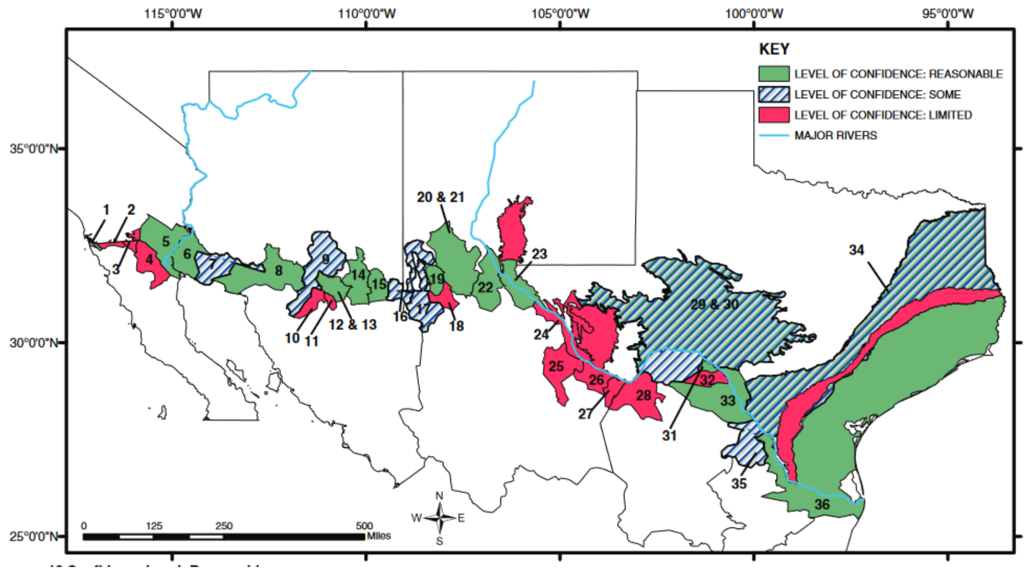
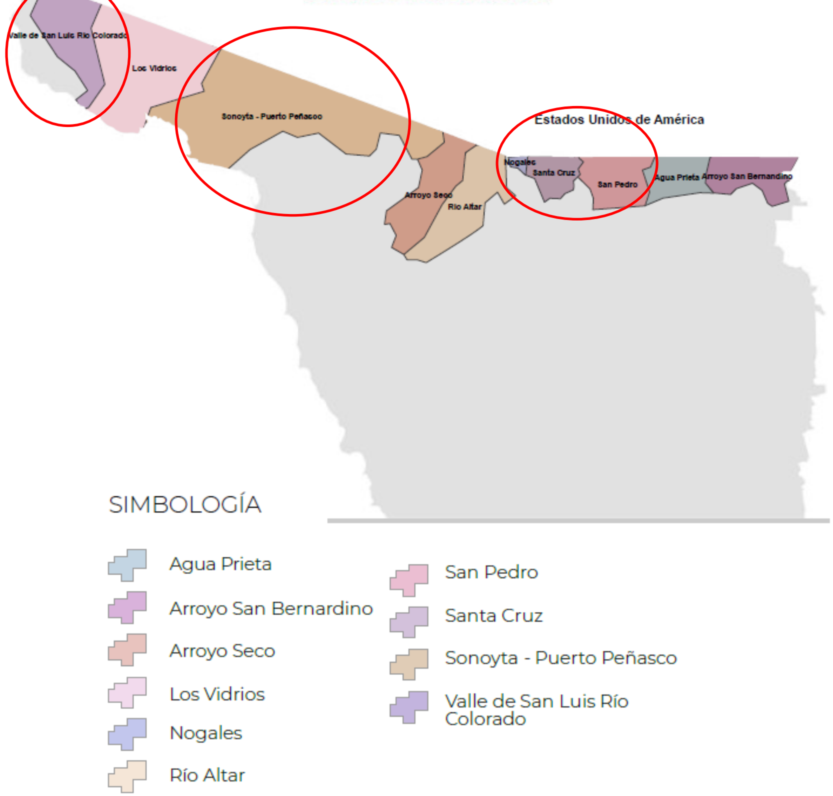
Transboundary Aquifers of the U.S. and Mexico

Megdal et al. 2022



Sanchez et al. 2021

FIGURA 1.28 ACUÍFEROS FRONTERIZOS DEL ESTADO DE SONORA.



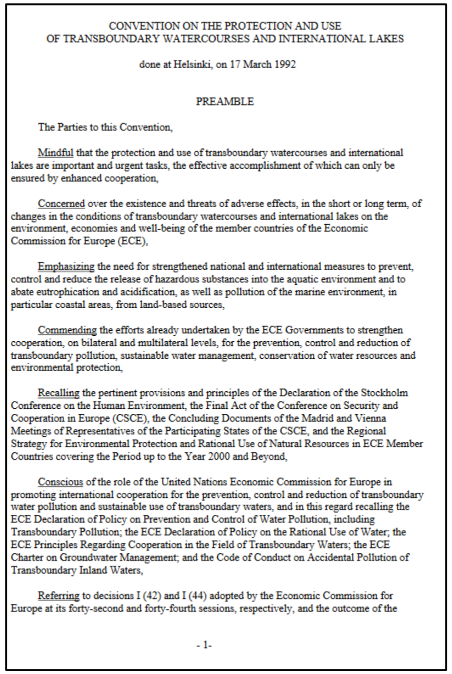
Gobierno del Estado de Sonora, 2024.

In the state of Sonora, CONAGUA recognizes five official transboundary aquifers: San Luis Río Colorado Valley, Sonoyta–Puerto Peñasco, Nogales, Santa Cruz, and San Pedro.

Transboundary Waters Research

At the global level, there are some tools that address the need to manage transboundary water resources.

All Conventions and Articles agree on the importance of information exchange and development of studies.



CONVENTION ON THE PROTECTION AND USE
OF TRANSBOUNDARY WATERCOURSES AND INTERNATIONAL LAKES

done at Helsinki, on 17 March 1992

PREAMBLE

The Parties to this Convention,

Mindful that the protection and use of transboundary watercourses and international lakes are important and urgent tasks, the effective accomplishment of which can only be ensured by enhanced cooperation,

Concerned over the existence and threats of adverse effects, in the short or long term, of changes in the conditions of transboundary watercourses and international lakes on the environment, economies and well-being of the member countries of the Economic Commission for Europe (ECE),

Emphasizing the need for strengthened national and international measures to prevent, control and reduce the release of hazardous substances into the aquatic environment and to abate eutrophication and acidification, as well as pollution of the marine environment, in particular coastal areas, from land-based sources,

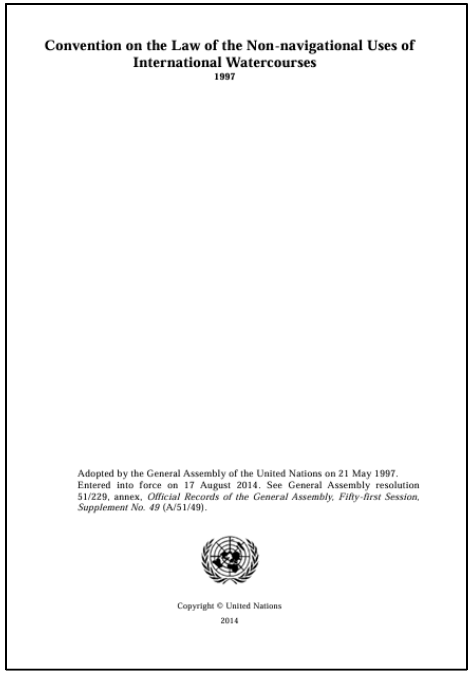
Commending the efforts already undertaken by the ECE Governments to strengthen cooperation, on bilateral and multilateral levels, for the prevention, control and reduction of transboundary pollution, sustainable water management, conservation of water resources and environmental protection,

Recalling the pertinent provisions and principles of the Declaration of the Stockholm Conference on the Human Environment, the Final Act of the Conference on Security and Cooperation in Europe (CSCE), the Concluding Documents of the Madrid and Vienna Meetings of Representatives of the Participating States of the CSCE, and the Regional Strategy for Environmental Protection and Rational Use of Natural Resources in ECE Member Countries covering the Period up to the Year 2000 and Beyond,

Conscious of the role of the United Nations Economic Commission for Europe in promoting international cooperation for the prevention, control and reduction of transboundary water pollution and sustainable use of transboundary waters, and in this regard recalling the ECE Declaration of Policy on Prevention and Control of Water Pollution, including Transboundary Pollution; the ECE Declaration of Policy on the Rational Use of Water; the ECE Principles Regarding Cooperation in the Field of Transboundary Waters; the ECE Charter on Groundwater Management; and the Code of Conduct on Accidental Pollution of Transboundary Inland Waters,

Referring to decisions I (42) and I (44) adopted by the Economic Commission for Europe at its forty-second and forty-fourth sessions, respectively, and the outcome of the

- 1-



Convention on the Law of the Non-navigational Uses of International Watercourses

1997

Adopted by the General Assembly of the United Nations on 21 May 1997. Entered into force on 17 August 2014. See General Assembly resolution 51/229, annex, *Official Records of the General Assembly, Fifty-first Session, Supplement No. 49* (A/51/49).

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2014

Draft articles on the Law of Transboundary Aquifers

2008

Text adopted by the International Law Commission at its sixtieth session, in 2008, and submitted to the General Assembly as a part of the Commission's report covering the work of that session. The report, which also contains commentaries on the draft articles, appears in *Official Records of the General Assembly, Sixty-third Session, Supplement No. 10* (A/63/10).

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INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO

El Paso, Texas
August 19, 2009

JOINT REPORT OF THE PRINCIPAL ENGINEERS REGARDING THE JOINT COOPERATIVE PROCESS UNITED STATES-MEXICO FOR THE TRANSBOUNDARY AQUIFER ASSESSMENT PROGRAM

To the Honorable Commissioners,
International Boundary and Water Commission,
United States and Mexico,
El Paso, Texas and Ciudad Juarez, Chihuahua.

Sirs:

We respectfully submit for your consideration this Joint Report recommending the joint cooperative process between the United States and Mexico to implement an assessment program for the transboundary aquifers shared by both countries.

I. Background

Since the decade of the 1970s, there exists within the framework of the International Boundary and Water Commission (IBWC), a process for the exchange of information on groundwater along the border between the United States and Mexico. Any issues of data or studies have been addressed on a case by case basis through mutual consultation as established in Resolution 6 of IBWC Minute No. 242.

By way of example, on December 2, 1997, the IBWC issued the "Joint Report of Principal Engineers Regarding Information Exchange and Mathematical Modeling in the El Paso, Texas and Ciudad Juarez, Chihuahua Area Aquifer." The IBWC arranged for the exchange of groundwater data between both countries and the development of a bilingual publication that was produced jointly under this effort.

On December 22, 2006, United States Public Law 109-448, the "United States-Mexico Transboundary Aquifer Assessment Act" was passed, establishing a program to evaluate transboundary aquifers between the United States and Mexico, which included the possibility of applying United States funds for assessment activities in Mexico.

II. International Boundary and Water Commission's Position and Process Framework

The IBWC, United States and Mexican Sections, are aware of the interest on both sides of the border to preserve and understand the aquifers used by both countries, whereby it is considered necessary to develop a team of binational experts to assess transboundary aquifers, exchange data, and if needed, develop new datasets.

Initiatives that include transboundary water resources are traditionally coordinated through the IBWC using the customary binational cooperation process used by both

INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO

Sections of the Commission. The IBWC, under this joint cooperative process, will provide the framework for coordination of binational aquifer assessment activities conducted by U.S. and Mexican agencies, universities, and others participating in the program.

III. Objectives

The objective of the joint cooperative process for groundwater research is to improve the knowledge base of transboundary aquifers between the United States and Mexico.

To further this process, the following will be carried out within the IBWC framework:

1. Facilitate the exchange of data and assure the concurrence of the United States and Mexico for binational aquifer assessment activities.
2. Facilitate agreement on the aquifers that will be evaluated jointly.
3. Establish and coordinate binational technical advisory committees for each identified transboundary aquifer.
4. Establish an official repository for binational project reports developed under the program.

IV. Framework/Process (Roles and Responsibilities)

1. Either of the two countries can propose an aquifer to study. Within the IBWC framework it will be determined whether the proposal is in the common interest and, as appropriate, a joint program developed.
2. For projects selected, the IBWC will coordinate with agencies from both countries to jointly define the scope of the assessment leading to a binational scope.
3. Binational Technical Groups will be established, coordinated by the IBWC, to address and define the scope of each joint assessment.
4. The IBWC will facilitate concurrence of joint work plans.
5. Whoever carries out the joint studies will update the Binational Technical Groups with the progress of the projects as frequently as is agreed upon in each case, and these Groups will make appropriate observations and recommendations until the studies are accepted.
6. The final reports which proceed from the joint studies will be published in English and Spanish and will be made available for publication once they have been approved within the IBWC framework.

V. Funding

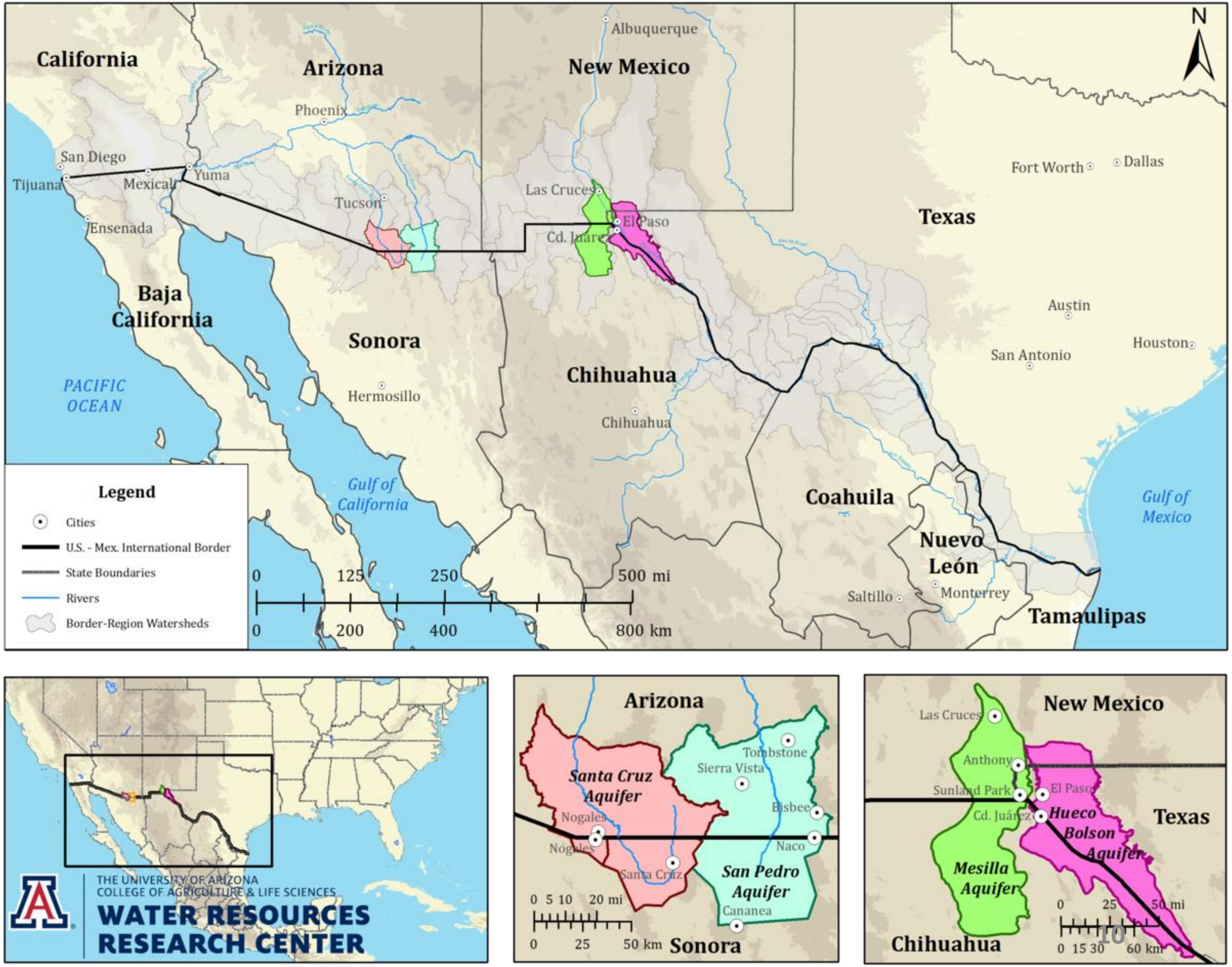
Each country will be responsible for any costs on projects conducted in its territory, in addition to selecting the participants and consultants to carry out the studies in that country. Either country may contribute to costs for work done in the other country. This contribution will be distributed according to the process agreed upon through the IBWC.

All projects and measures considered under this joint cooperative process are subject to the availability of funds and it is understood that agreeing to pursue with the evaluation

-The Transboundary Aquifer Assessment Program is a binational effort to evaluate shared aquifers.

-Initial focus: Santa Cruz, San Pedro, Mesilla, and Hueco Bolson aquifers, due to population growth, demand, and water quality concerns.

TAAP Aquifers of Focus



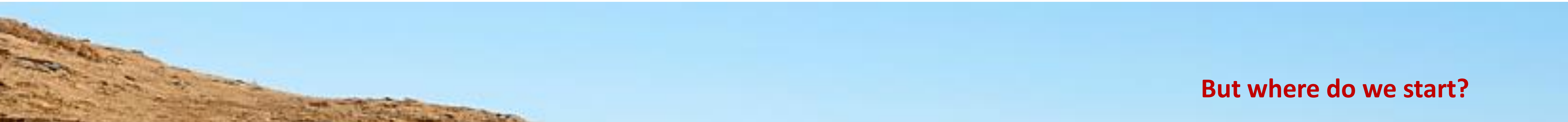
Transboundary Aquifers

- **TAAP formal U.S.–Mexico cooperation** began in 2009 under the IBWC Cooperative Framework.
- A **2023 amendment (H.R. 5874)** proposes extending TAAP and adding new priority aquifers (excl. Yuma).
- TAAP advanced studies of the San Pedro and Santa Cruz aquifers, including water balance modeling.

2016 TAAP meeting in El Paso, TX.

2017 TAAP Technical Meeting in Rio Rico, AZ

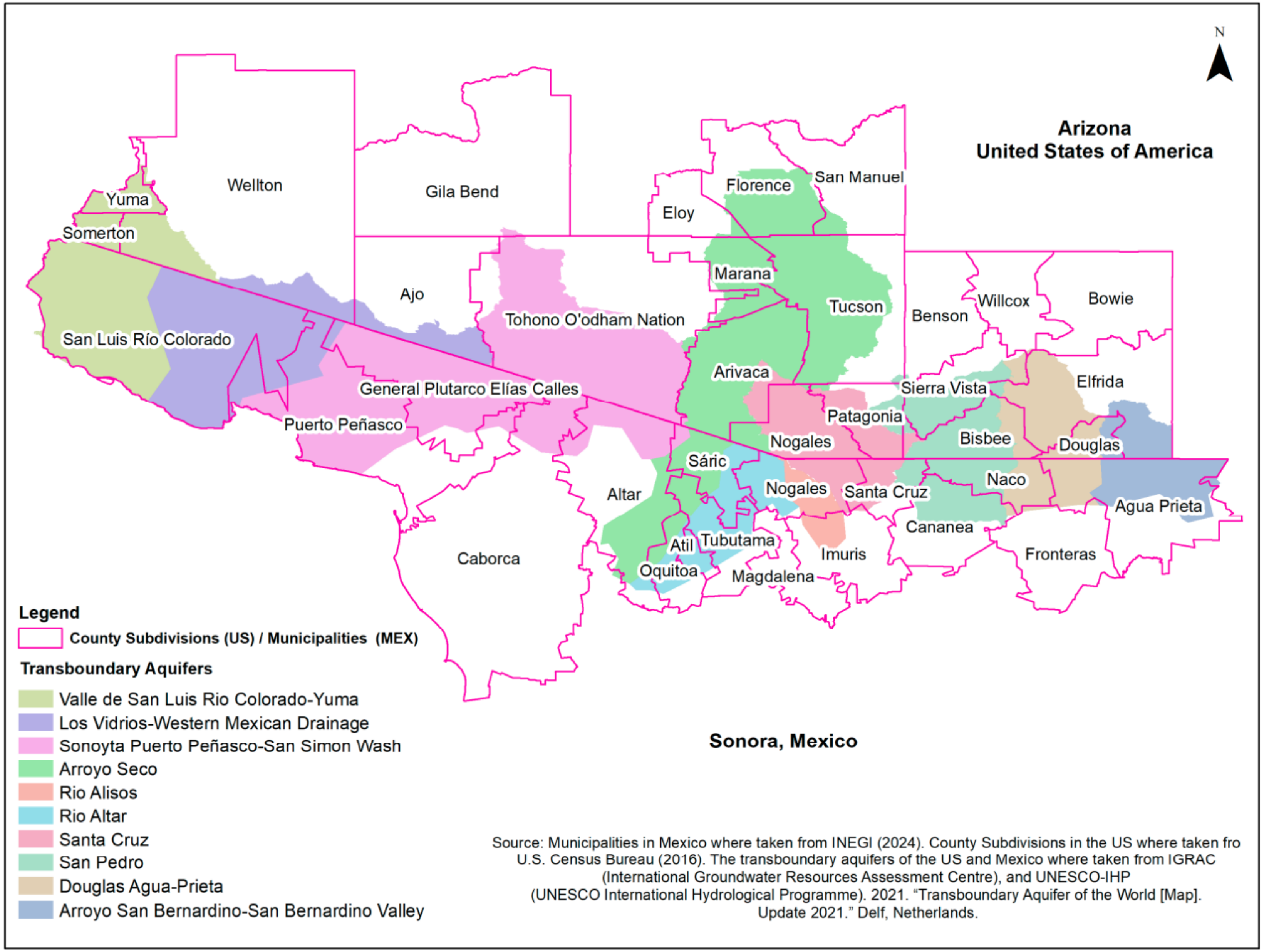
However, the region's shared climate and groundwater reliance highlight the need to expand research to other aquifers.



But where do we start?

Aquifer Prioritization Approach

- Develops a multicriteria method to prioritize transboundary aquifers in the Arizona–Sonora region.
- Supports decision-makers in identifying aquifers that require further assessment.
- Uses publicly available data and indicators such as groundwater use, population, and transboundary extent.
- Aims to optimize resource allocation for regional groundwater research and policy.
- Provides a replicable framework for other U.S.–Mexico border regions and global transboundary contexts.



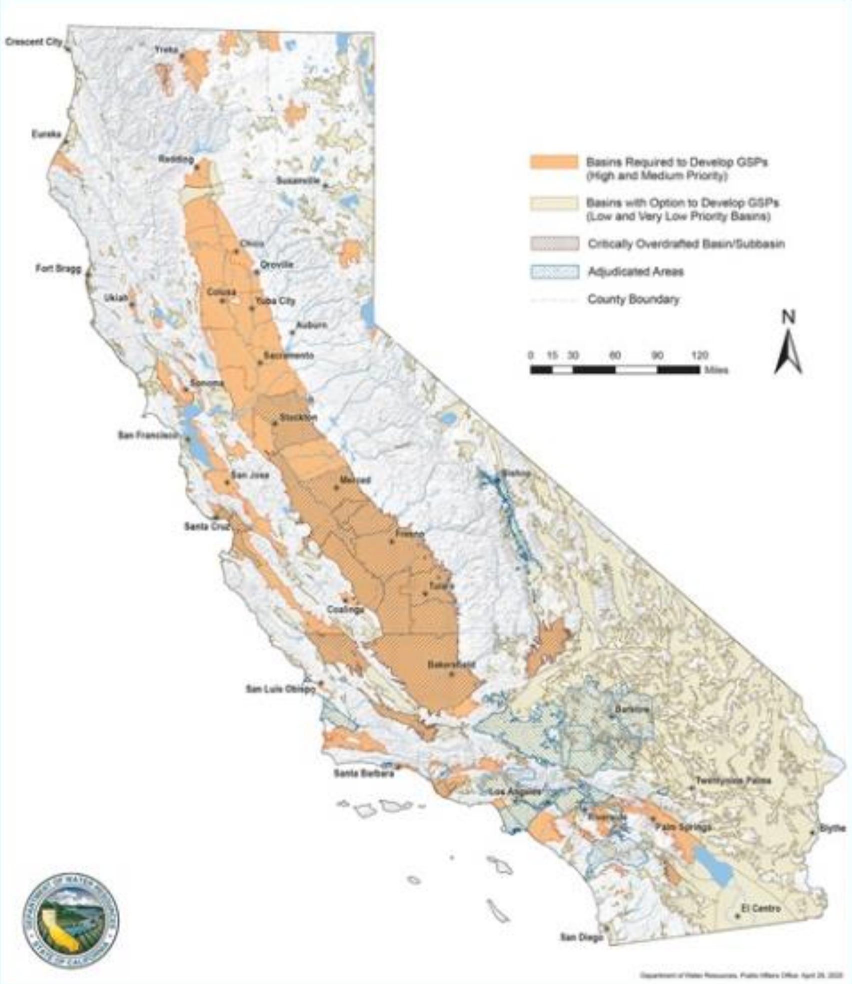
Aquifer prioritization

- Prioritization methods are used globally (e.g., California, Illinois, Arizona) based on multiple criteria.
- This study focuses on Arizona–Sonora aquifers using public data and indicators such as water stress, governance, and socioeconomic factors.

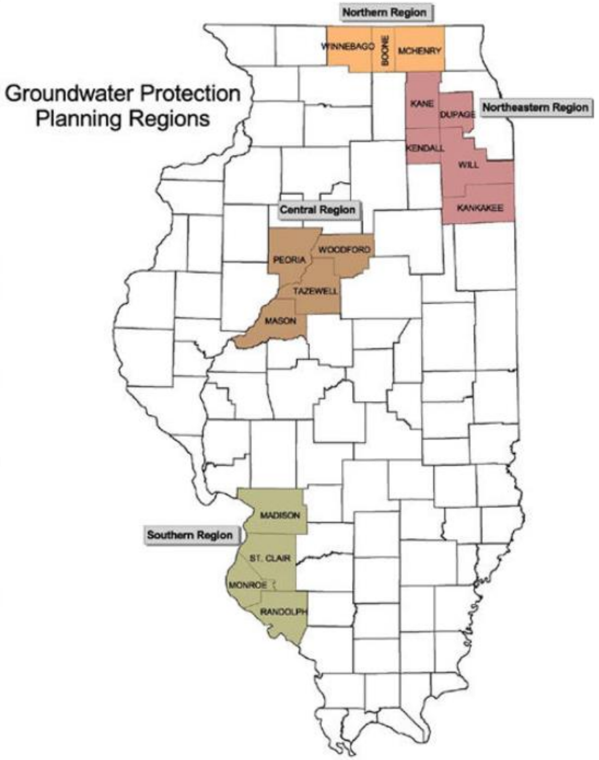
Groundwater for Sustainable Development, volume 12, pages 100501

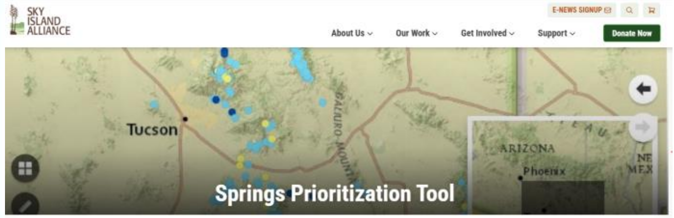
Prioritization of sites for Managed Aquifer Recharge in a semi-arid environment in western India using GIS-Based multicriteria evaluation strategy

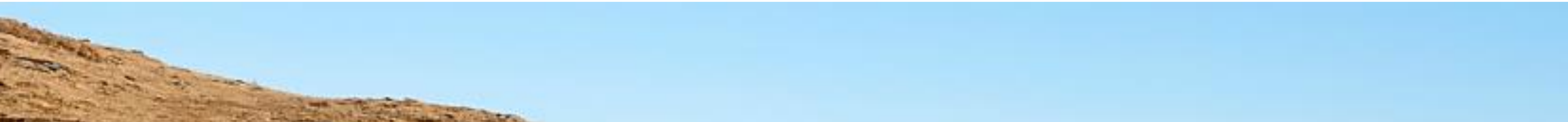
Amit Vishwakarma[1], Ajanta Goswami[1], Benudhar Pradhan[1]



Statewide Map of Current SGMA Basin Prioritization
Released: May 1, 2020







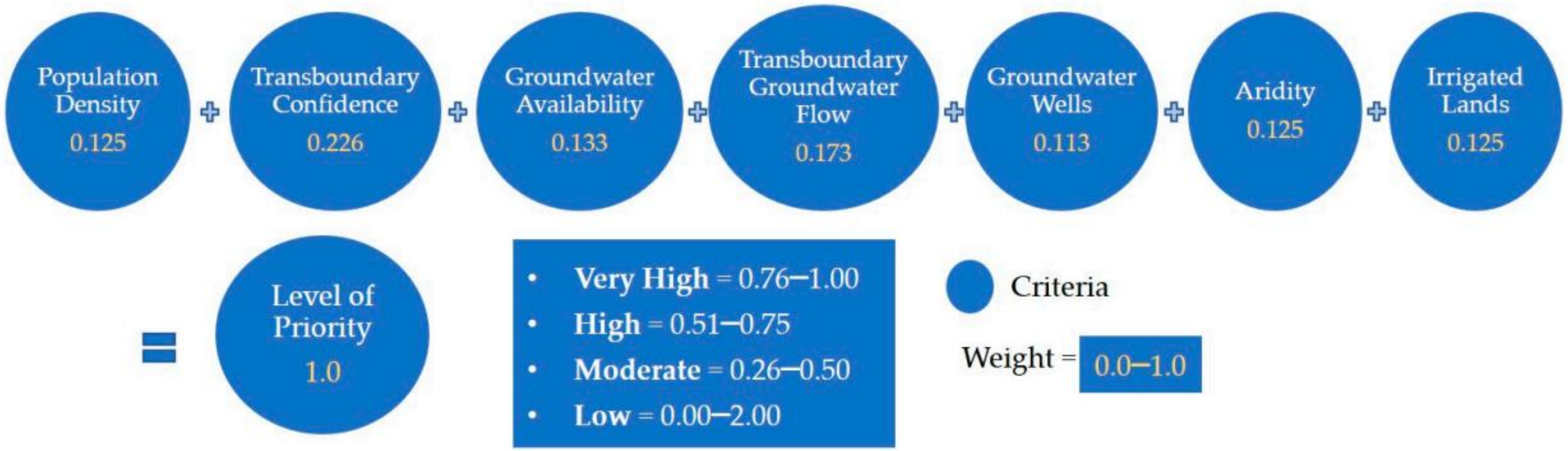
Multicriteria Analysis

•Multicriteria analysis (MCA) techniques are recognized for effectively supporting water management decisions, allowing systematic evaluation and prioritization.

•MCA helps decision-makers assign relative importance (weights) to multiple criteria, facilitating comprehensive assessments of alternatives.

•MCA is particularly suitable for integrating diverse factors—such as population density, groundwater availability, and transboundary connectivity—into decision-making frameworks.

•MCA is advantageous over single-criterion assessments, hydrological modeling, or cost–benefit analysis, as these traditional methods cannot integrate multiple interacting dimensions effectively.



Data Sources and Criterion Selection

Criteria were chosen based on data availability, reliability, and applicability to other aquifers

Population Density

•Indicates water demand and potential pressure on aquifer resources.
•Data sources: U.S. Census Bureau (2020), INEGI (2020); analyzed using GIS.

Transboundary Confidence

•Categorizes aquifers based on the certainty of cross-border connectivity: reasonable, some, or limited.
•Framework established by Sanchez et al. (2016); higher confidence indicates higher priority.

Groundwater Availability

•Measures balance between recharge and groundwater extraction.
•Calculated using CONAGUA methodology (NOM-011-CONAGUA-2015); results in Million Cubic Meters (MCM) per year.
•Positive availability suggests sustainability; negative indicates stress or overexploitation.

Transboundary Groundwater Flow

•Estimates horizontal groundwater flow across the international boundary, highlighting shared dependency.
•Based on CONAGUA's water availability reports (NOM-011-CONAGUA-2015); results expressed in MCM per year.

Groundwater Flow

•Counts registered wells as a proxy for extraction pressure.
•Data sources: Arizona Department of Water Resources GIS Portal (U.S.) and Public Registry of Water Rights (CONAGUA, Mexico).
•A higher number of wells suggests greater extraction and higher aquifer priority.

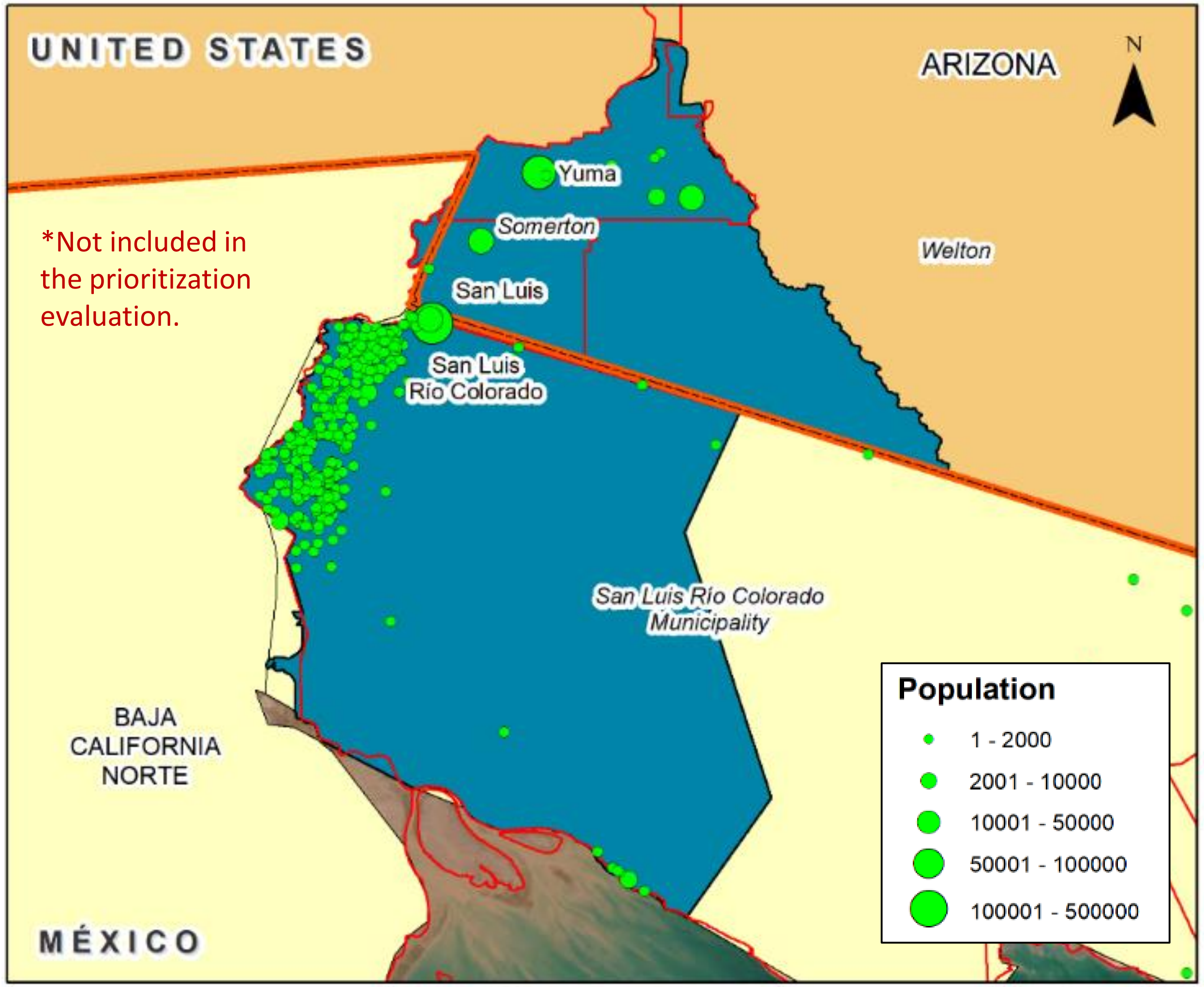
Aridity

•Developed an Aridity Index (AI) indicating climatic stress, using the ratio of precipitation to potential evapotranspiration and barren land cover changes.
•Lower AI indicates higher aridity; calculated from TerraClimate dataset.

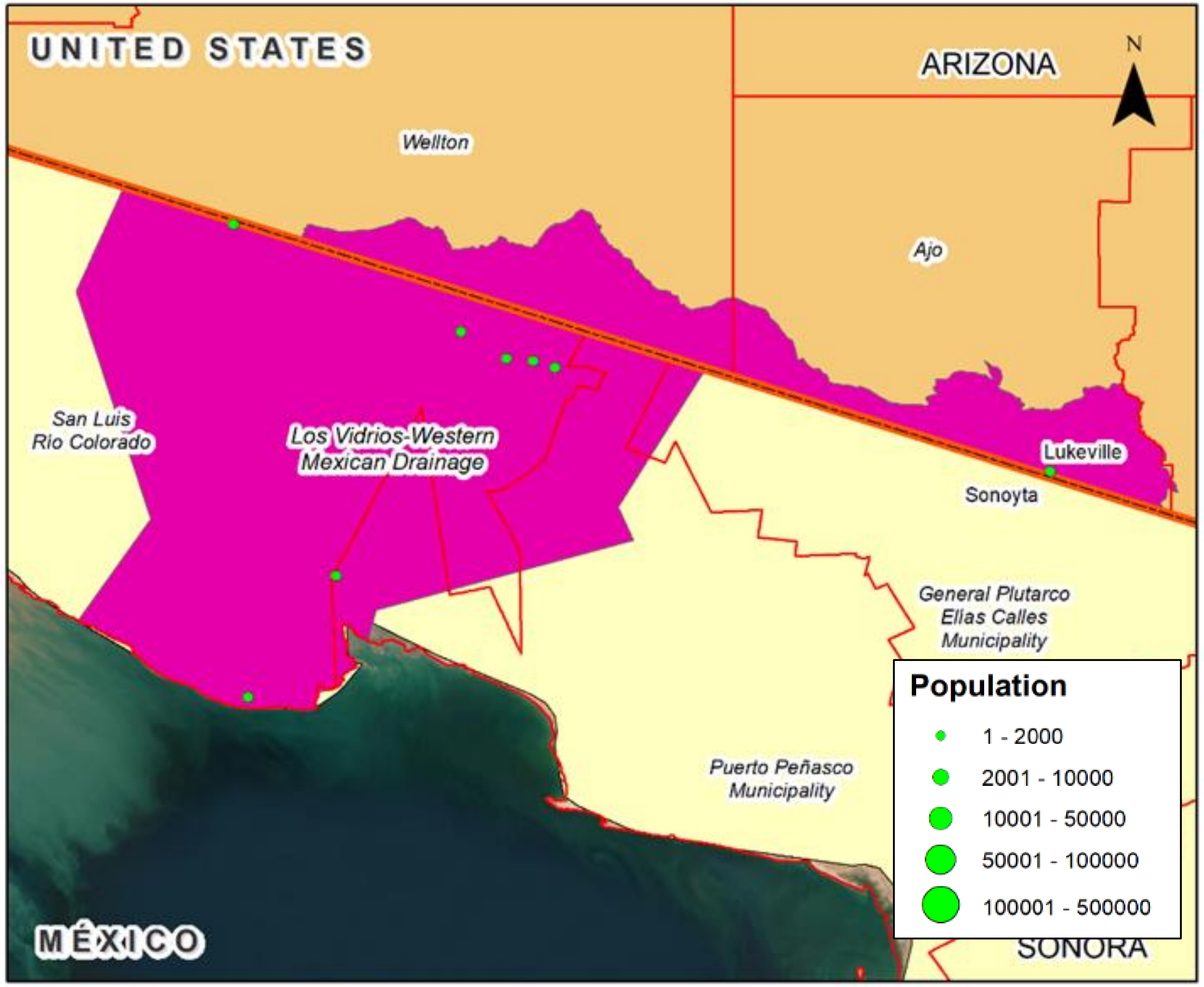
Irrigated lands

•Measures areas irrigated by groundwater, directly reflecting water demand.
•Data sourced from FAO and World Bank global maps of irrigated areas; expressed in hectares.

Population Density

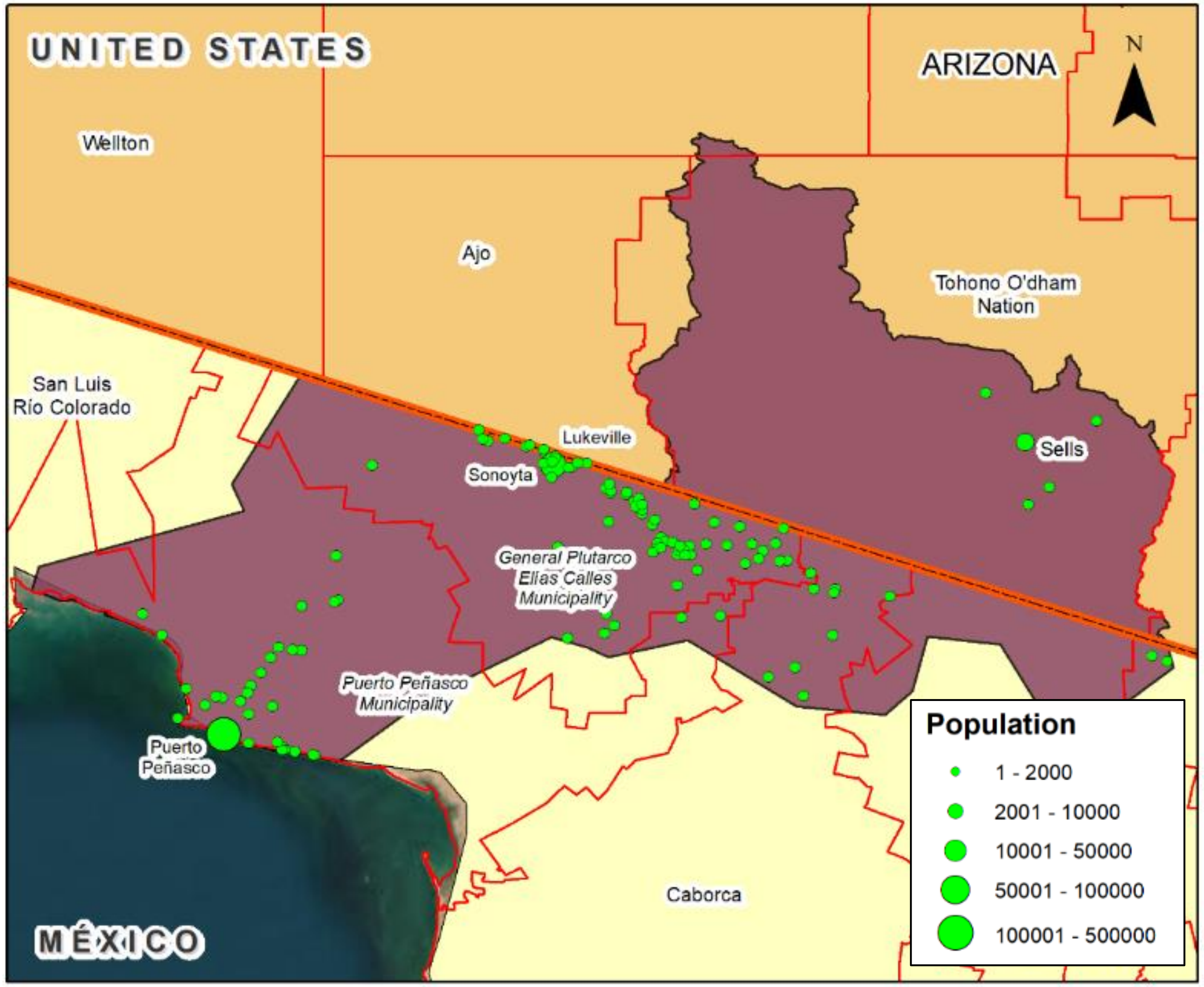


Valle de San Luis Río Colorado – Yuma Aquifer.

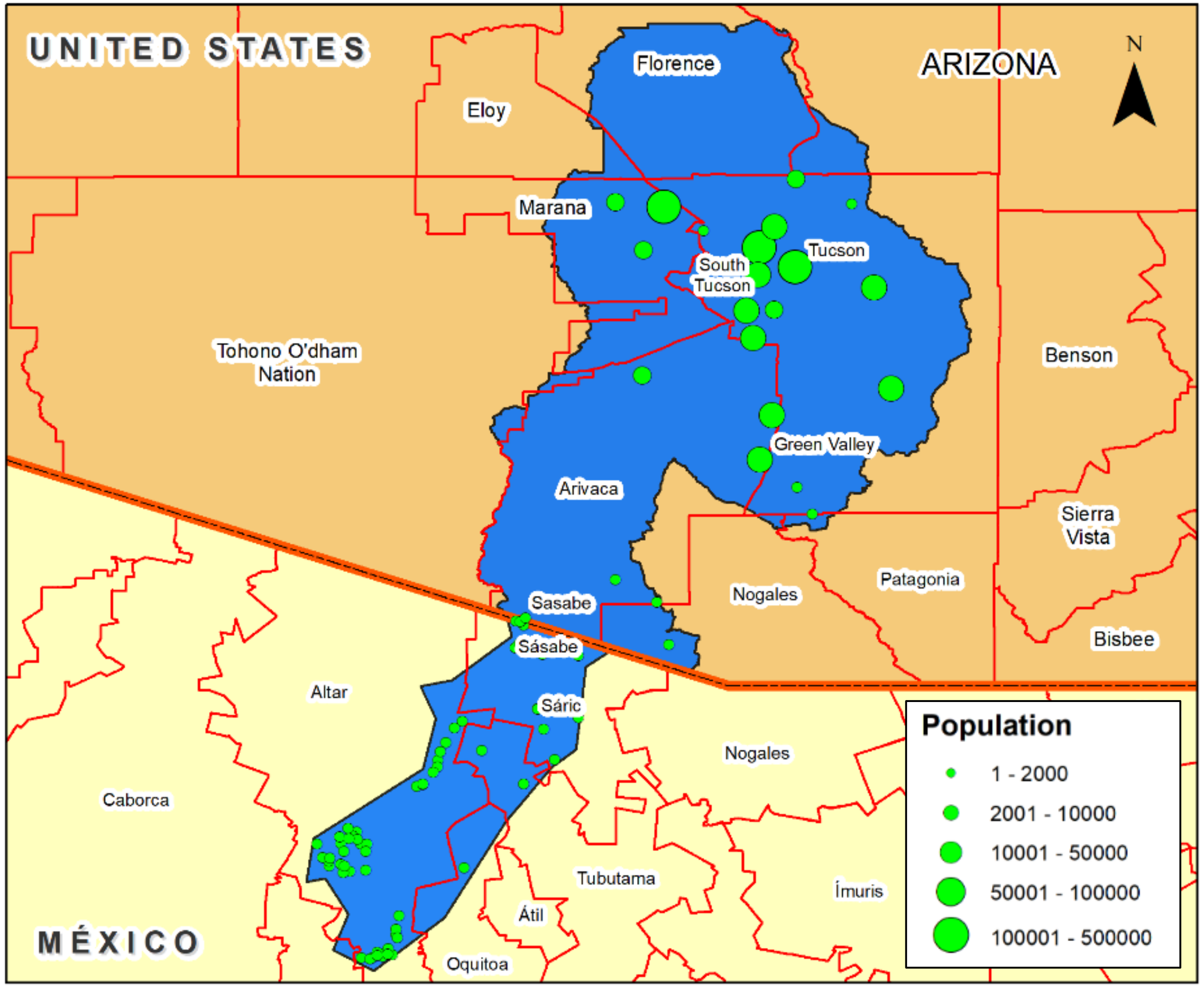


Los Vidrios-Western Mexican Drainage Aquifer

Population Density



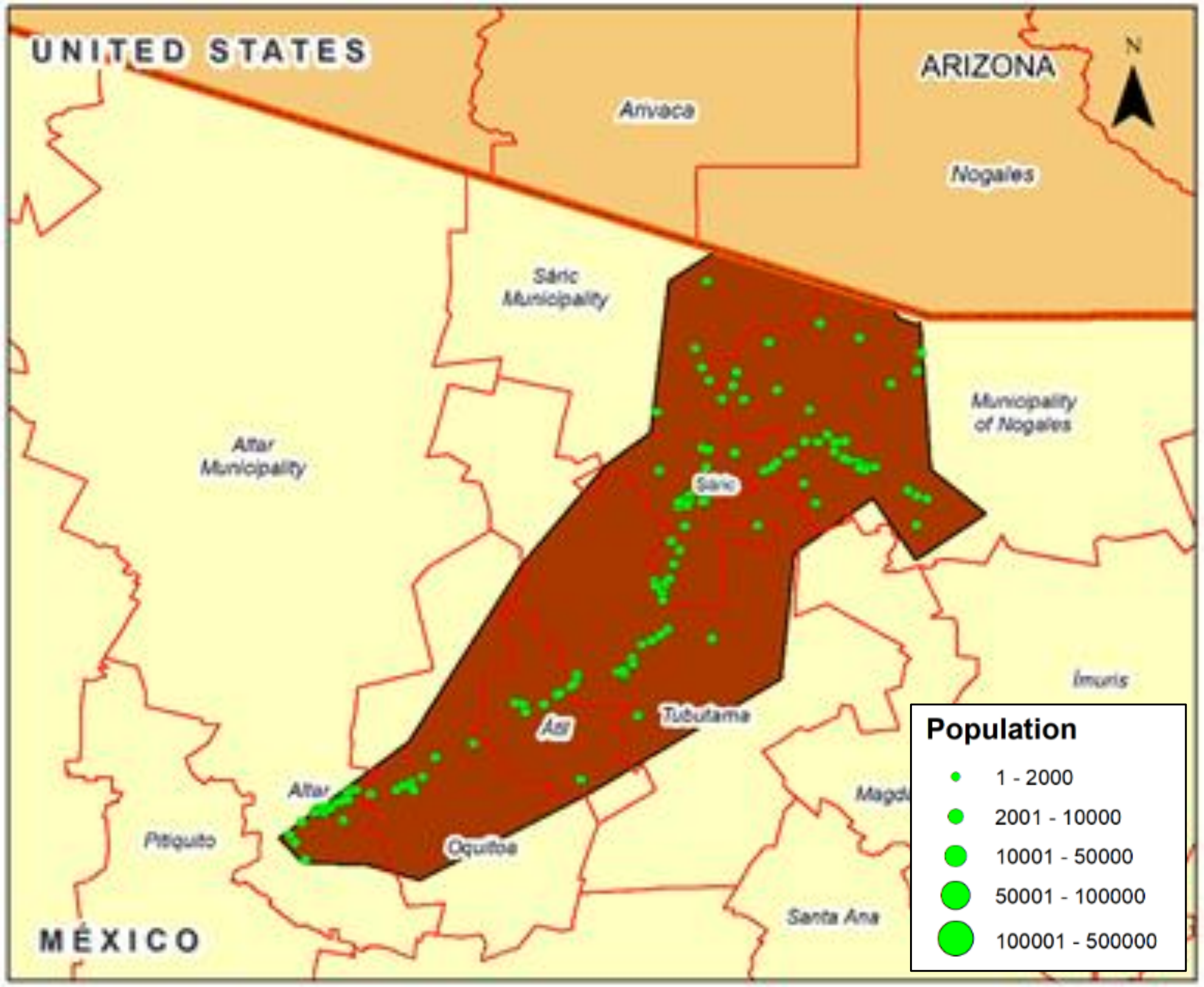
Sonoyta Puerto Peñasco-San Simon Wash Aquifer.



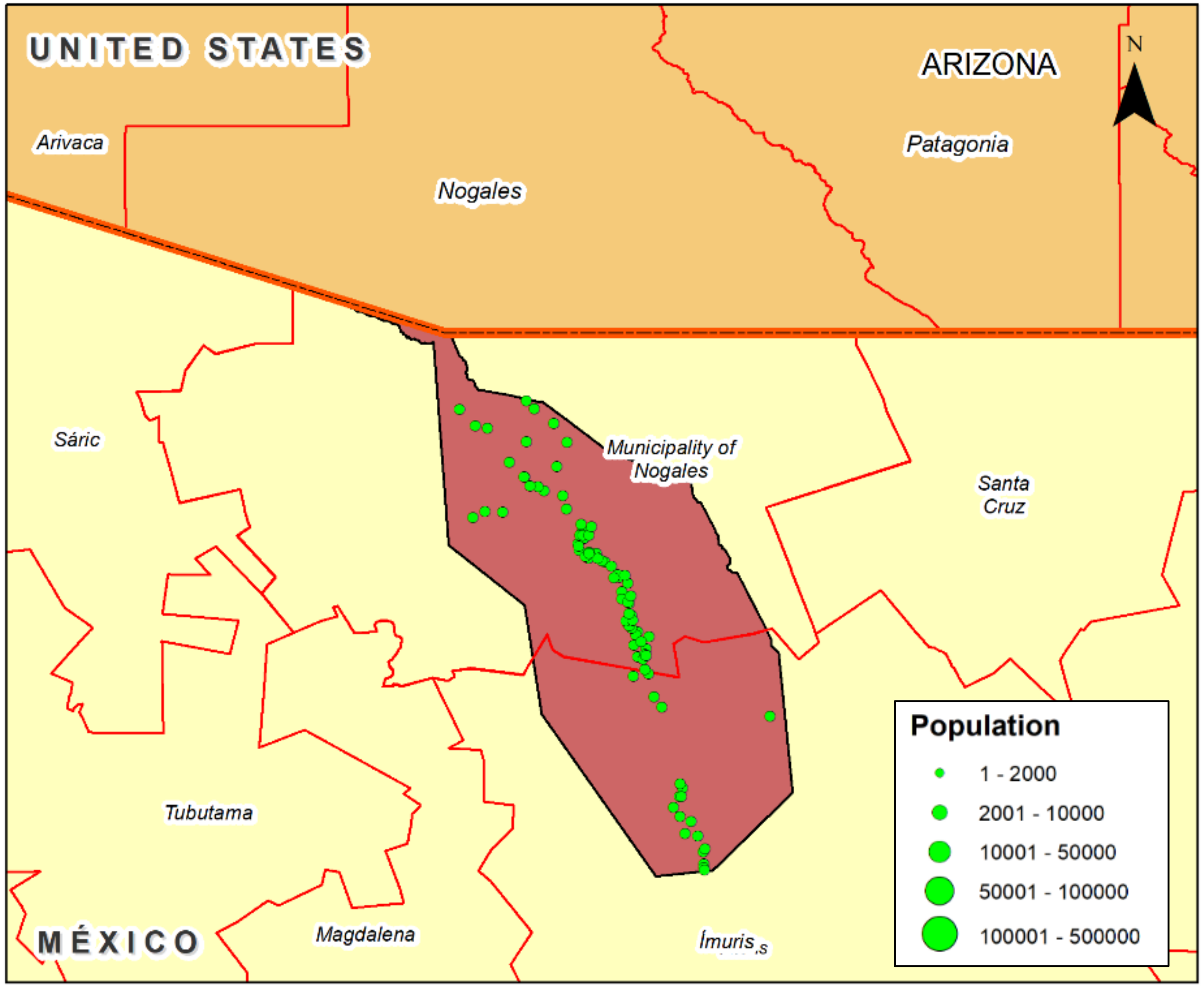
*Not included in the prioritization evaluation.

Arroyo Seco Aquifer.

Population Density

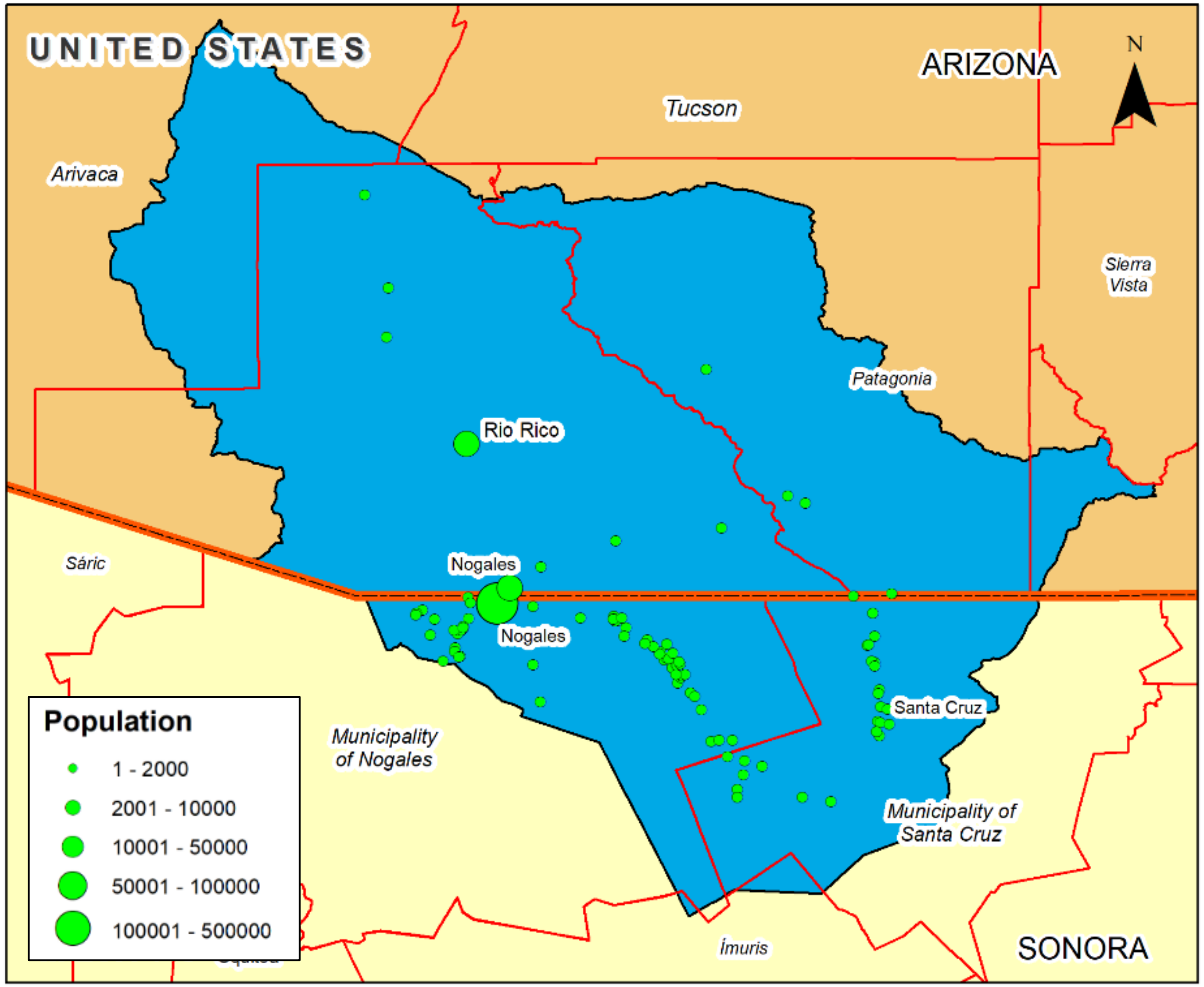


Río Altar Aquifer

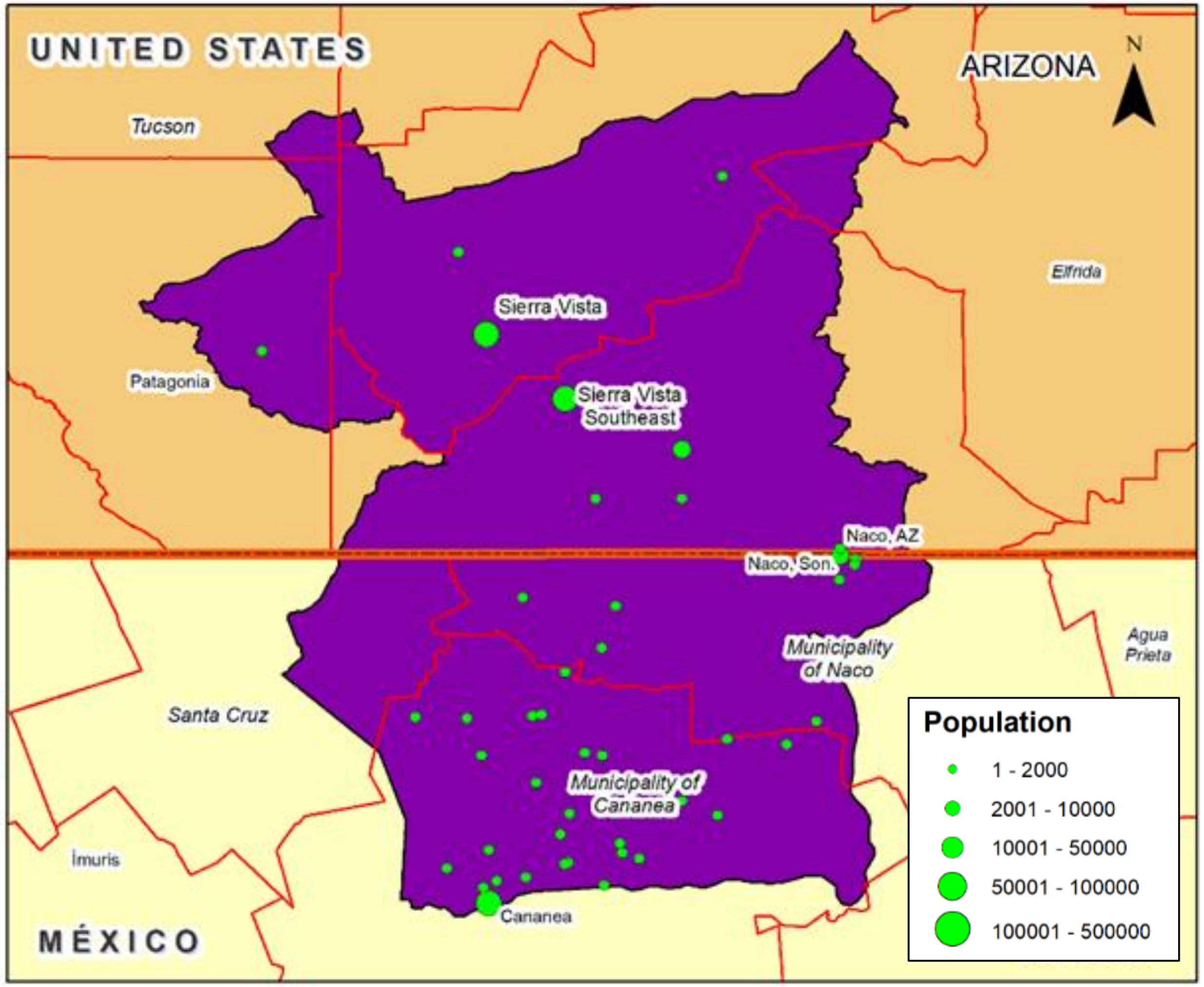


Río Alisos Aquifer

Population Density

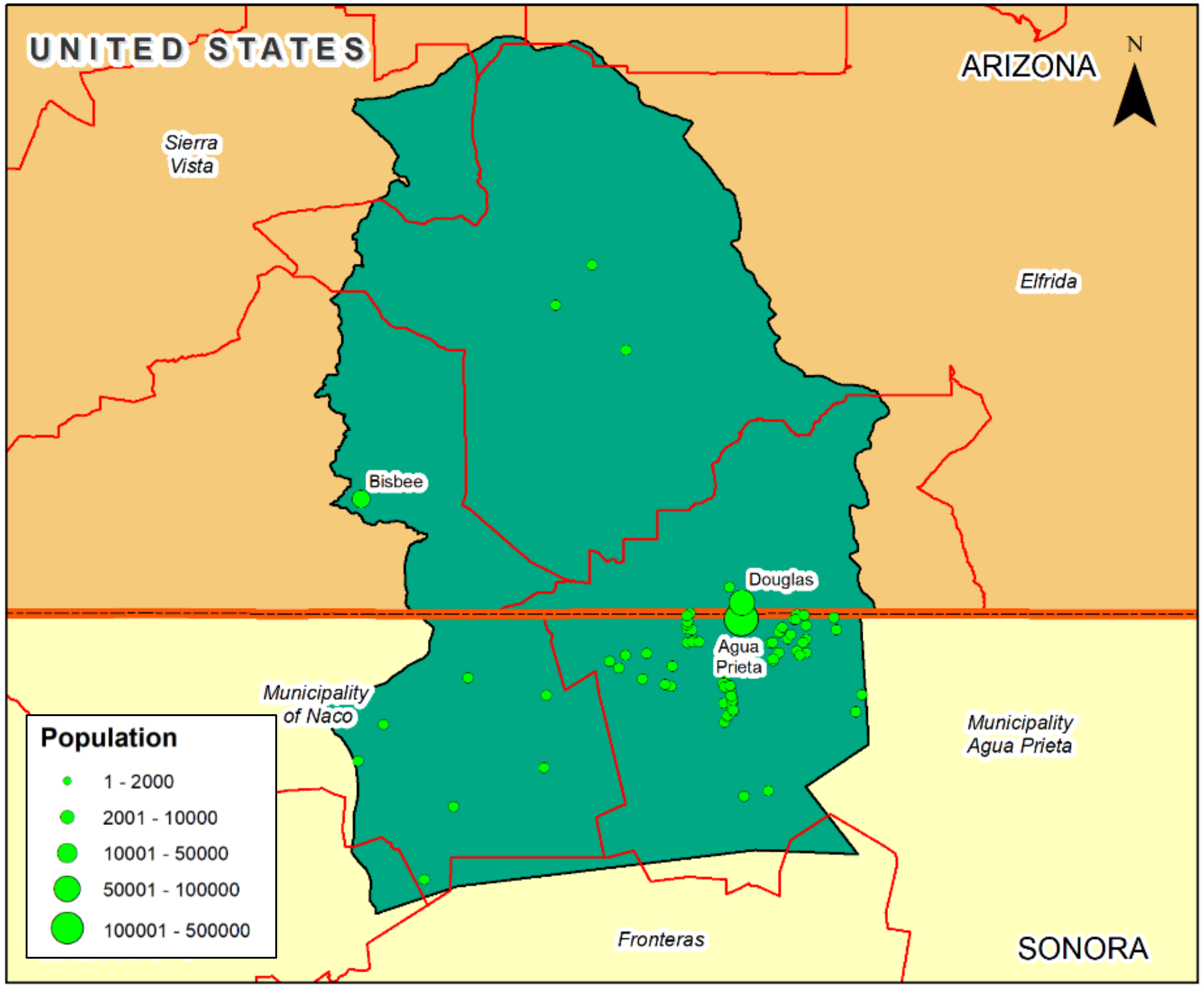


Santa Cruz Aquifer

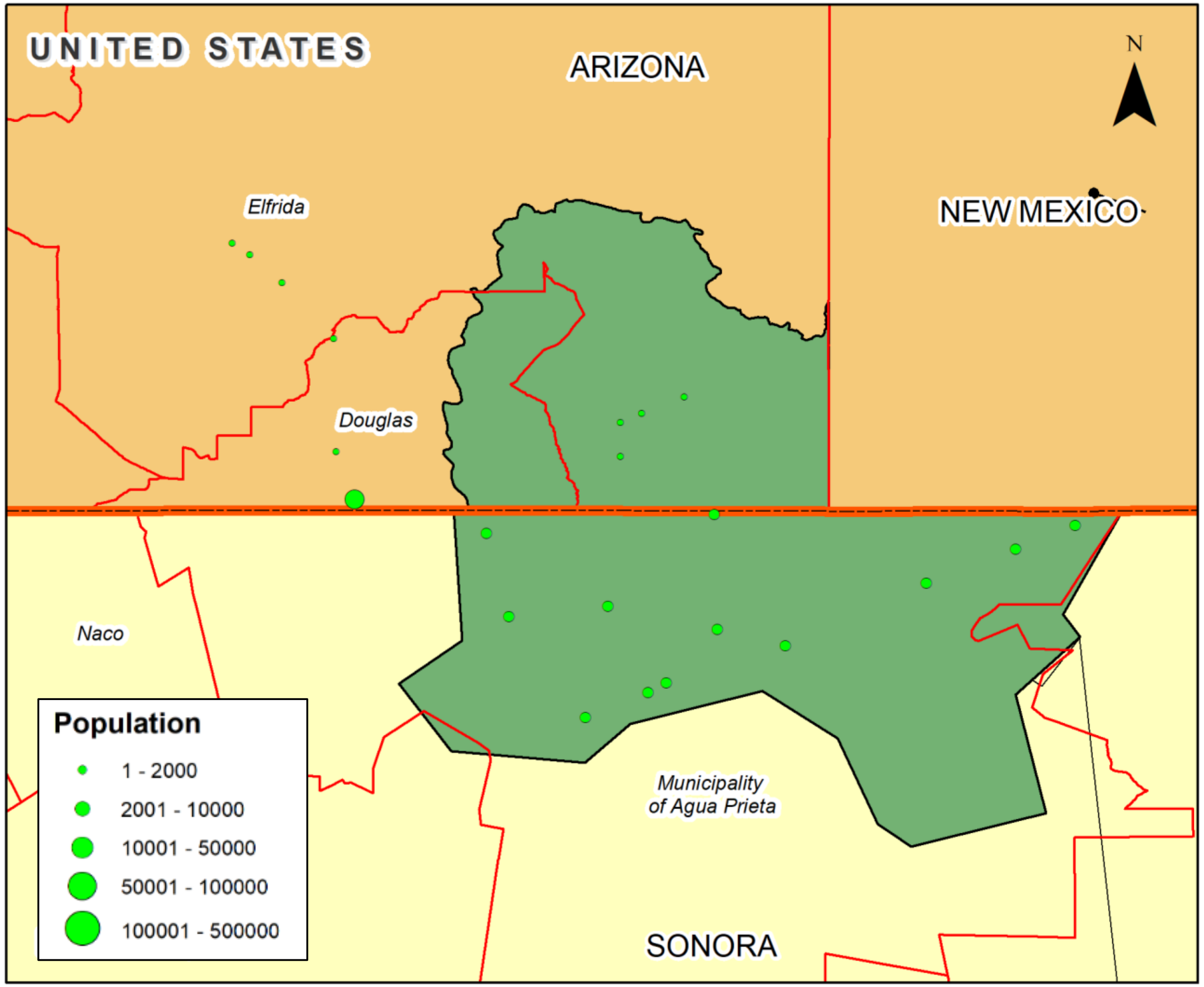


San Pedro Aquifer

Population Density

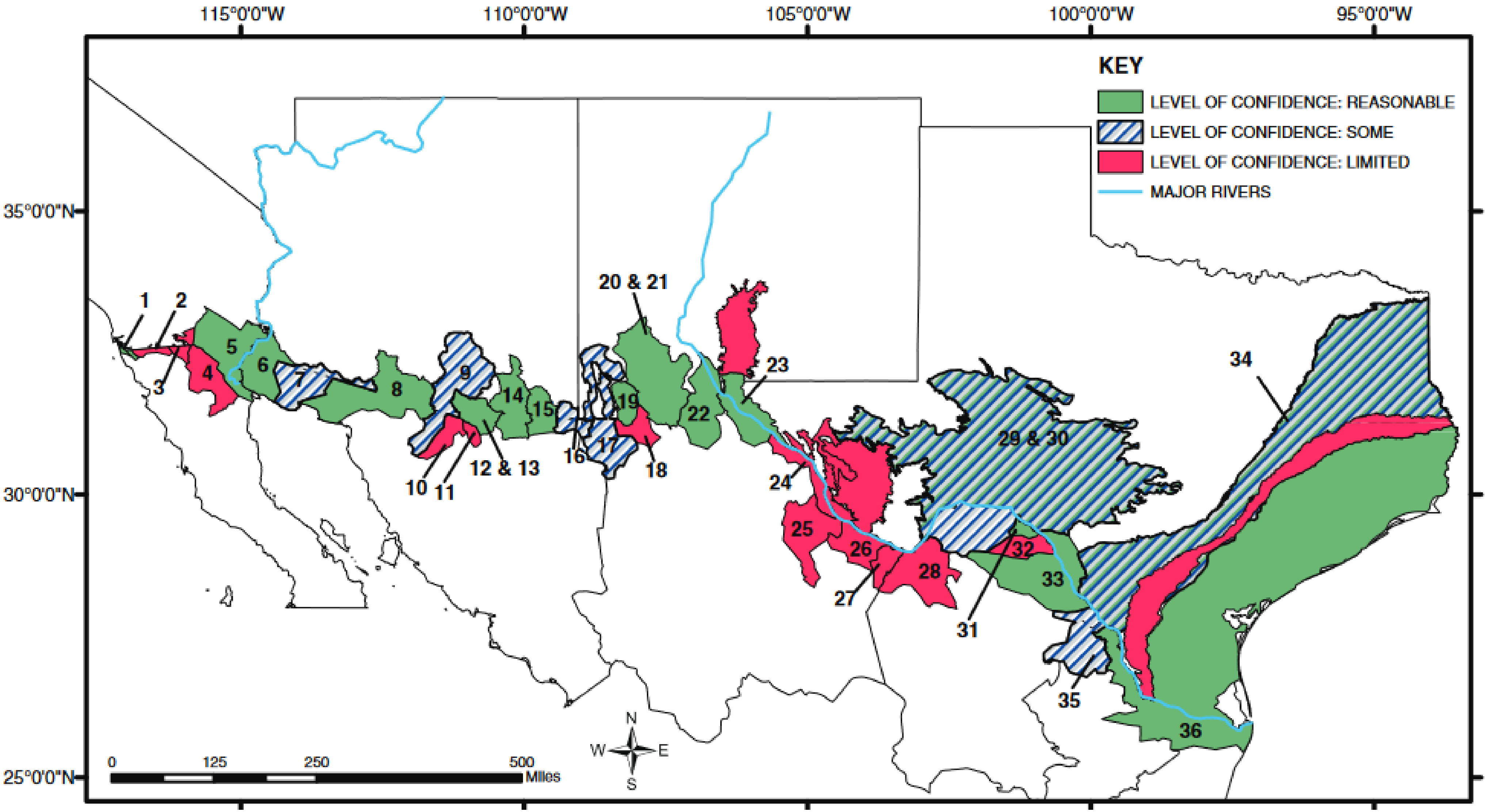


Douglas-Agua Prieta Aquifer.



Arroyo San Bernardino-San Bernardino Valley Aquifer.

Transboundary Confidence



Sanchez, Rosario, and Laura Rodriguez. 2021. "Transboundary Aquifers between Baja California, Sonora and Chihuahua, Mexico, and California, Arizona and New Mexico, United States: Identification and Categorization." *Water* 13 (20): 2878. https://doi.org/10.3390/w13202878.

Transboundary Groundwater flow

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GERENCIA DE AGUAS SUBTERRÁNEAS

ACTUALIZACIÓN DE LA DISPONIBILIDAD MEDIA ANUAL DE AGUA EN EL ACUÍFERO NOGALES (2650), ESTADO DE SONORA

CIUDAD DE MÉXICO, 2024

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CIUDAD DE MÉXICO, 2024

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ACTUALIZACIÓN DE LA DISPONIBILIDAD MEDIA ANUAL DE AGUA EN EL ACUÍFERO VALLE DE SAN LUIS RÍO COLORADO (2601), ESTADO DE SONORA

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SUBDIRECCIÓN GENERAL TÉCNICA

GERENCIA DE AGUAS SUBTERRÁNEAS

ACTUALIZACIÓN DE LA DISPONIBILIDAD MEDIA ANUAL DE AGUA EN EL ACUÍFERO LOS VIDRIOS (2602), ESTADO DE SONORA

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GERENCIA DE AGUAS SUBTERRÁNEAS

ACTUALIZACIÓN DE LA DISPONIBILIDAD MEDIA ANUAL DE AGUA EN EL ACUÍFERO RÍO ALTAR (2608), ESTADO DE SONORA

CIUDAD DE MEXICO, 2024

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GERENCIA DE AGUAS SUBTERRÁNEAS

ACTUALIZACIÓN DE LA DISPONIBILIDAD MEDIA ANUAL DE AGUA EN EL ACUÍFERO RÍO SAN PEDRO (2616), ESTADO DE SONORA

CIUDAD DE MÉXICO, 2024

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ACTUALIZACIÓN DE LA DISPONIBILIDAD MEDIA ANUAL DE AGUA EN EL ACUÍFERO SONOYTA-PUERTO PEÑASCO (2603), ESTADO DE SONORA

CIUDAD DE MÉXICO, 2024

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SUBDIRECCIÓN GENERAL TÉCNICA

GERENCIA DE AGUAS SUBTERRÁNEAS

ACTUALIZACIÓN DE LA DISPONIBILIDAD MEDIA ANUAL DE AGUA EN EL ACUÍFERO RÍO AGUA PRIETA (2629), ESTADO DE SONORA

CIUDAD DE MÉXICO, 2024

CONAGUA
COMISIÓN NACIONAL DEL AGUA

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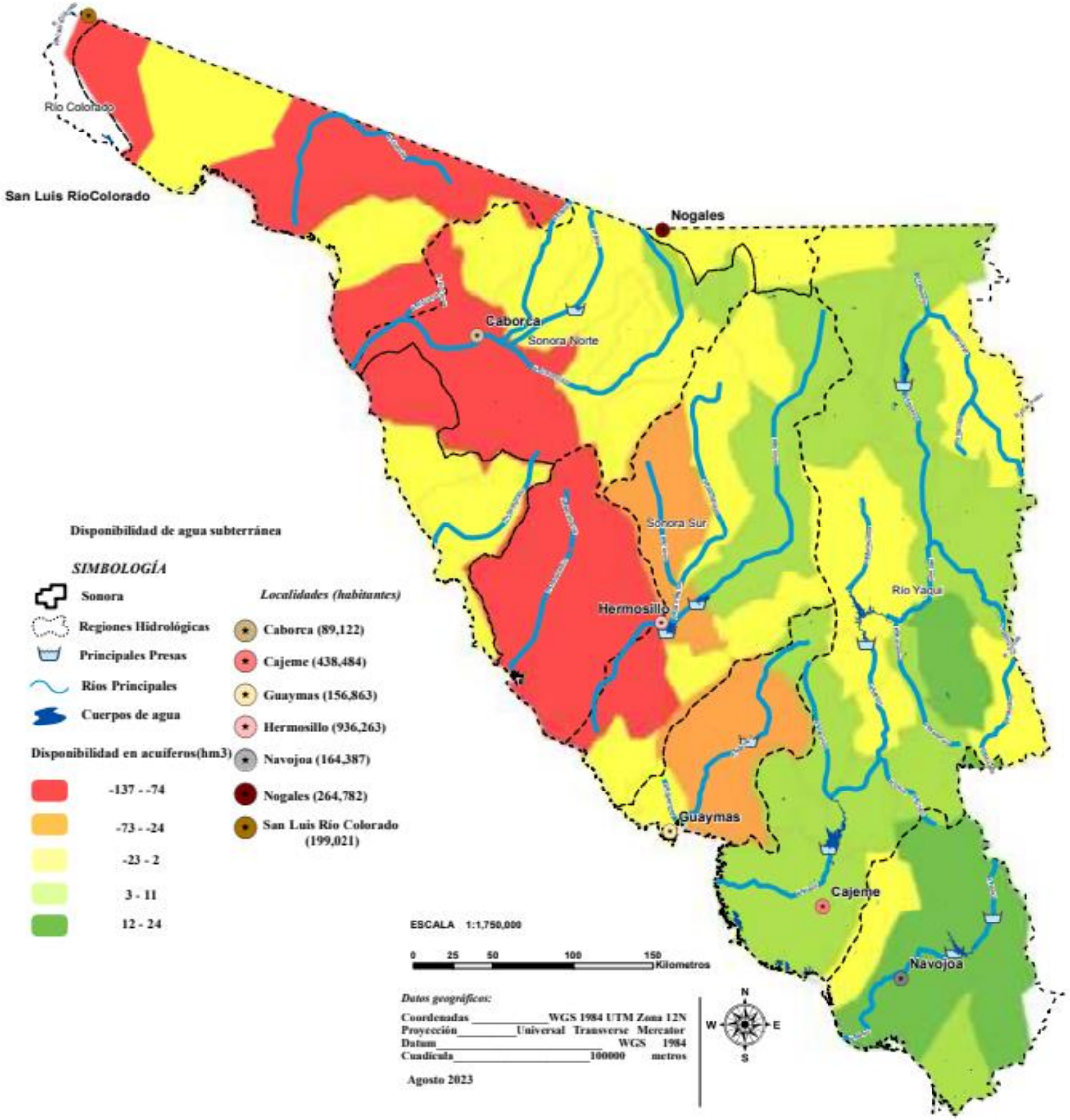
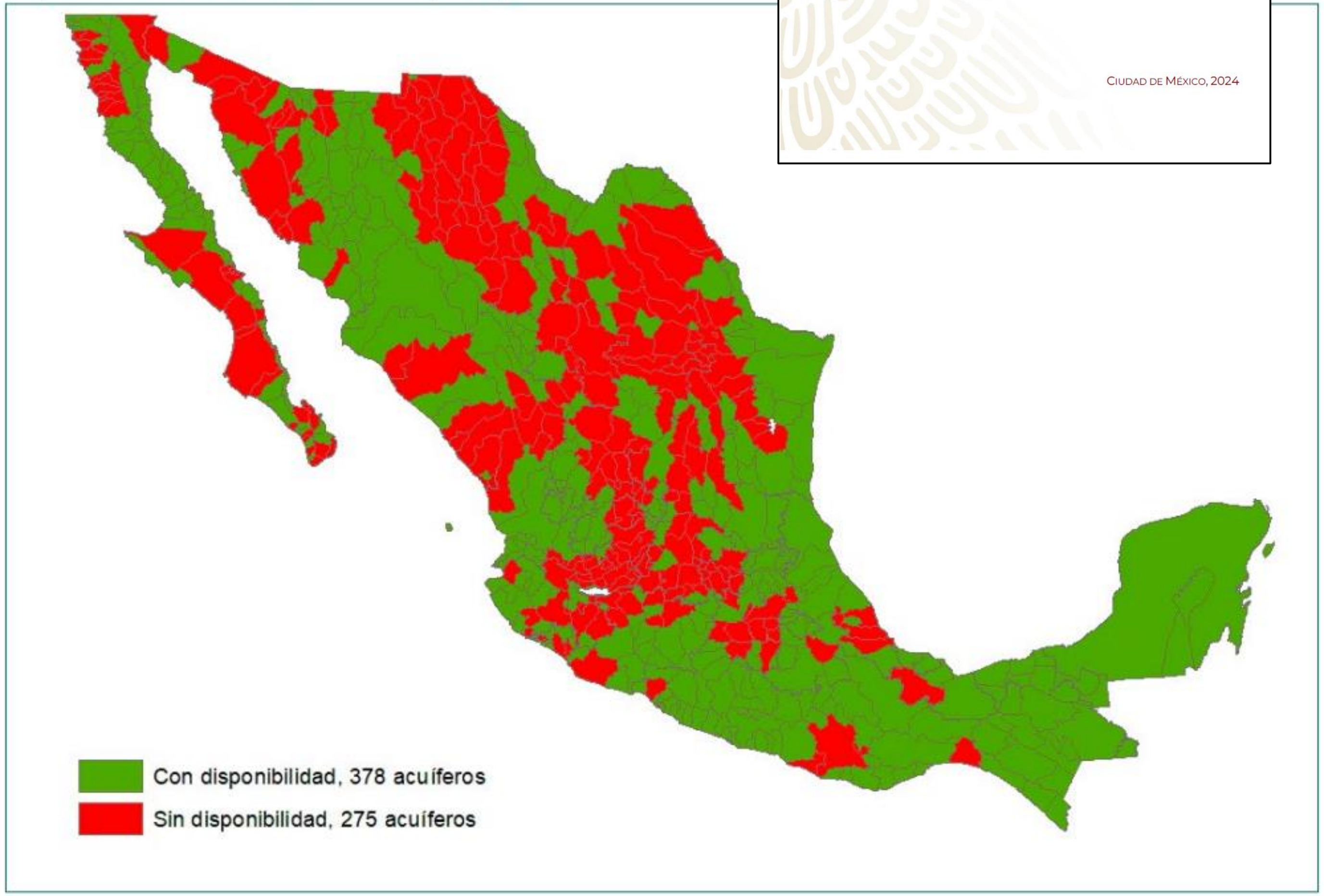
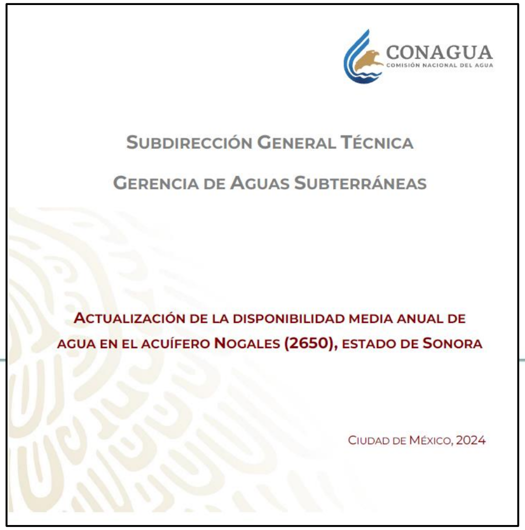
Groundwater availability





Fuente: CONAGUA (2023c).


CONAGUA
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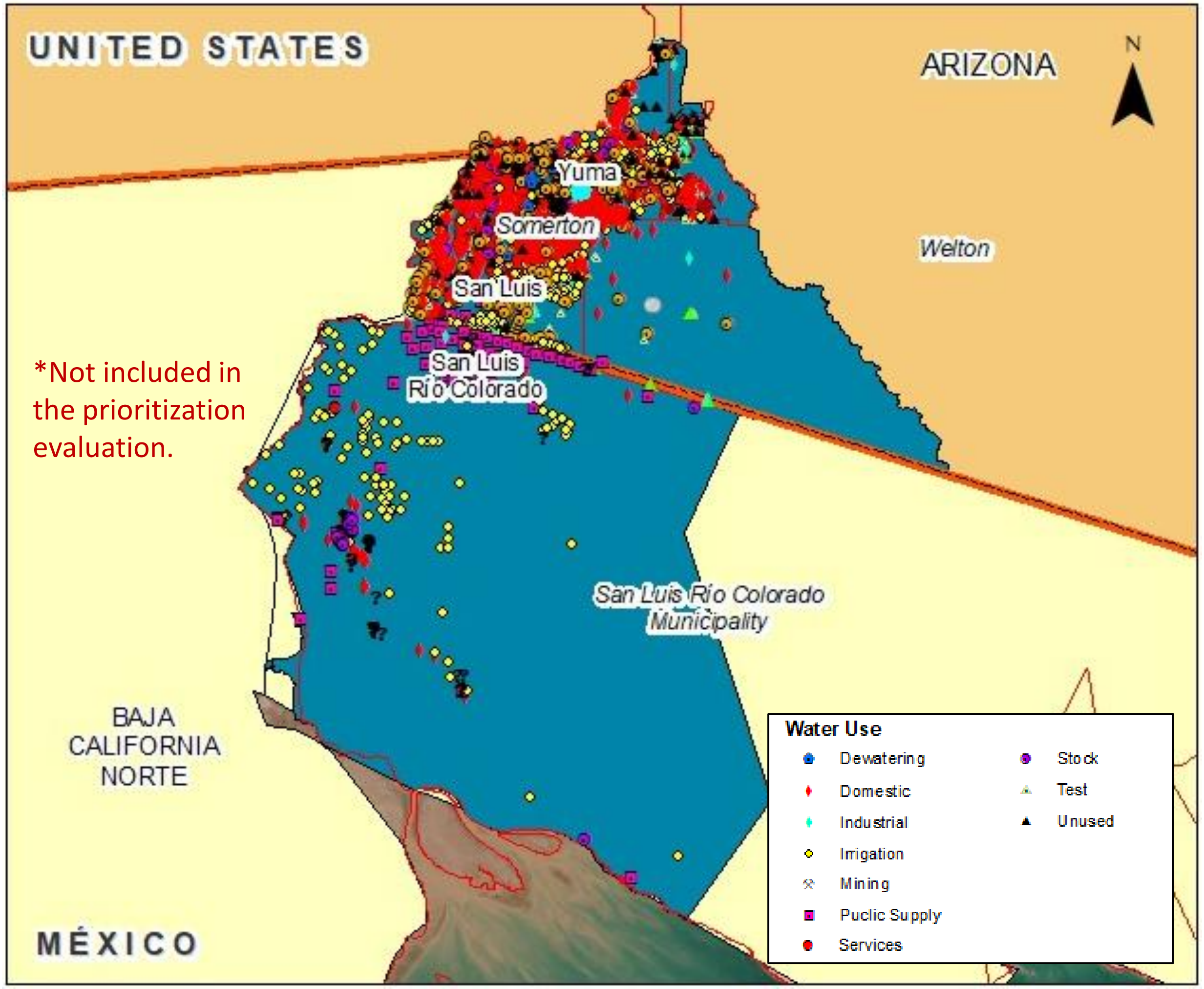
Gerencia de Aguas Subterráneas

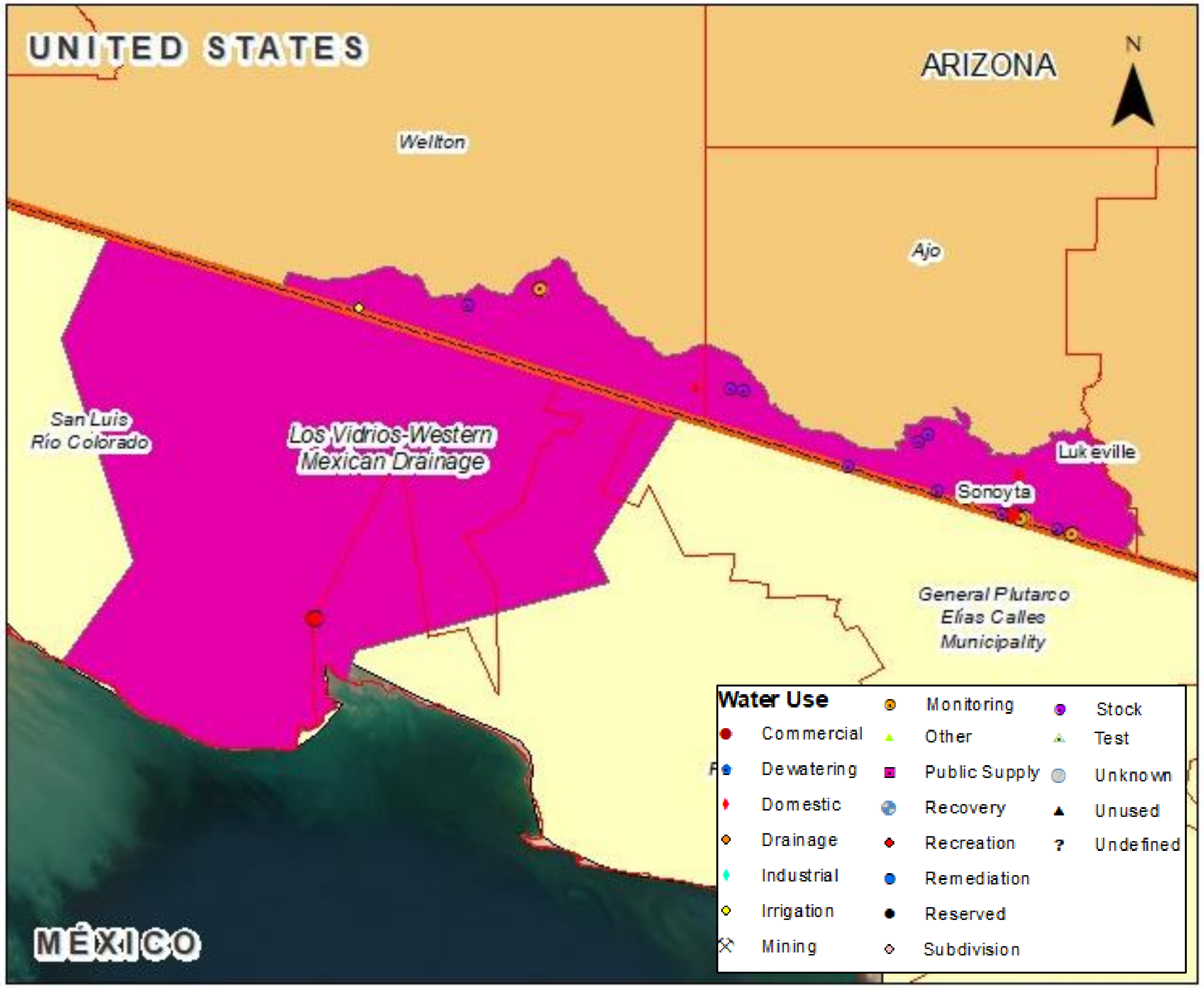
Actualización de la disponibilidad media anual de agua en el acuífero Nogales (2650), Estado de Sonora

Ciudad de México, 2024

Groundwater wells

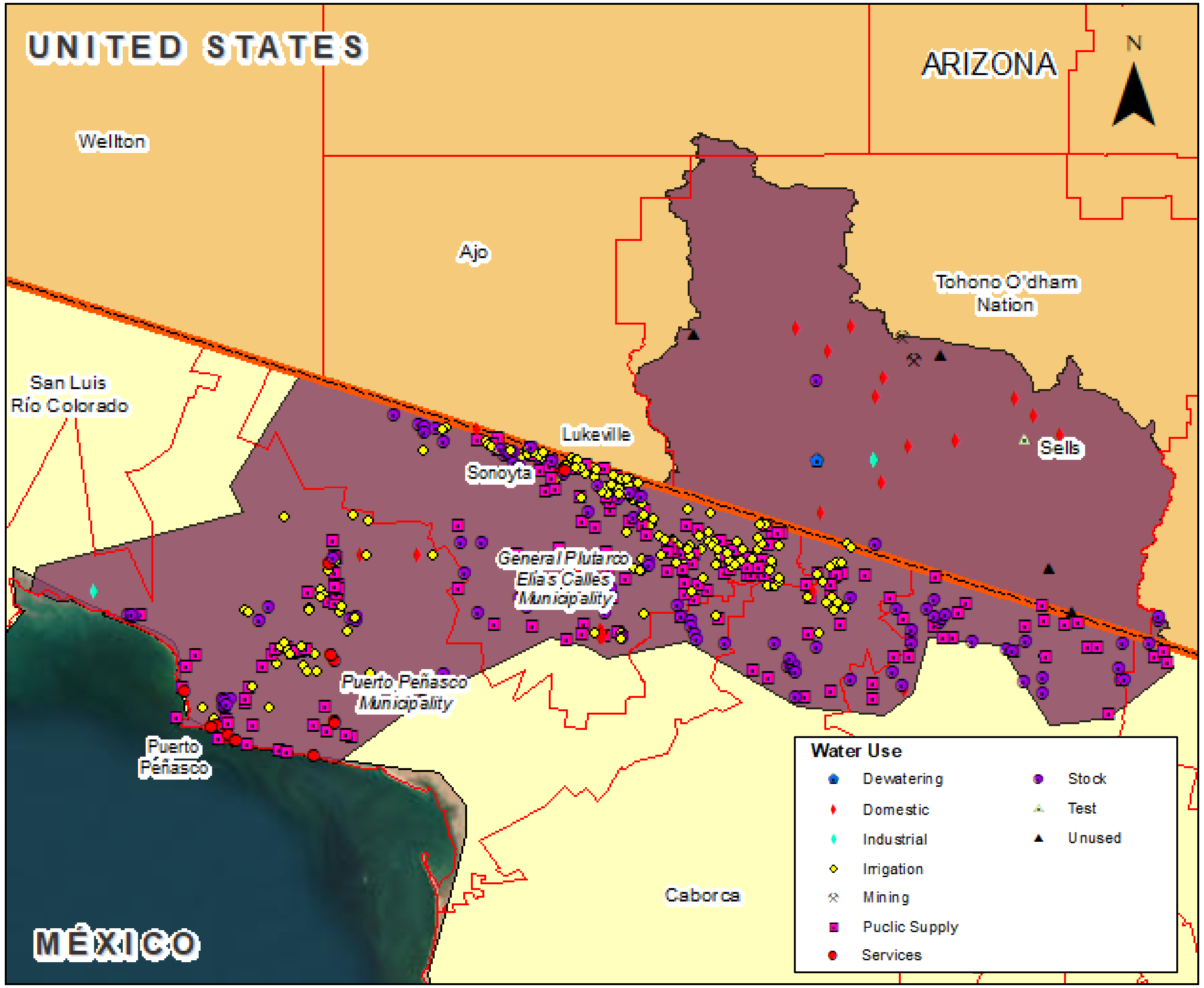


Valle de San Luis Río Colorado – Yuma Aquifer.

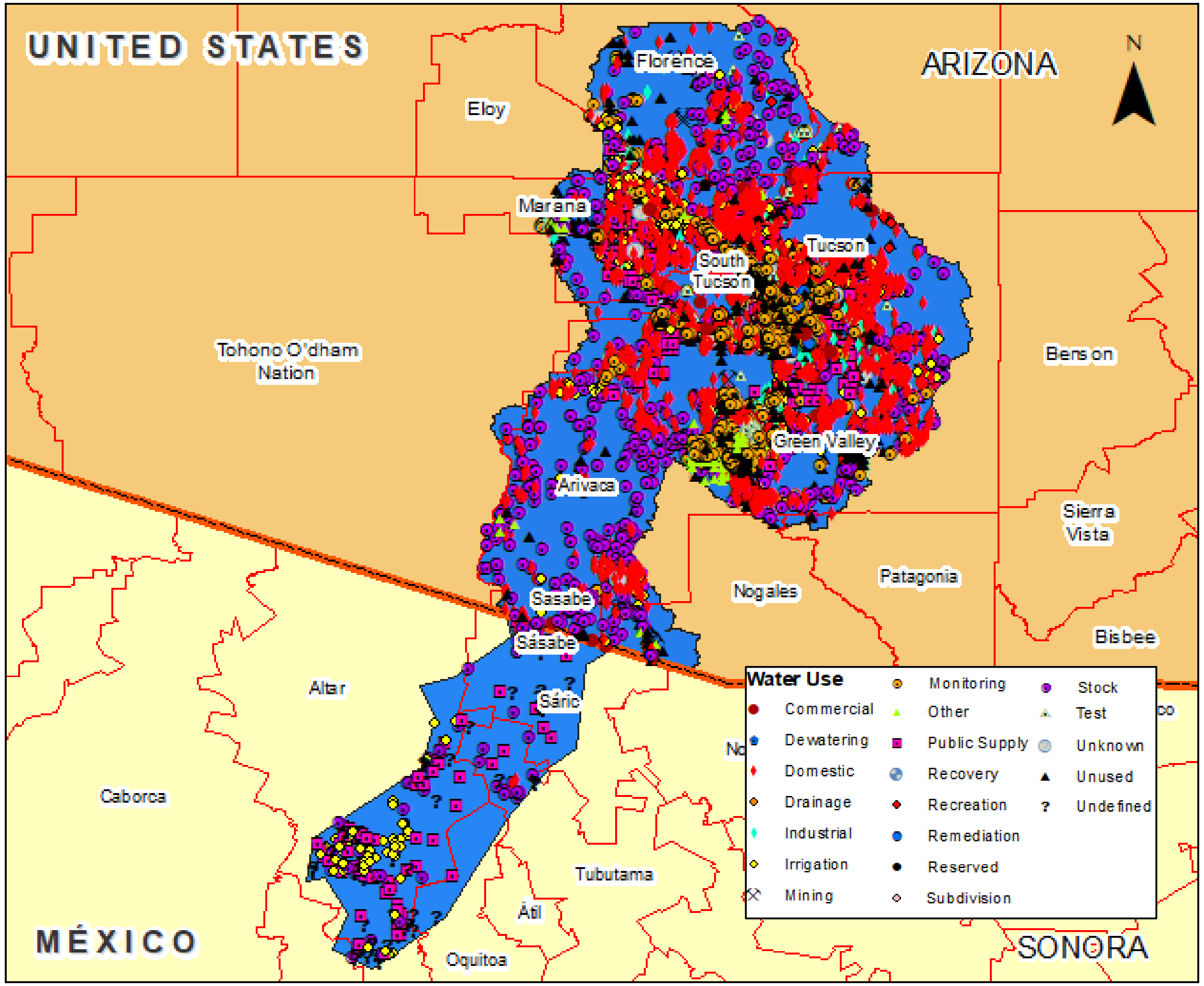


Los Vidrios-Western Mexican Drainage Aquifer

Groundwater wells



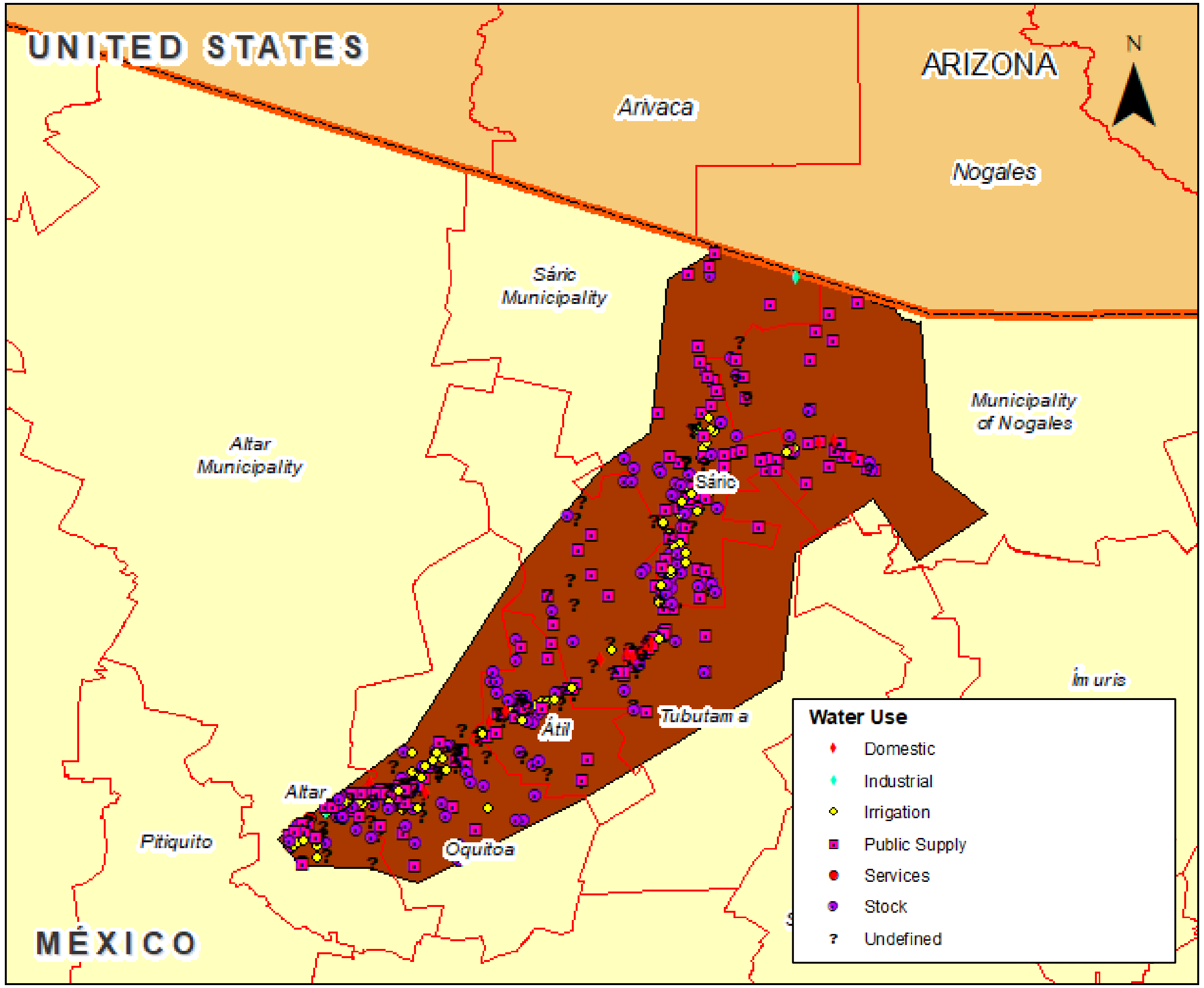
Sonoyta Puerto Peñasco-San Simon Wash Aquifer.



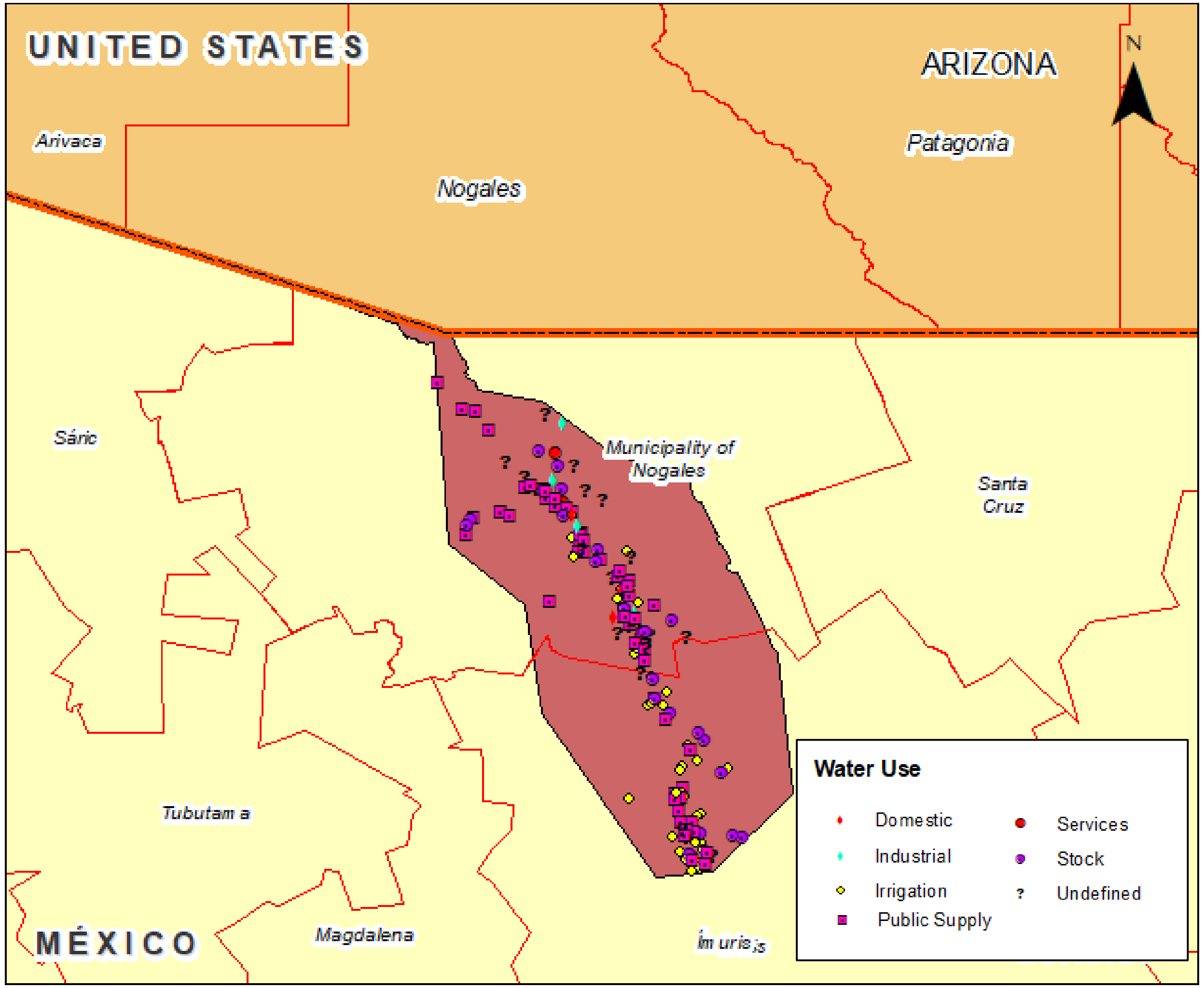
*Not included in the prioritization evaluation.

Arroyo Seco Aquifer.

Groundwater wells

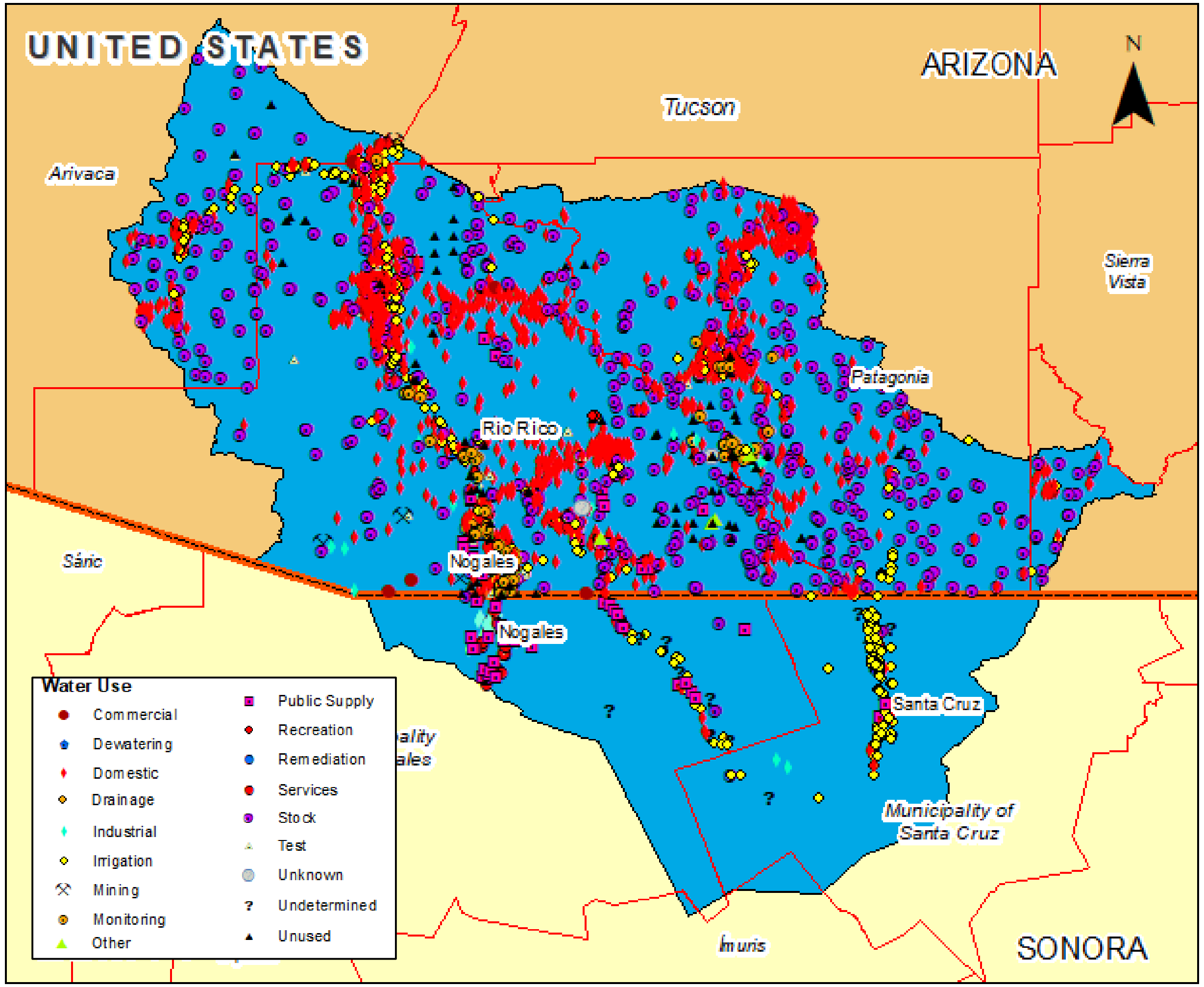


Río Altar Aquifer

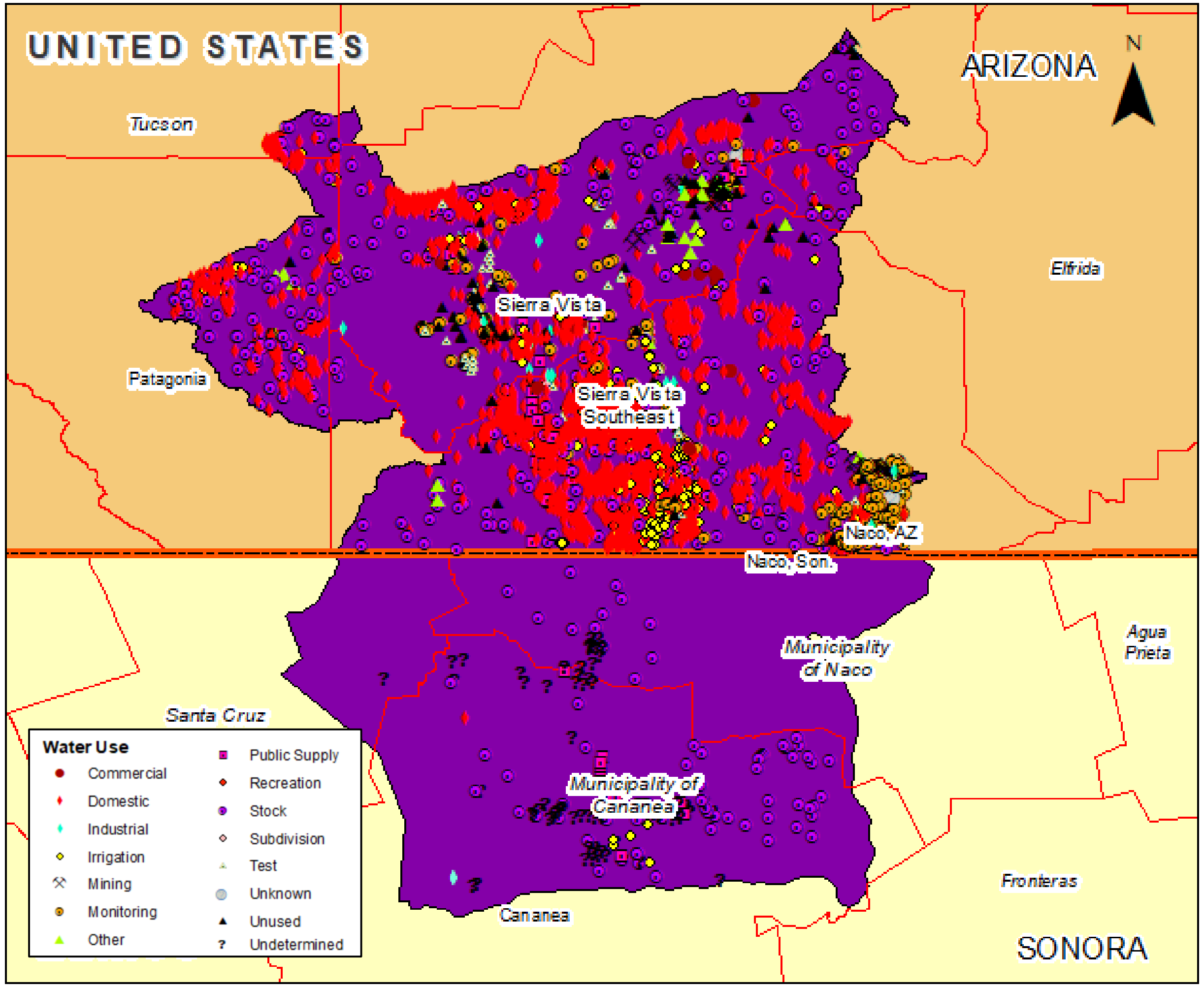


Río Alisos Aquifer

Groundwater wells

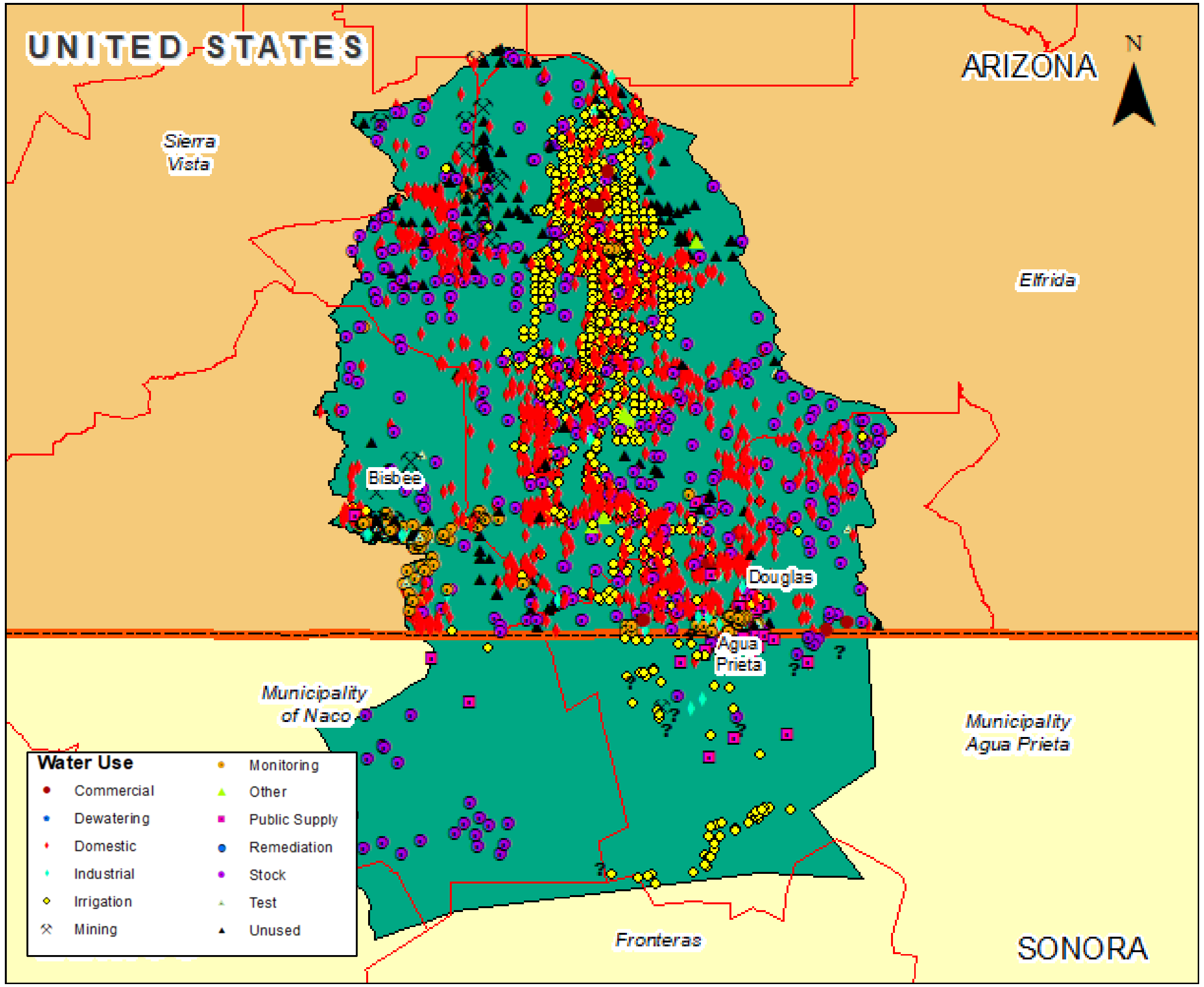


Santa Cruz Aquifer.

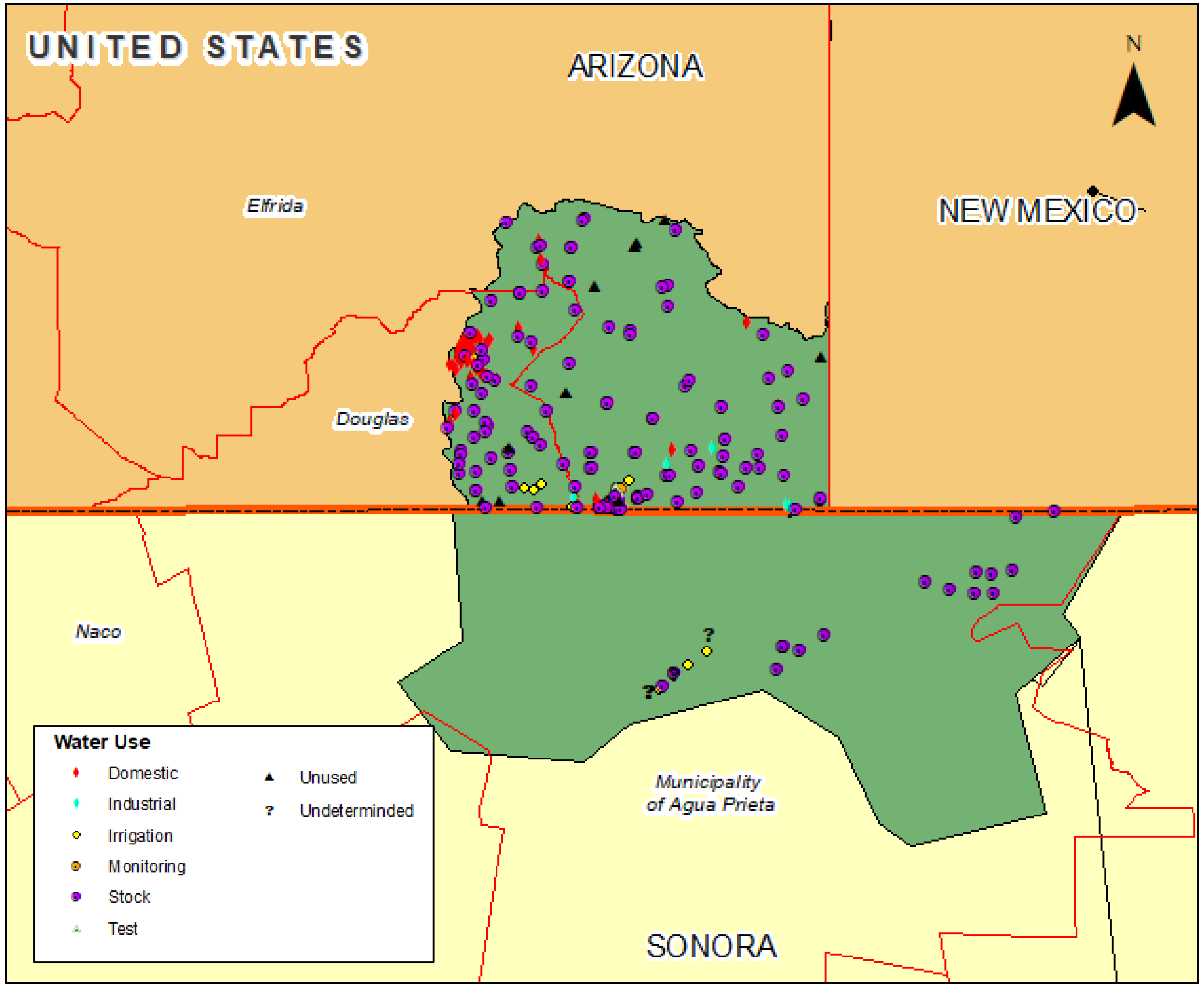


San Pedro Aquifer.

Groundwater wells



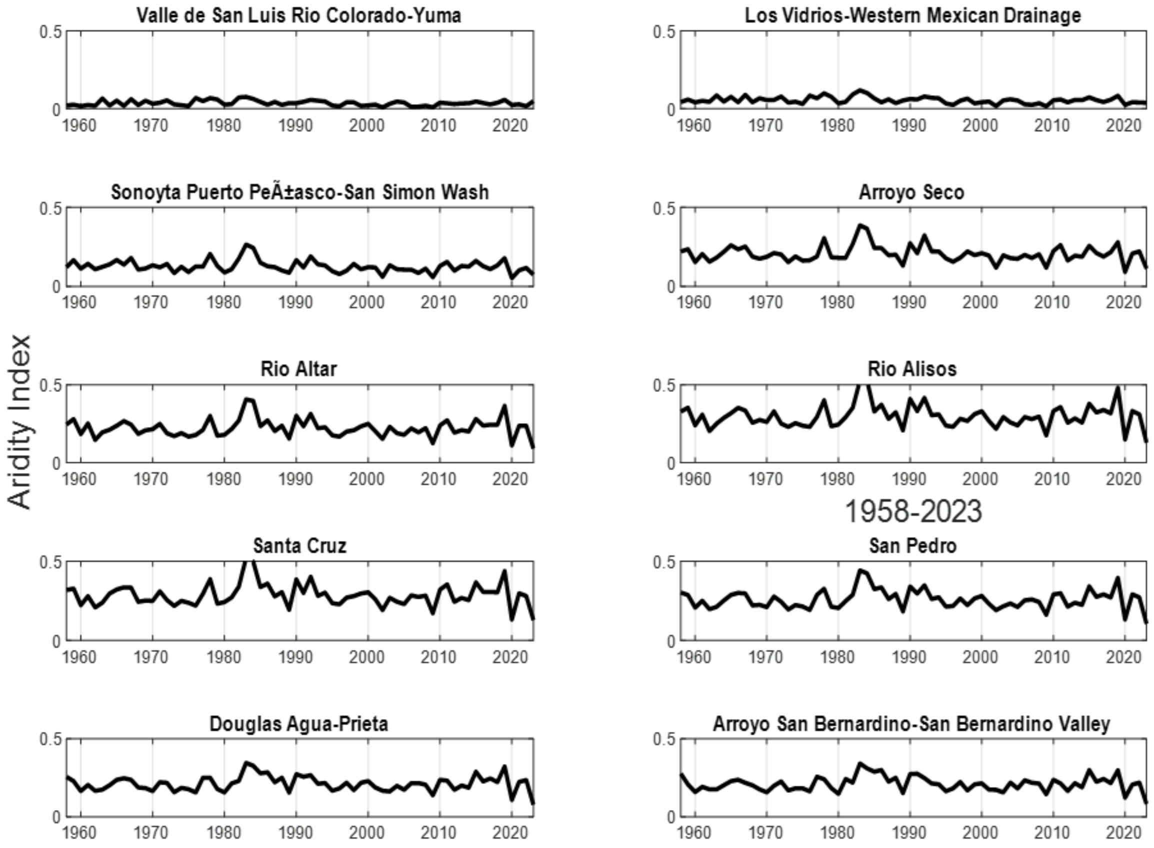
Douglas-Agua Prieta Aquifer.



Arroyo San Bernardino-San Bernardino Valley Aquifer.

Aridity

1958-2023 annual Aridity Index time series of the Arizona-Sonora transboundary aquifers basins



Basin area average AI and the relative change

		1978-2000	2001-2023	Change	Rank
1	Valle de San Luis Rio Colorado-Yuma*	0.042	0.031	-26.6%	1
2	Los Vidrios-Western Mexican Drainage	0.062	0.046	-24.9%	2
3	Sonoyta Puerto Penasco-San Simon Wash	0.14	0.11	-19.2%	3
4	Arroyo Seco*	0.23	0.19	-17%	4
5	Rio Altar	0.24	0.21	-12.5%	8
6	Rio Alisos	0.33	0.29	-12.7%	7
7	Santa Cruz	0.31	0.27	-14.3%	5
8	San Pedro	0.28	0.24	-13.6%	6
9	Douglas Aqua-Prieta	0.23	0.2	-12.5%	9
10	Arroyo San Bernardino-San Bernardino Valley	0.23	0.2	-12.1%	10

*Not included in the prioritization evaluation.

Irrigated Lands

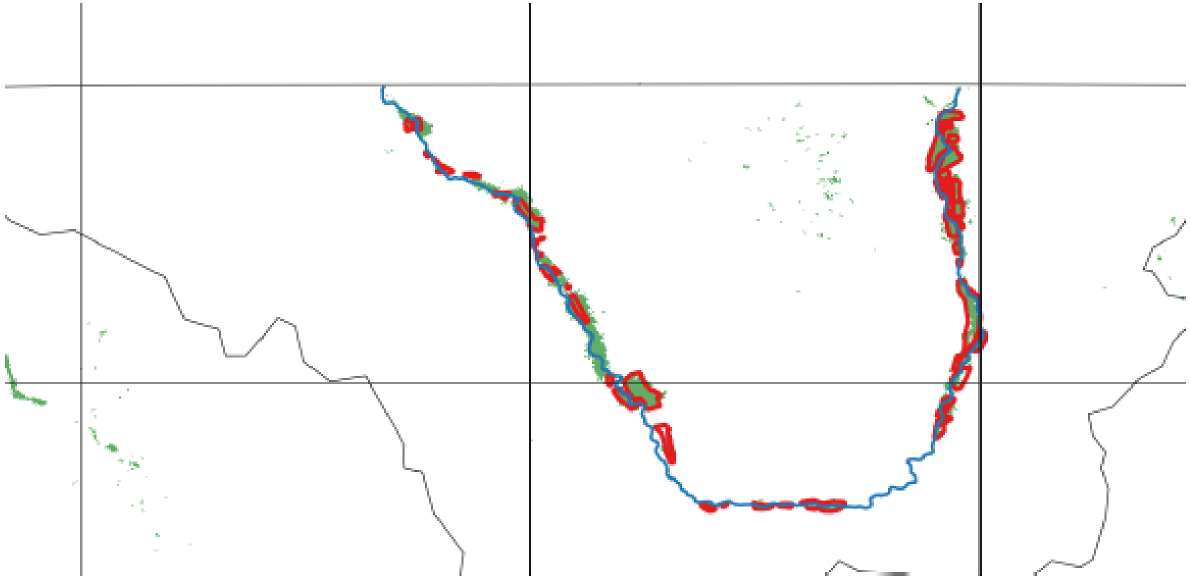


Figure 3: NAEA 30m (2015) Cropland category (green) and the identified fields delineated from GoogleEarth (red outline). The Santa Cruz River main channel is indicated as a blue line.

Table 1: Irrigation demand for the various estimated cultivated areas

Source	Ag Area (km^2)	Irrigation demand[1] (MCM/Yr)	Corrected Irrigation Demand[2] (MCM/Yr)
CONAGUA (2020)	8.3	4.9	11.5
INEGI	15.7	9.3	21.8
LANDSAT 8	17	10.0	23.6
GoogleEarth	14.4	8.5	20.0
NAEA 30m (2010)	21.43	12.6	29.8
NAEA 30m (2015)	21.77	12.8	30.3
ADWR (1997)	13.3	-	-
Corallo (1964)	9.3	-	-
Anderson (1955)	9.9	-	-

[1]Calculated as the difference between the estimated consumptive use and the average annual
[2]Calculated as #1 but considering effective rainfall is 37% of annual rainfall and irrigation efficiency of 60%.

Figure 4: Loss or gain of shrubland by comparing 2015 and 2010 NAEA 30m land cover maps for the SCRB-MX. The analysis is available from: https://storymaps.arcgis.com/collections/c6ec1f9a8199450283557e21eef481b1?item=1

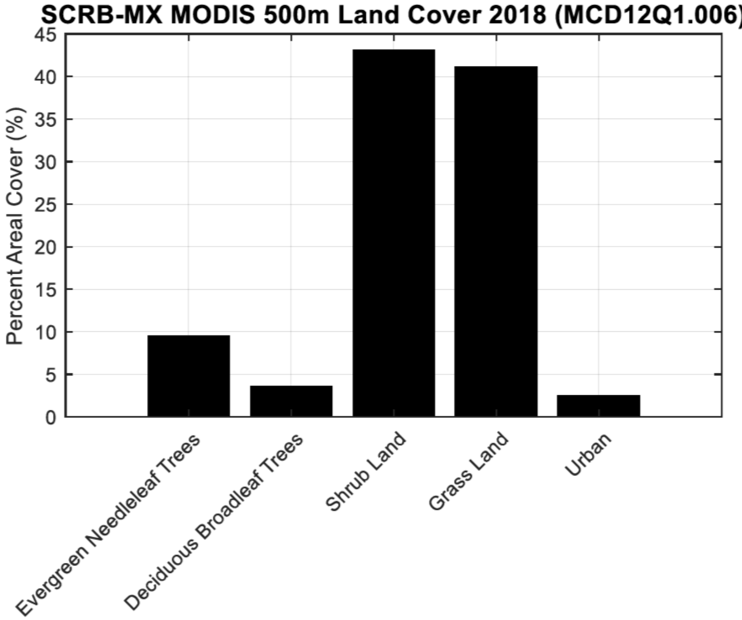


Figure 5: Areal distribution (%) of Land cover categories in the SCRB-MX, data from the 2018 MODIS 500m land cover dataset.

Assigning Weights to Criteria

Population Density

Assigning weights to each criterion is crucial in Multicriteria Analysis (MCA), as weights determine each criterion's relative influence on decision-making.

Analytic Hierarchy Process (AHP)

This study employs AHP (Saaty, 1987), a structured MCA framework, to determine criteria weights through systematic pairwise comparisons.

Higher Weight to Transboundary Criteria

Criteria specifically relevant to transboundary aquifers, such as 'Transboundary Confidence' and 'Transboundary Groundwater Flow,' received higher weights due to their critical importance.

Pairwise Comparisons

Each criterion is directly compared to others using a scale (equal, moderately more important, strongly more important) to build a comparative matrix reflecting relative preferences.

Normalization

Comparison matrices are normalized to produce priority vectors, numerical weights (0 to 1) indicating each criterion's relative importance.

Priority Calculation

Final aquifer prioritization is calculated by combining criterion weights and data using the following formula:

Priority Level = (Weight Criterion 1 × Weight Alternative 1 × Result Alternative 1) + (Weight Criterion 2 × Weight Alternative 2 × Result Alternative 2) + . . . + (Criterion j × Weight Alternative j × Result Alternative j).

Analyzed Criteria

The criteria considered in this MCA included population density, transboundary confidence, groundwater availability, transboundary groundwater flow, number of wells, aridity index, and irrigated lands.

Aquifer Name	Aquifer Area (km^2)	Population	Population Density (Person/km^2)	Transboundary Confidence	Groundwater Availability (MCM */Year)	Transboundary Groundwater Flow (MCM/year)	No. of Ground-water Wells	Aridity Index (% Change)	Irrigated Lands (Hectares)
Los Vidrios–Western Mexican Drainage	7189.21	53	0.01	Some	0.00	4	MX: 1 U.S.: 33 Total: 34	−24.9	374
Sonoyta–Puerto Peñasco–San Simon Wash	14,731	79,339	5.4	Reasonable	−83.72	9	MX: 525 U.S.: 27 Total: 552	−19.2	5495
Río Altar	2794	11,188	4.0	Limited	0.00	7.3	MX: 558 U.S.: 0 Total: 558	−12.5	9146
Río Alisos	890	3264	3.7	Limited	0.00	0	MX:173 U.S.: 0 Total: 173	−12.7	2196
Santa Cruz	3891	306,989	78.9	Reasonable	0.00	2	MX: 297 U.S.: 3855 Total: 4152	−14.3	2965
San Pedro	4469	115,749	25.9	Reasonable	−6.71	10.8	MX: 177 U.S.: 5883 Total: 6060	−13.6	1054
Douglas–Agua Prieta	3780	116,019	30.7	Reasonable	−0.05	2.6	MX: 127 U.S.: 4009 Total: 4136	−12.5	5035
Arroyo San Bernardino	2658.08	108	0.04	Some	0.00	8.4	MX: 25 U.S.: 249 Total: 274	−12.1	364

Note: * MCM: Millions of cubic meters.

Table 2. Weight of each criterion for transboundary aquifer prioritization.

Criteria	Weight of Criteria	Alternative	Weight of Alternative	Unit of Alternative
Population density	0.125	■ 0–20 ■ 20–40 ■ 40–60 ■ 60–80	■ 0.096 ■ 0.161 ■ 0.277 ■ 0.466	Persons per square kilometer
Transboundary confidence	0.226	■ Limited ■ Some ■ Reasonable	■ 0.164 ■ 0.297 ■ 0.539	NA
Groundwater availability	0.113	■ −25–0 ■ −50–−25 ■ −75–−50 ■ −100–−75	■ 0.096 ■ 0.161 ■ 0.277 ■ 0.466	Millions of cubic meters (MCM/year)
Transboundary groundwater flow	0.173	■ 0–40 ■ 40–80 ■ 80–120 ■ 120–160	■ 0.096 ■ 0.161 ■ 0.277 ■ 0.466	Millions of cubic meters (MCM/year)
Groundwater wells	0.113	■ 0–100 ■ 100–1000 ■ 1000–10,000 ■ 10,000–22,000	■ 0.096 ■ 0.161 ■ 0.277 ■ 0.466	Number of wells
Aridity	0.125	■ −12–−16 ■ −16–−20 ■ −20–−24 ■ −24–−26	■ 0.096 ■ 0.161 ■ 0.277 ■ 0.466	Relative change in aridity index (%)
Irrigated lands	0.125	■ 0–3000 ■ 3000–6000 ■ 6000–9000 ■ 9000–13,000	■ 0.096 ■ 0.161 ■ 0.277 ■ 0.466	Hectares

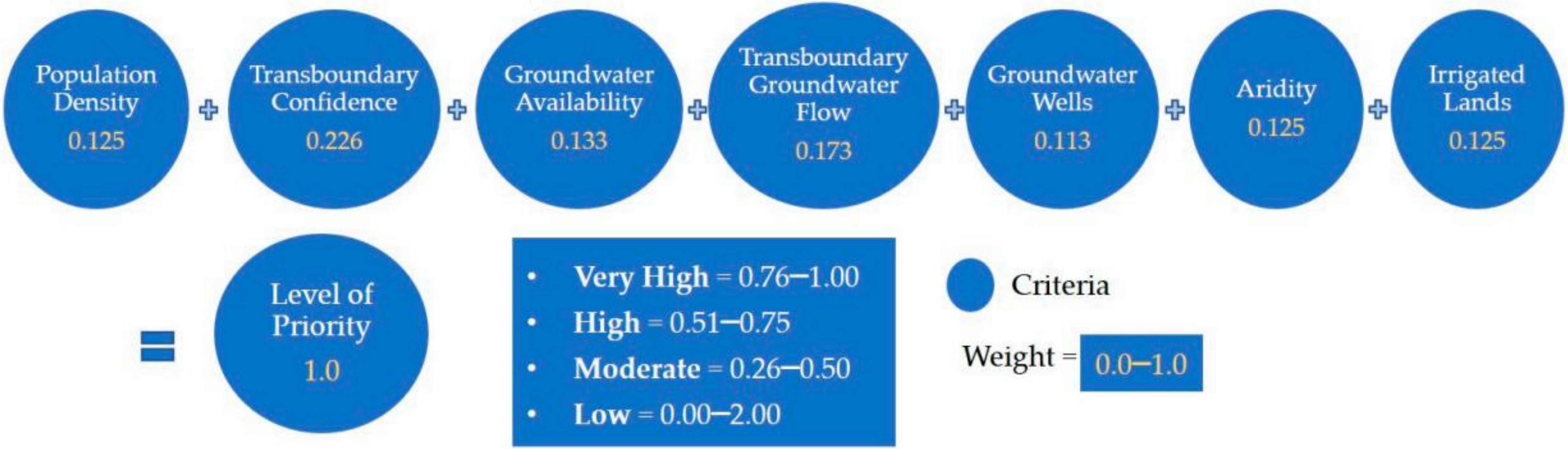


Figure 2. Transboundary aquifer prioritization process.

Table 3. AHP scores and level of priority.

Aquifer Name	Population Density	Transboundary Confidence	Groundwater Availability	Transboundary Groundwater Flow	No. of Ground-water Wells	Aridity Index	Irrigated Lands	AHP Score	Level of Priority
Sonoyta–Puerto Peñasco–San Simon Wash System	0.096	0.539	0.466	0.161	0.161	0.161	0.161	0.564	1
Santa Cruz Aquifer	0.477	0.539	0.096	0.096	0.277	0.096	0.096	0.546	2
San Pedro Aquifer	0.161	0.539	0.096	0.277	0.277	0.096	0.096	0.529	3
Douglas–Agua Prieta Aquifer	0.161	0.539	0.096	0.096	0.277	0.096	0.161	0.481	4
Los Vidrios–Western Mexican Drainage	0.096	0.297	0.096	0.096	0.096	0.466	0.096	0.388	5
Río Altar	0.096	0.164	0.096	0.161	0.161	0.096	0.466	0.364	6
Arroyo San Bernardino–San Bernardino Valley Aquifer	0.096	0.297	0.096	0.161	0.161	0.096	0.096	0.331	7
Río Alisos Aquifer	0.096	0.164	0.096	0.096	0.161	0.096	0.096	0.245	8

Eight transboundary aquifers in the Arizona–Sonora region were analyzed using a multicriteria approach that assigned a priority level based on a weighted set of criteria.

The resulting priority rankings were as follows:

(1) Sonoyta–Puerto Peñasco San Simon Wash System,

(2) Santa Cruz,

(3) San Pedro,

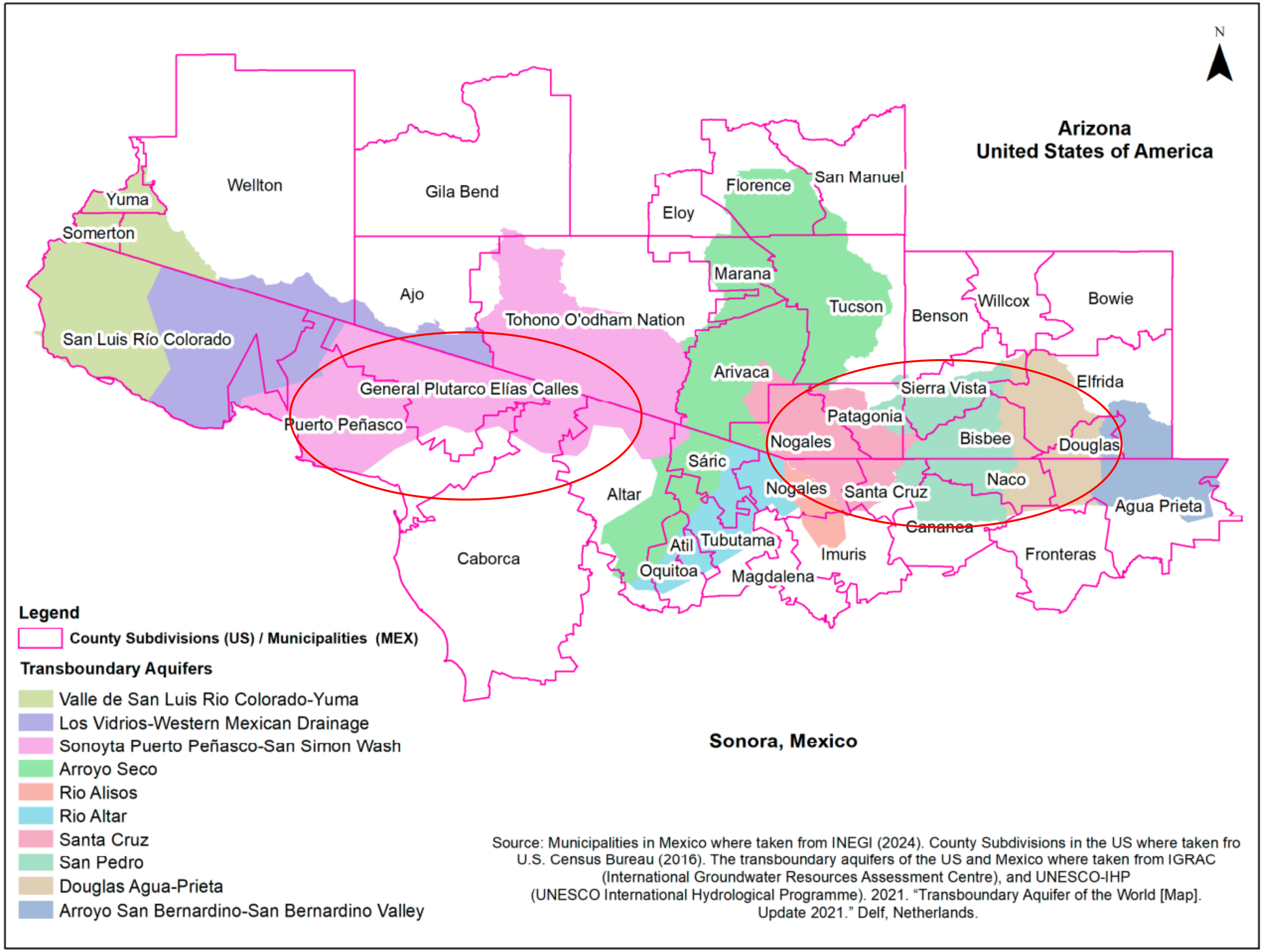
(4) Douglas–Agua Prieta,

(5) Los Vidrios–Western Mexican Drainage,

(6) Río Altar,

(7) Arroyo San Bernardino San Bernardino Aquifer, and

(8) Río Alisos Aquifer.



Aquifer Prioritization Results

Highest Priority: Sonoyta–Puerto Peñasco–San Simon Wash System

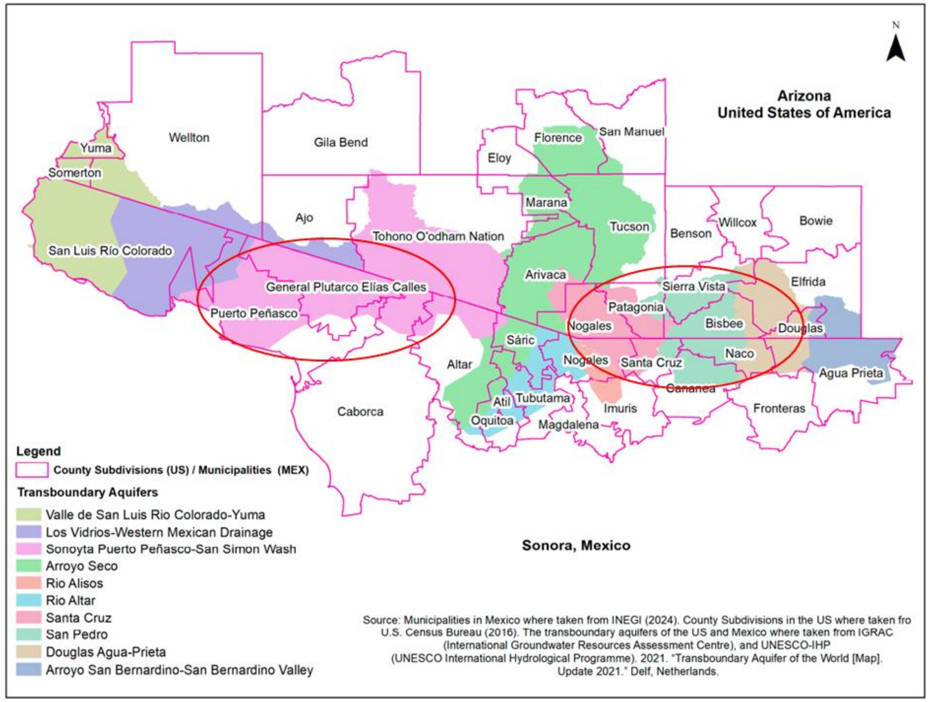
- Reasonable transboundary confidence
- Groundwater deficit: −83.72 MCM/year
- Wells: 525
- Irrigated land: 5495 hectares
- Aridity index: −19.2%

Current TAAP Aquifers: Santa Cruz & San Pedro

- Groundwater availability: 0.0 & −6.17 MCM/year
- Moderate deficits, slightly lower priority

Next Priority: Douglas–Agua Prieta Aquifer

- Groundwater deficit: −0.05 MCM/year
- Wells: 4136
- Irrigated land: 5035 hectares
- Aridity index: −12.5%



Lower Priority Aquifers: Los Vidrios–Western Mexican Drainage, Río Altar, Arroyo San Bernardino–San Bernardino Valley, Río Alisos

- Moderate-to-low priority, lower immediate need

Discussion

- ***Multicriteria Analysis (MCA) Application:***
  - Widely used in water-resource decision-making.
  - Criteria tailored to specific regional objectives

- ***Criteria Selection & Limitations:***
  - Water quality excluded due to inconsistent binational data.
  - Governance and hydro-political factors excluded due to quantification challenges.
  - Lack of consistent groundwater-level data limited assessment accuracy (we considered number of wells in this evaluation).
  - Highlights need for binational standardized monitoring.

- **Future Recommendations:**
  - Stakeholder engagement for complementary insights.
  - Methodology replicable, adaptable, robust for future assessments.
  - Data sets support informed management and responsible aquifer use.

Conclusions

- The multicriteria approach effectively identifies transboundary aquifers needing further assessment.
- San Pedro and Santa Cruz aquifers are confirmed as high priorities, aligned with TAAP focus.The Sonoyta–Puerto Peñasco–San Simon Wash System ranks highest due to severe groundwater stress.
- Data gaps and inconsistent monitoring across the border limited some criteria.
- Despite limitations, binationally available data revealed key stressors on groundwater availability.
- The framework supports future assessments and is applicable to other U.S.–Mexico border aquifers and global contexts.

Thank you!