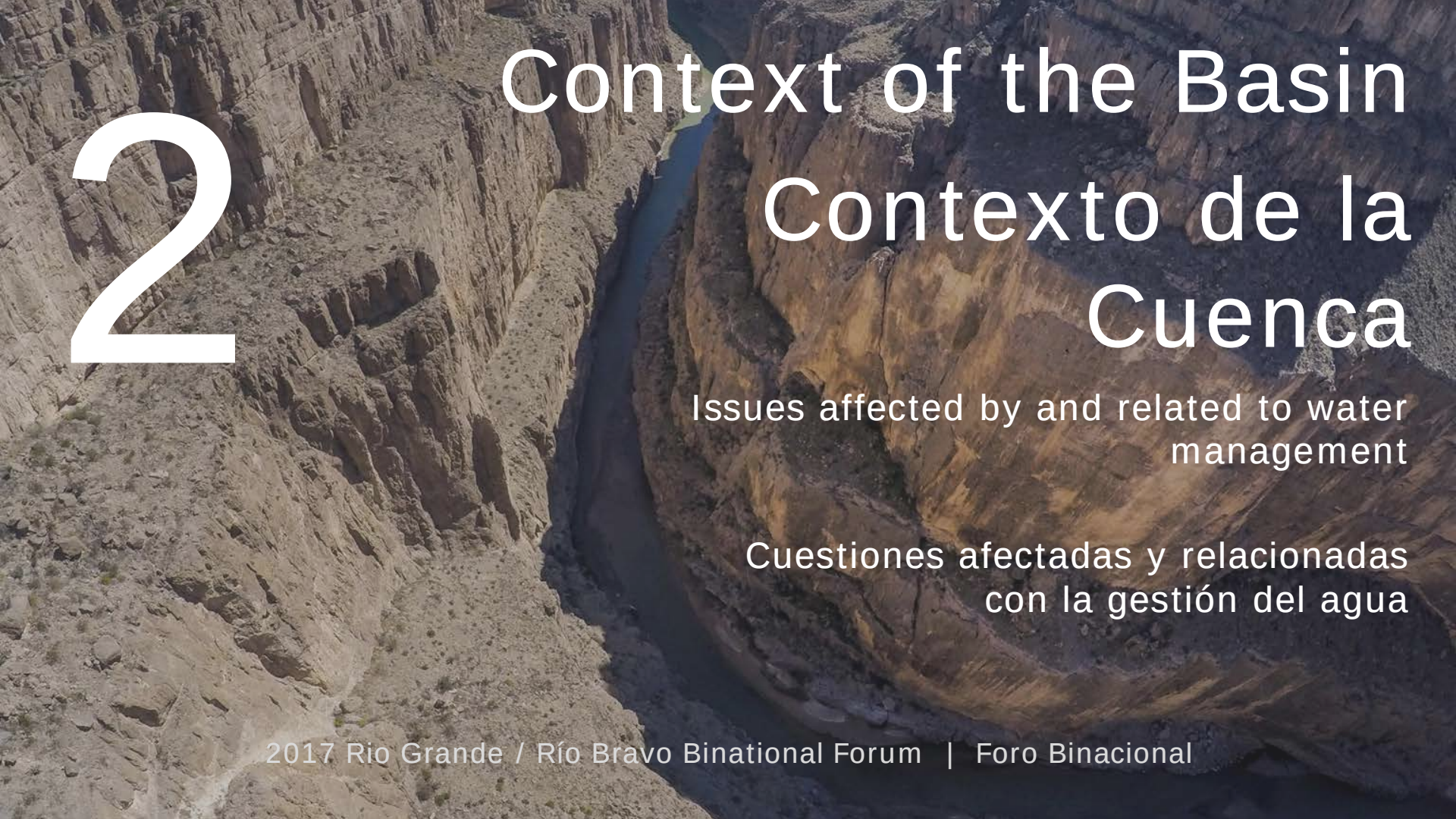


2

Context of the Basin
Contexto de la Cuenca

Issues affected by and related to water management

Cuestiones afectadas y relacionadas con la gestión del agua

Context of the Basin
Contexto de la Cuenca

Mike Langston
South Central Climate Science Center

Sam Sandoval
University of California–Davis

Jack Friedman, Stephanie Paladino
University of Oklahoma

Ismael Aguilar Barajas
Tecnológico de Monterrey

Jad Ziolkowska
University of Oklahoma

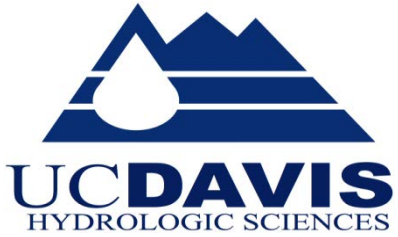
David Gutzler
University of New Mexico

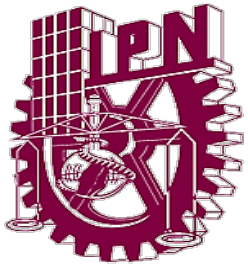
Phaedra Budy
Utah State University

University of California, Davis
Department of Land, Air and Water Resources

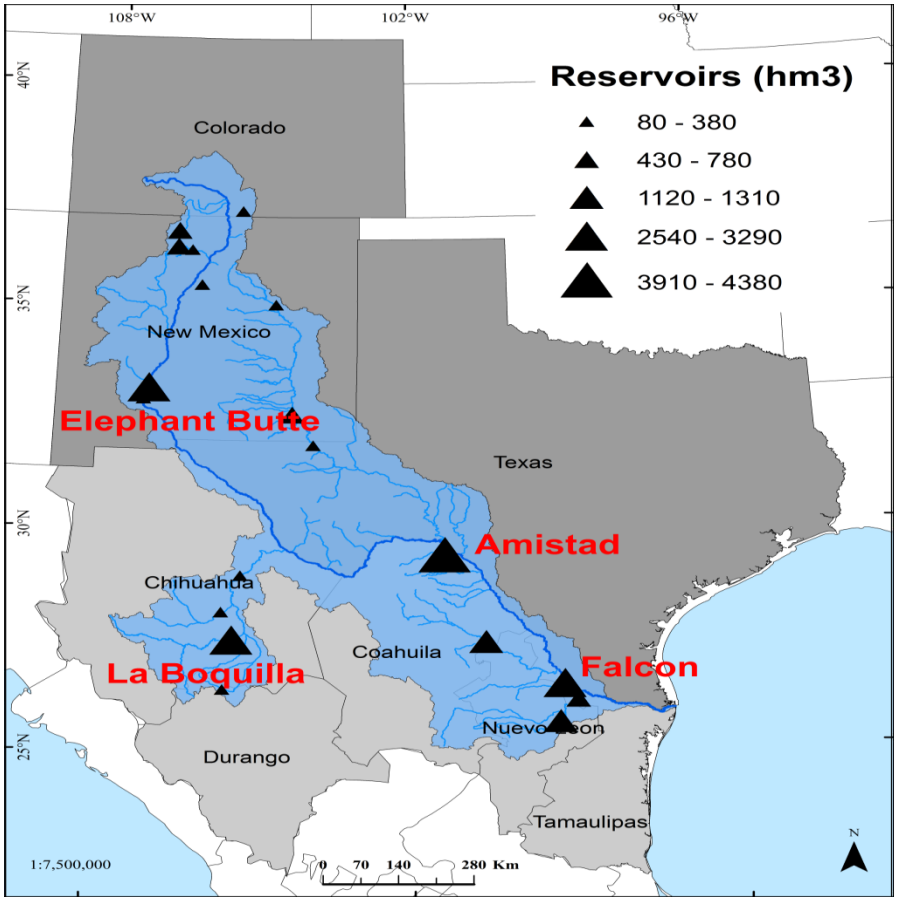
Context of the Basin: Hydrology and Water Resources Management

Samuel Sandoval Solis, PhD &
J. Pablo Ortiz Partida, PhD Candidate
In collaboration with:
John (Jack) Schmidt and Todd Bly





Rio Grande – Rio Bravo: RGB



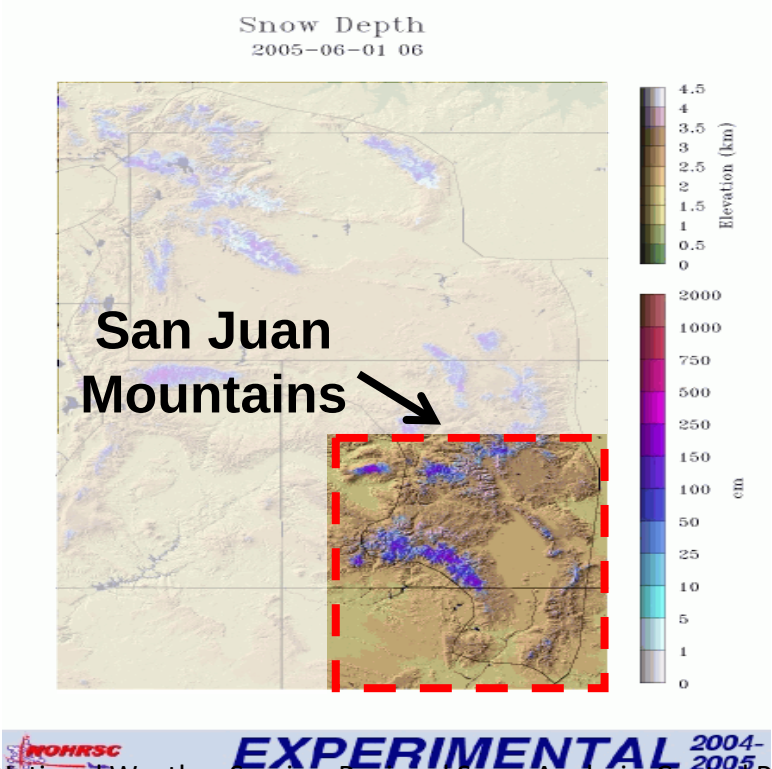
Basic Information

- 3 States in the US (CO, NM, TX)
- 5 States in Mexico (Chi, Coah, Dur, NL, Tam)
- Area ≈550k km^2
- Precipitation: 189mm to 2260mm/year
- Temperature: -2^{o}C to 24^{o}C
- Multiple reservoirs (map showing only >80hm^3)

Climate Drivers

Northern Branch: Snowmelt

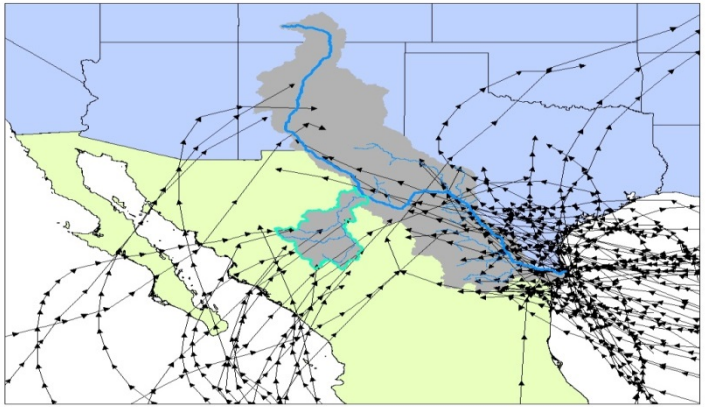
Snowmelt from San Juan Mountains



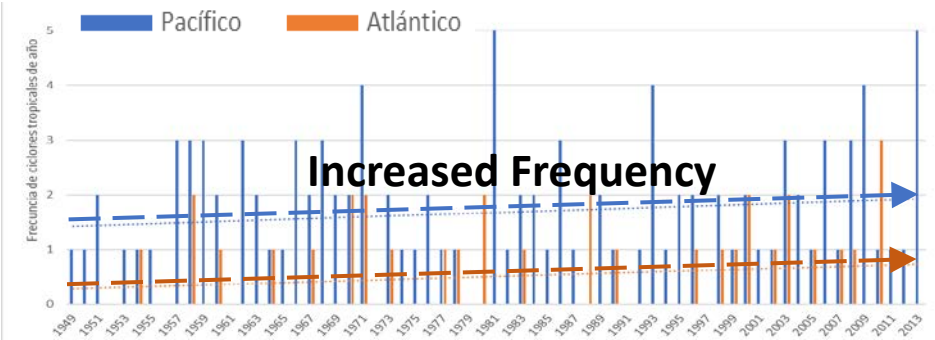
NOAA National Weather Service. Regional Snow Analysis. Central Rockies

Southern Branch: Monsoon

Pacific & Gulf of Mexico

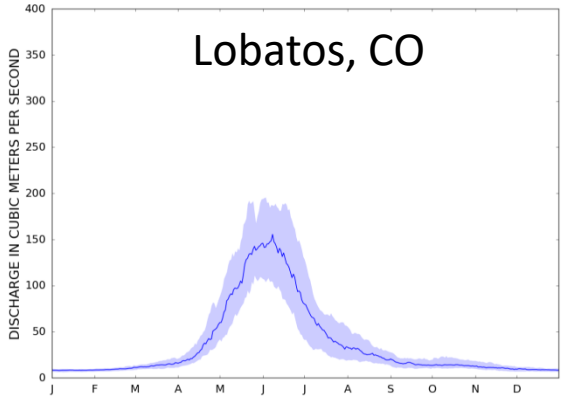


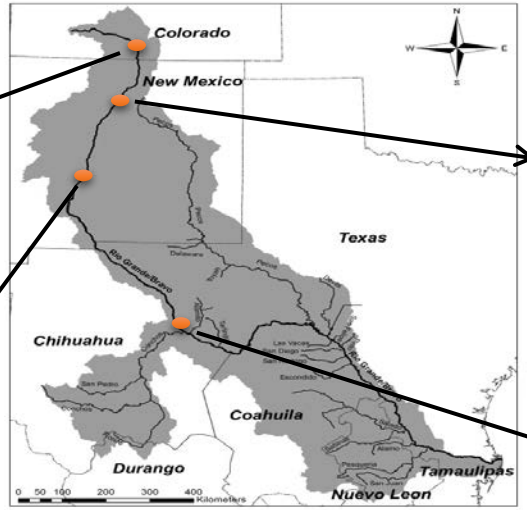
Sandoval-Solis, S. (2010). Effect of Extreme Storms on Treaty Obligations in the Rio Conchos. Final Report. Water Management Research Group. University of California, Davis. Davis, California.

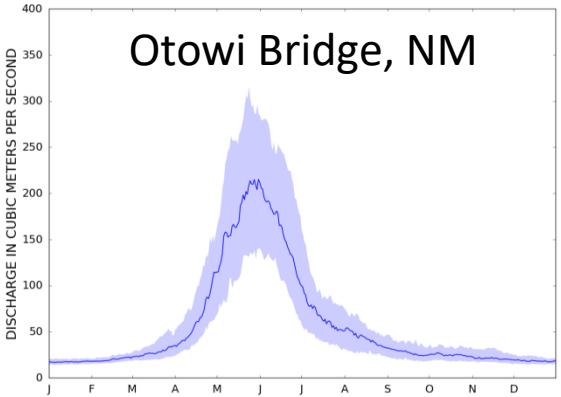


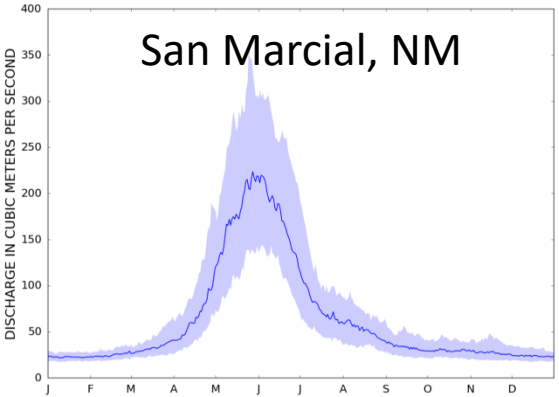
Sayto et al. (2017). Aproximación e impacto directo de ciclones tropicales a la cuenca del Río Conchos, Chihuahua, México.

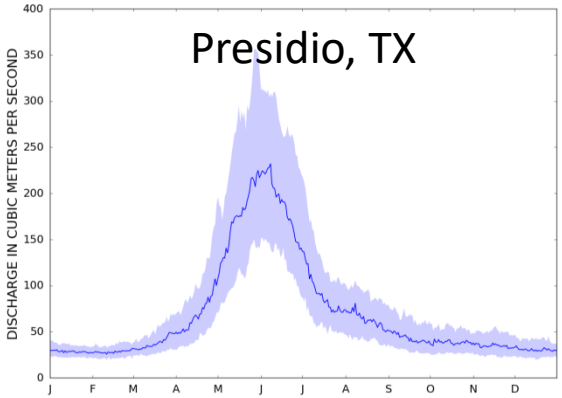
Natural hydrology : Northern Branch





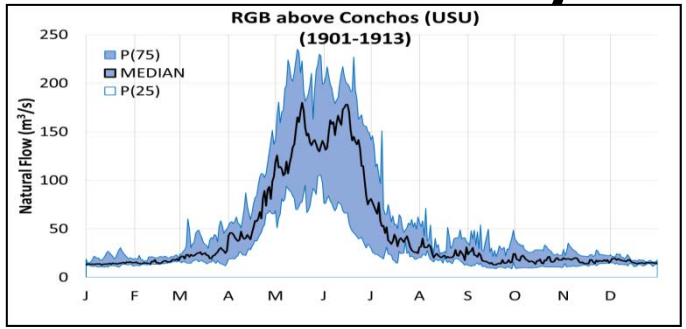


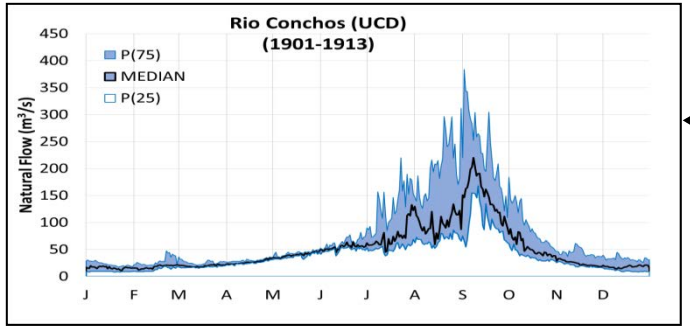


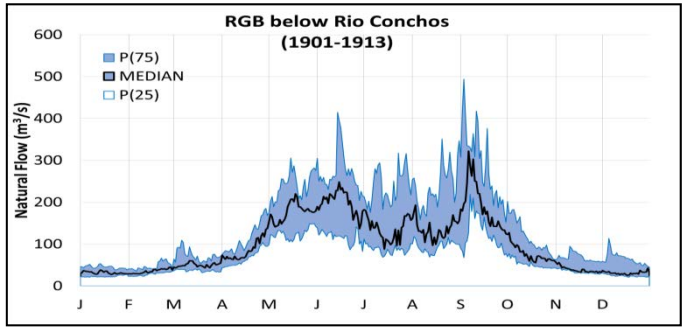


Blythe, T., and Schmidt, J. (2017). Estimating the natural flow regime of rivers with long-standing development: the northern branch of the Rio Grande. J. Water Resources Research. Submitted

Natural hydrology : Southern Branch







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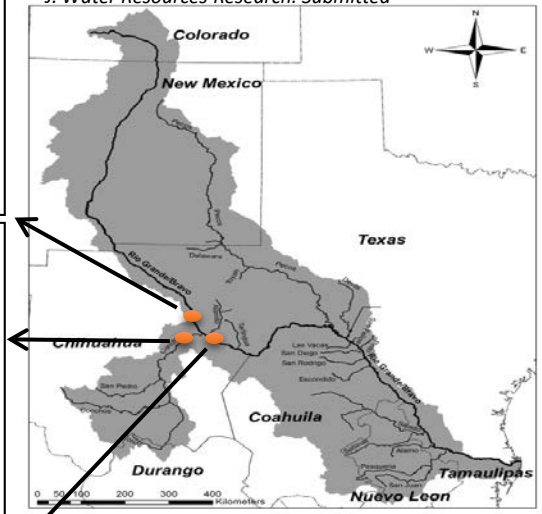
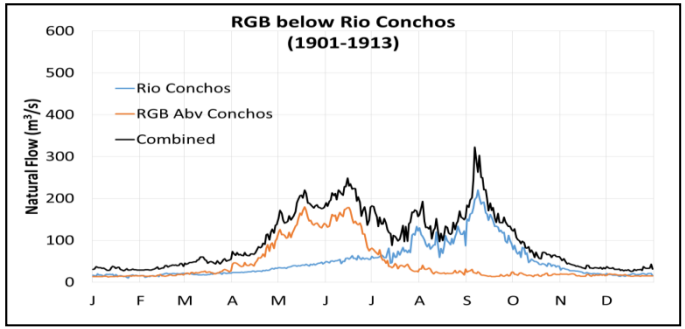
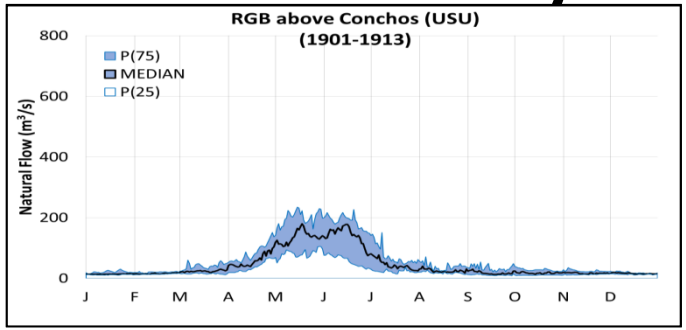
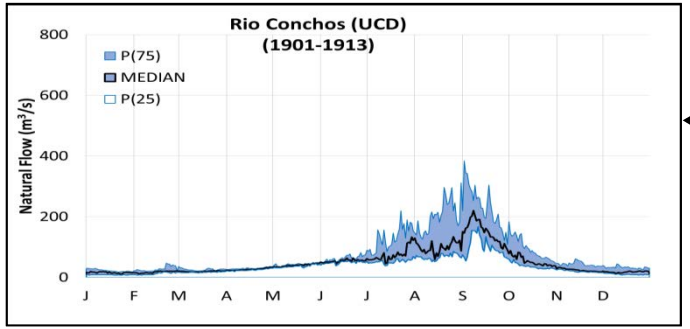


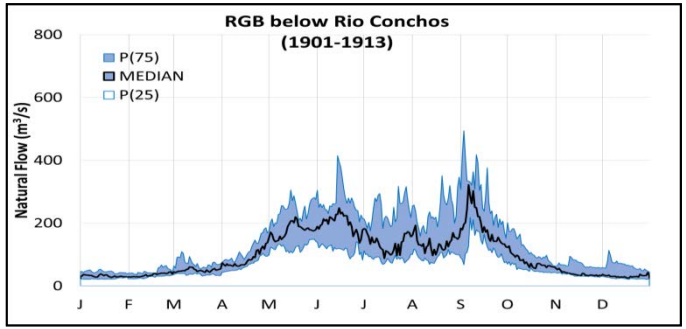


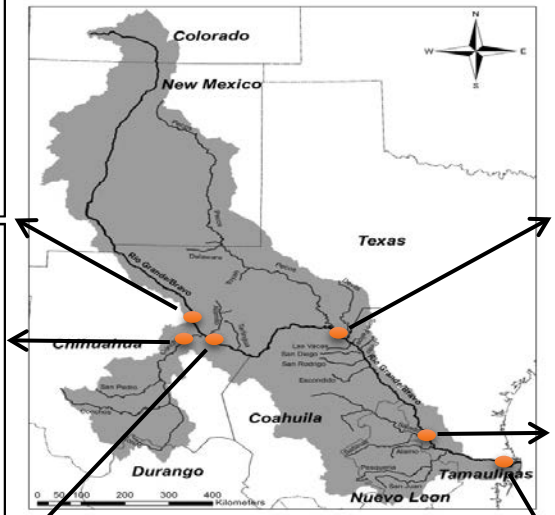
Gonzalez-Escorcia, Y.A. (2017). Determining the Natural Flow in the Transboundary Rio grande/Bravo Basin. Master Thesis. Instituto Politecnico Nacional, University of California, Davis. Davis, CA.

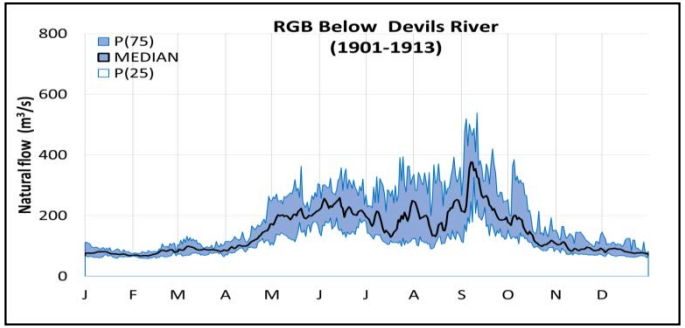
Natural hydrology : Southern Branch

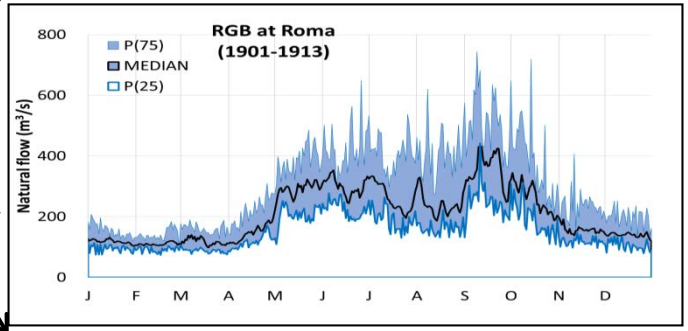


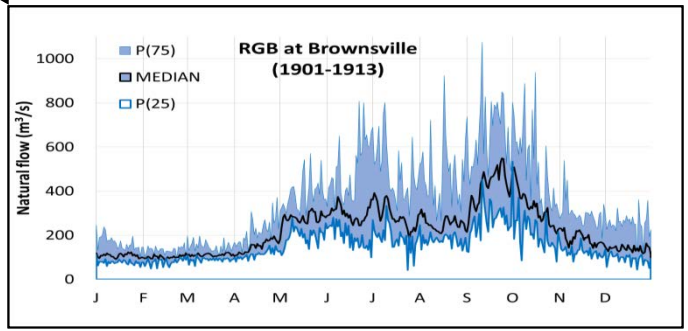






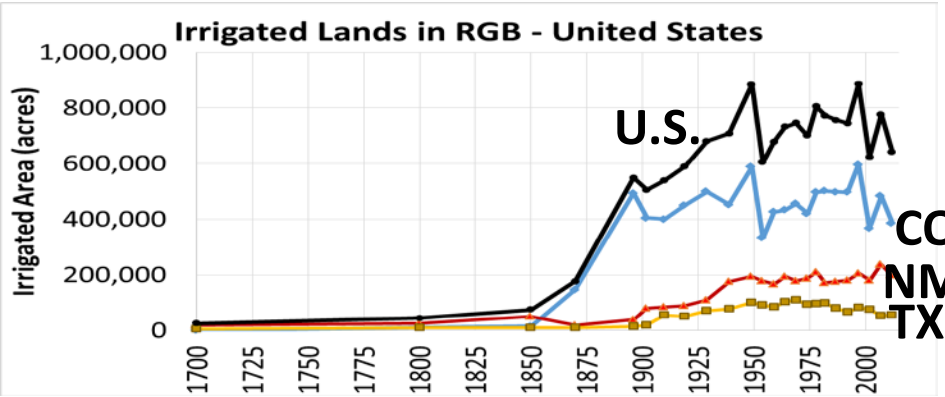




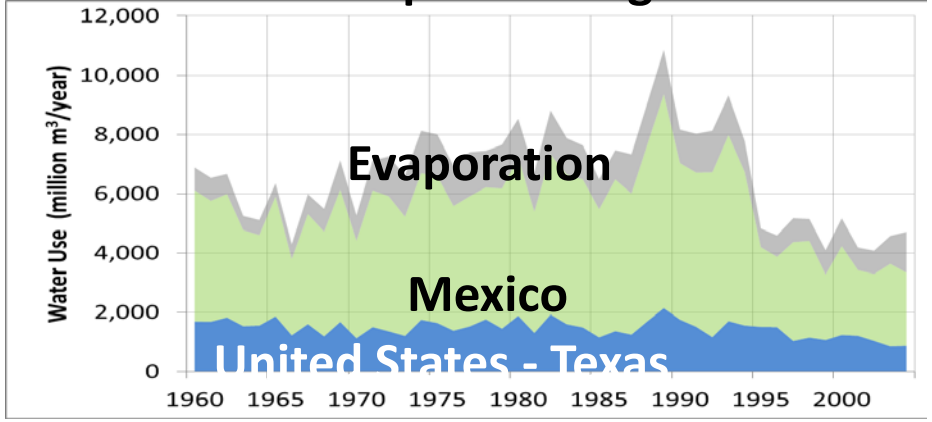


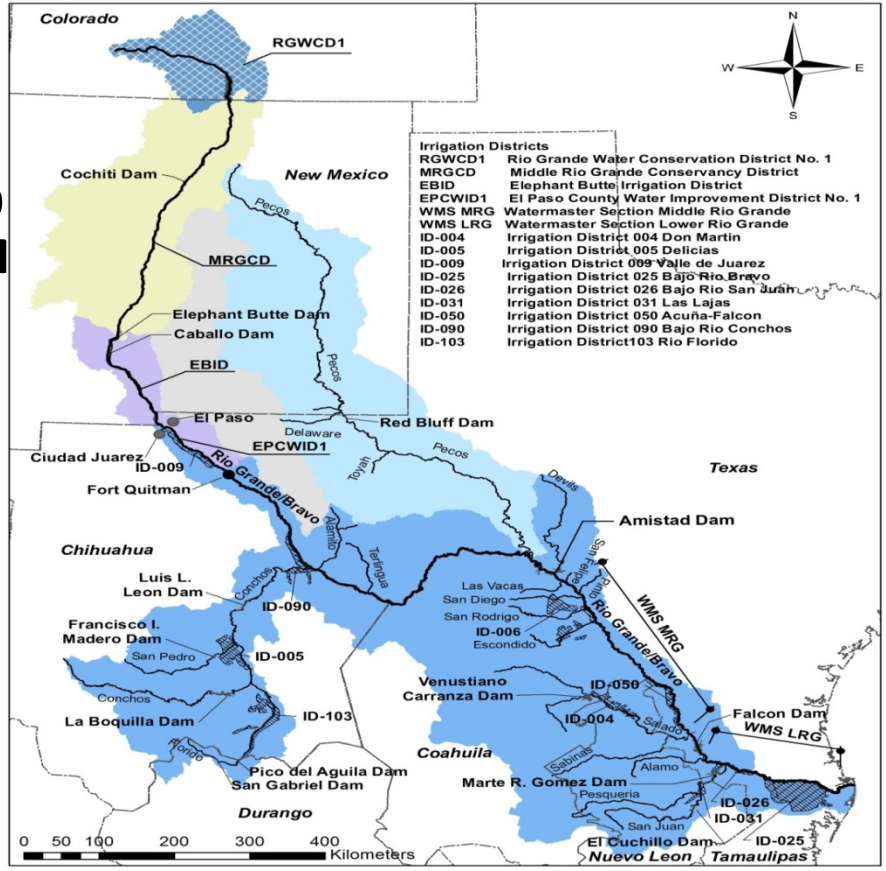
Gonzalez-Escorcia, Y.A. (2017). Determining the Natural Flow in the Transboundary Rio grande/Bravo Basin. Master Thesis. Instituto Politecnico Nacional, University of California, Davis. Davis, CA.

Water Use Drivers

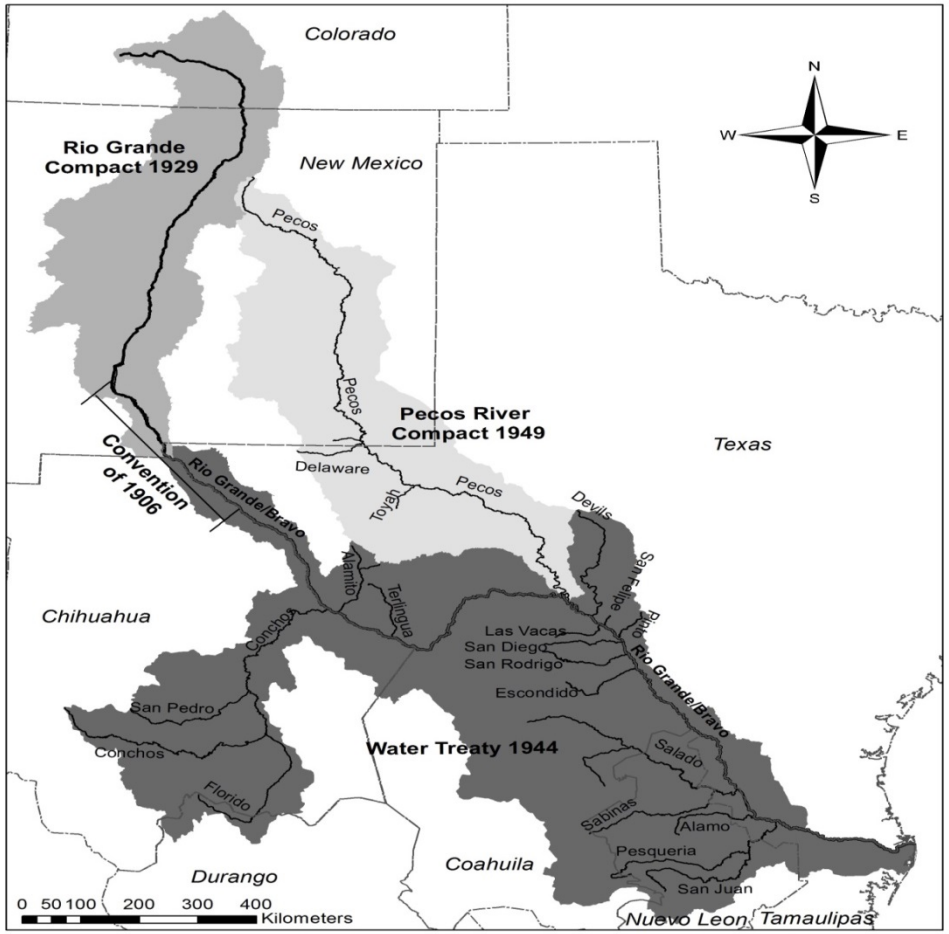


Water Consumption along the border





Water Agreements



Between States

- Rio Grande Compact (1929)
- Pecos River Compact (1949)
- Reglamento del Rio Bravo*

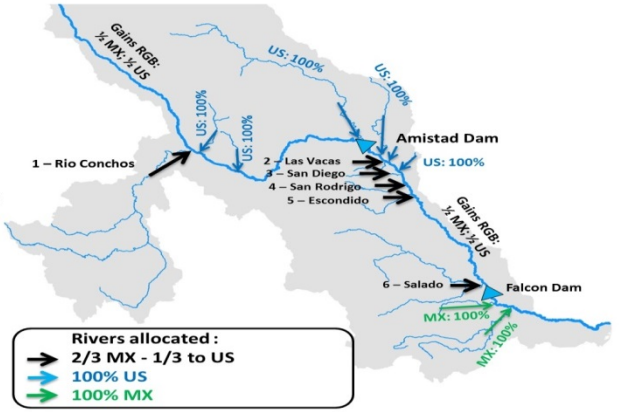
Between Nations

- Texas Independence (1836)
- Guadalupe-Hidalgo Treaty (1848)
- Convention of 1906
- Treaty of 1944
  - Including 323 minutes

** In progress*

TREATY OF 1944 – RIO GRANDE / RIO BRAVO

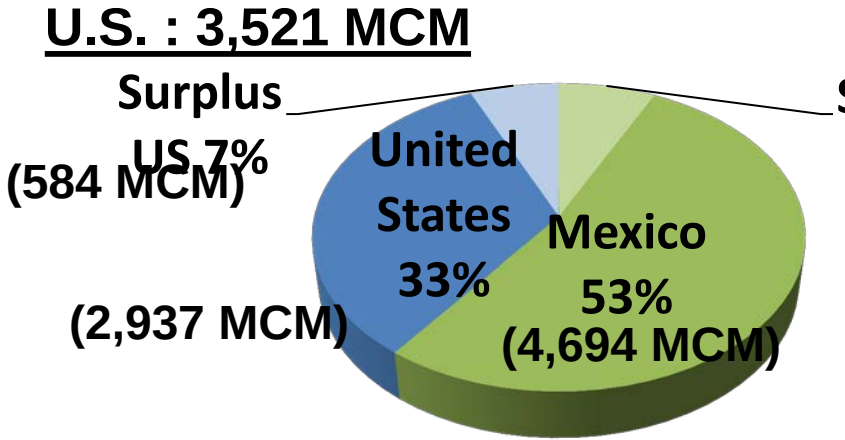
- **For Mexico:**
  - ***2/3 of 6 Mexican Tributaries***
  - ½ of Gains – Losses
  - All waters from San Juan And Alamos River
- **For the U.S.:**
  - All water from US tributaries
  - ***1/3 of 6 Mexican Tributaries, this 1/3 shall not be less than 431 MCM/year (350 TAF) on 5 year cycles***
  - ½ Gains Losses
  - ***Re-set of treaty cycles*** every 5 years or in **<5 years if the U.S. active storage** in both international dams **is filled** with U.S. water



ESTIMATED WATER USE (1900 - 1944) [1,2]

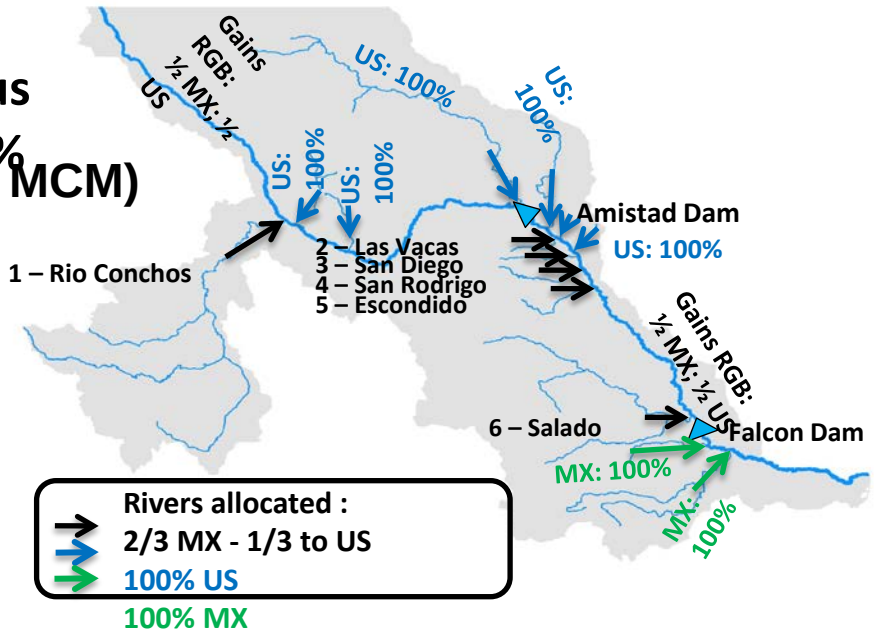
RGB below Fort Quitman: 8,859 MCM

U.S. : 3,521 MCM



Mexico: 5,338 MCM

MCM: million m^3/year

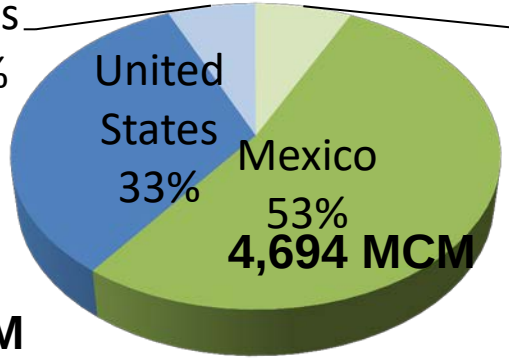


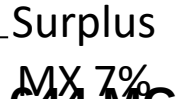
1- Orive-Alba, Adolfo (1945). "Informe técnico sobre el tratado internacional de aguas presentado ante el H. Senado mexicano" Comisión Nacional de Irrigación.
2- Enrique-Coyro, E., (1976). "El Tratado entre México y los Estados Unidos de América sobre Ríos Internacionales." Facultad de Ciencias Políticas y Sociales. UNAM

COMPARISON 1900-44 VS 1950-04 [4,5]

U.S.: 3,521 MCM

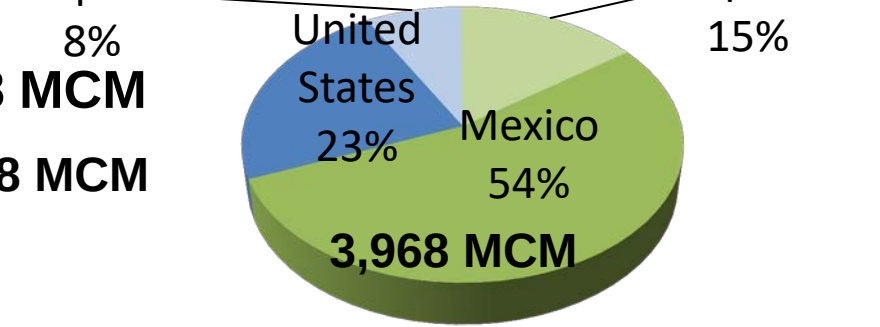
RGB below F.Q. (1900-1940): 8,859 MCM





MX: 5,338 MCM

17% less water



U.S.: 2,278 MCM

1,688 MCM

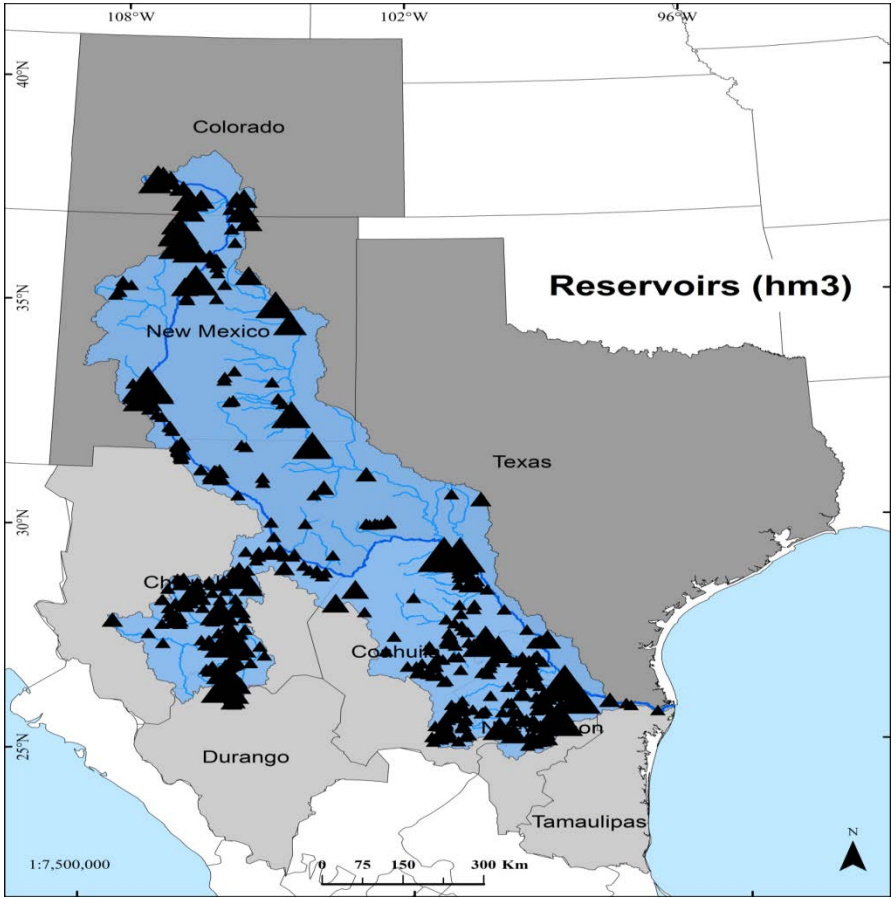
RGB below F.Q. (1950-2004): 7,358 MCM

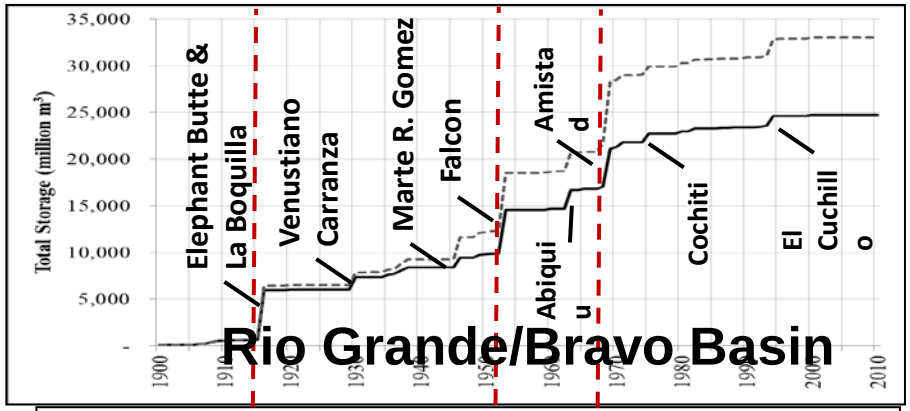
MX: 5,080 MCM

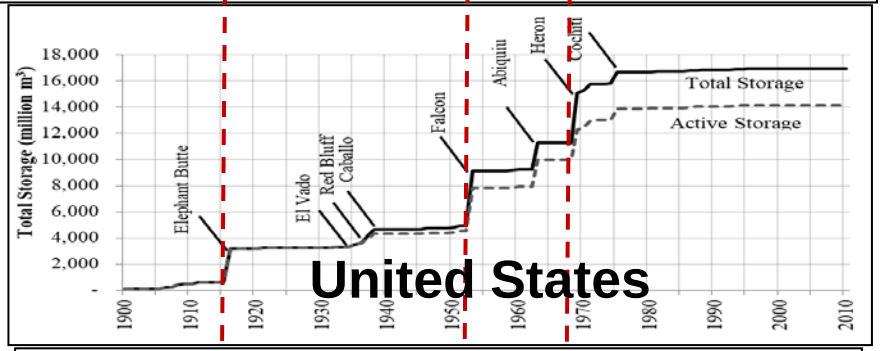
4 – CONAGUA (2008). "Disponibilidad media anual de las aguas superficiales en la cuenca del Rio Bravo." Diario Oficial de la Federación. 29 de Septiembre de 2008

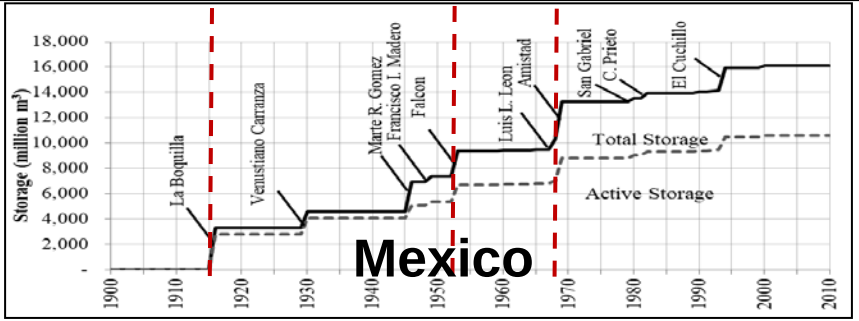
5 - Brandes Company, B.L. (2003) "Water Availability Modeling for the Río Grande Basin: Naturalized Streamflow Data, Final Report." TCEQ, Austin, TX

Water Infrastructure



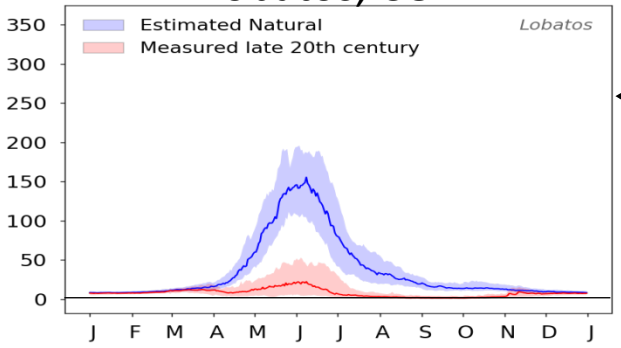






Recent hydrology : Northern Branch

Lobatos, CO



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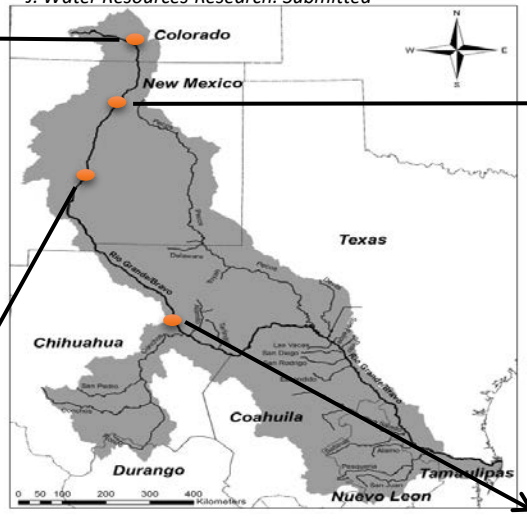
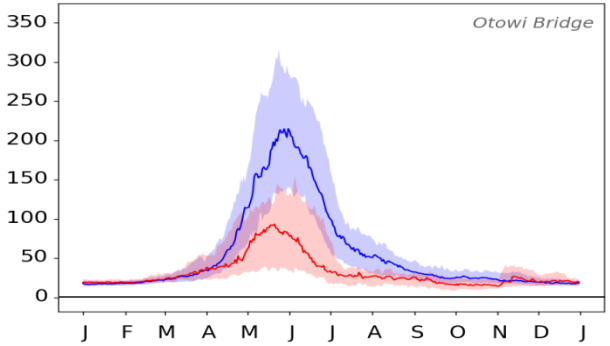
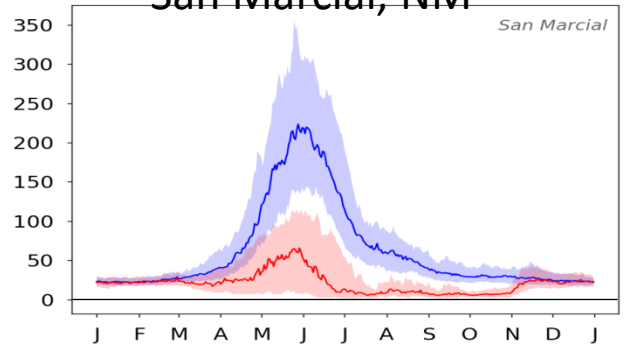


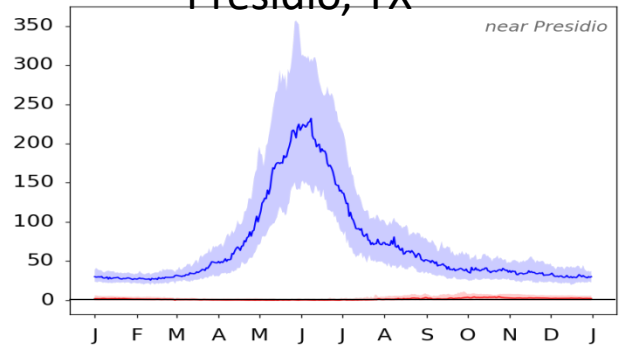
Otowi Bridge, NM



San Marcial, NM



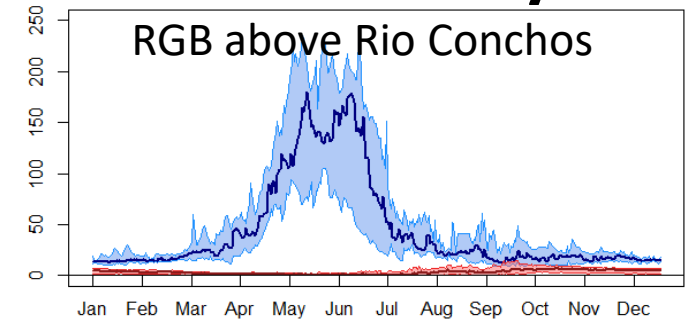
Presidio, TX



Natural

Regulated

Recent hydrology : Southern Branch



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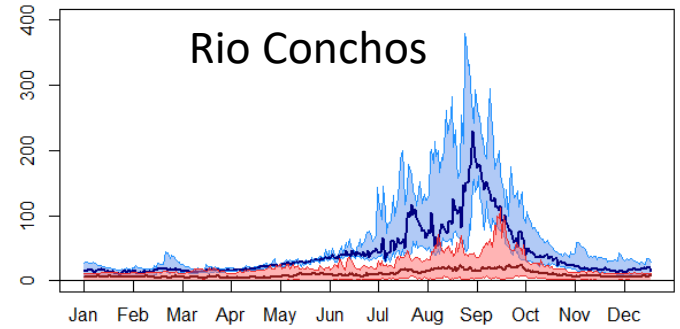
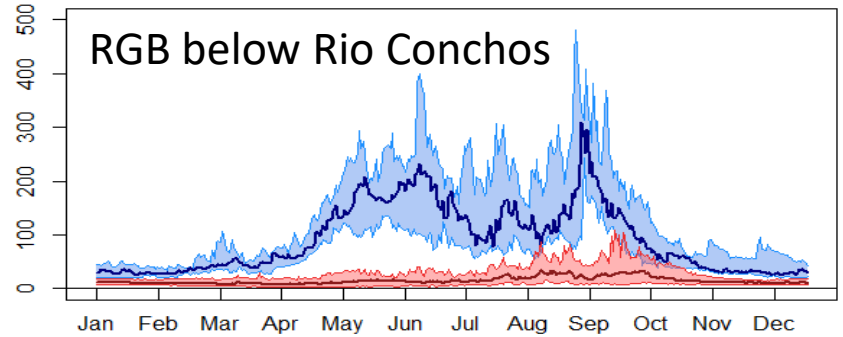
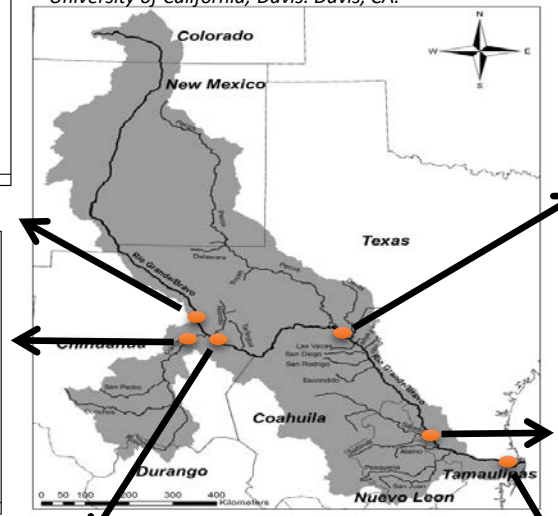
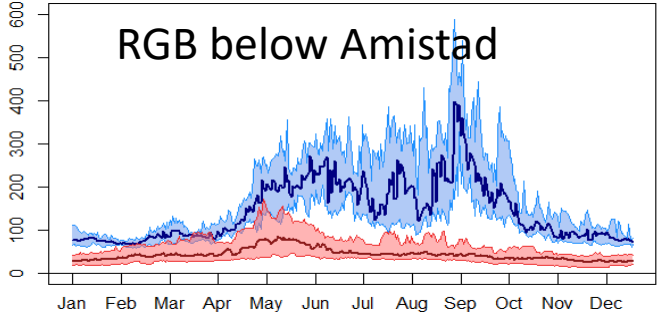
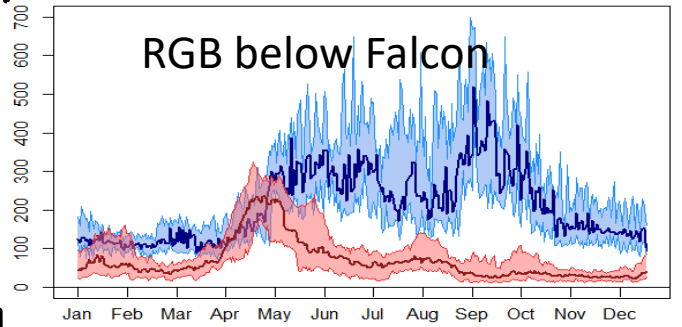


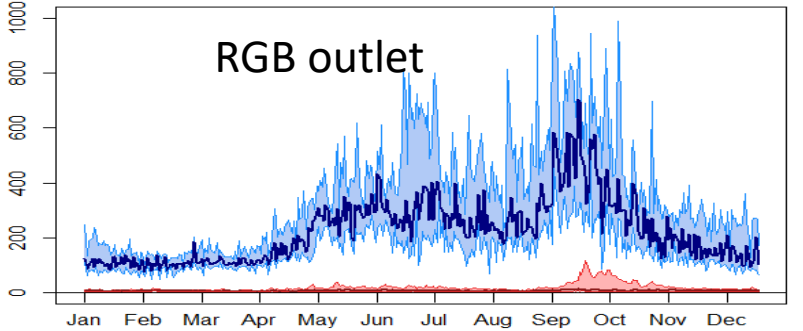




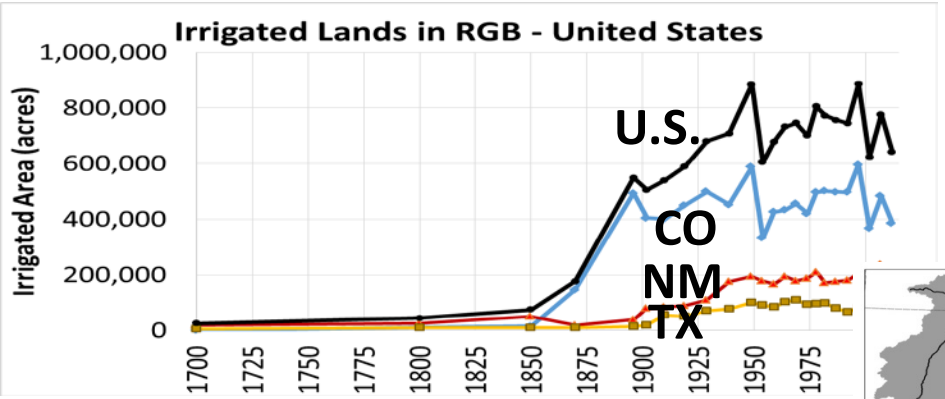
Natural
Regulated

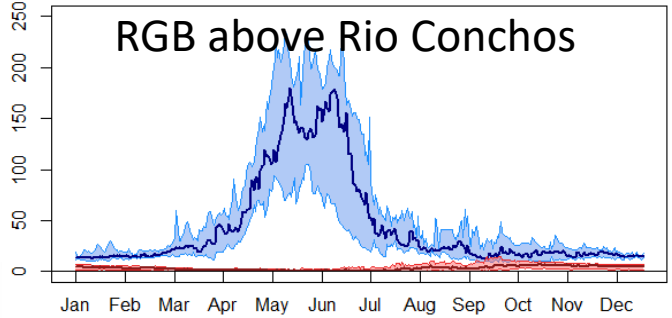




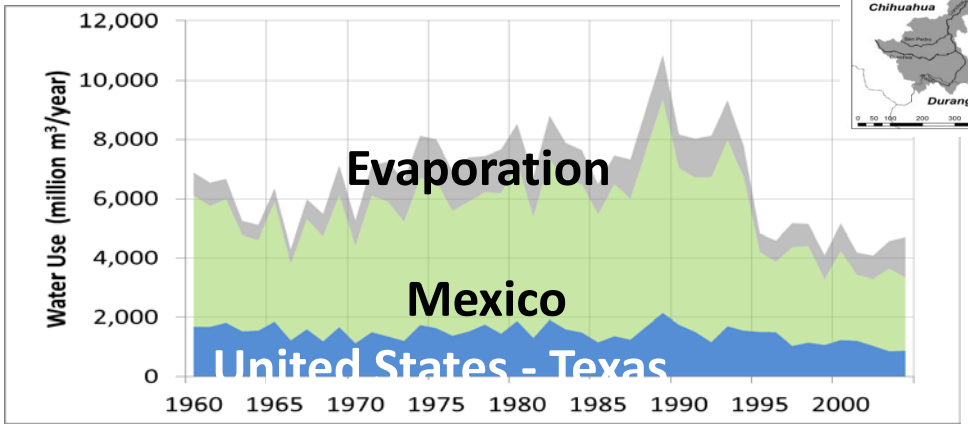


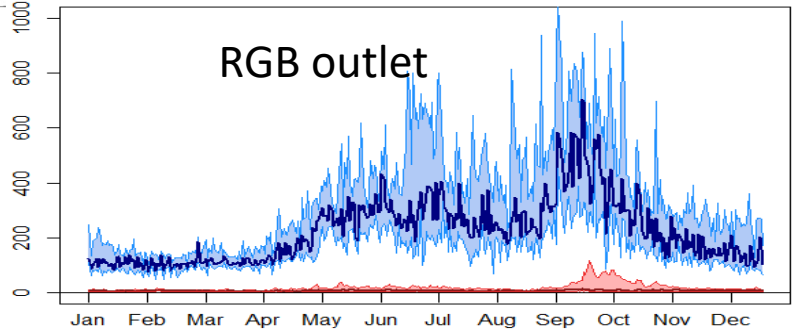
Reservoir Storage 2.5 times the Nat. Wat. Availability





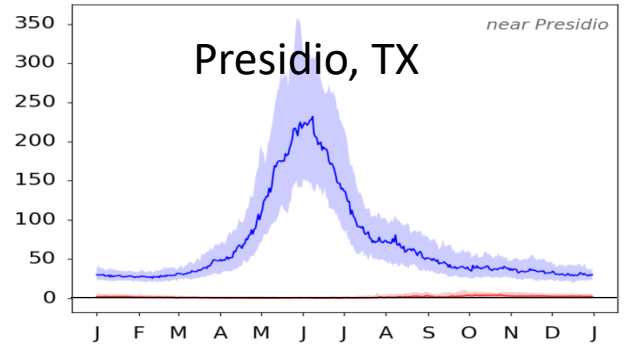
So what?

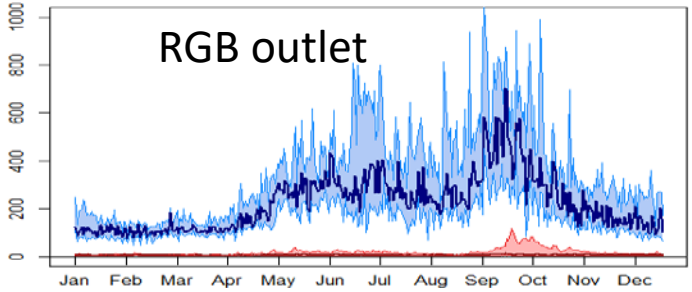


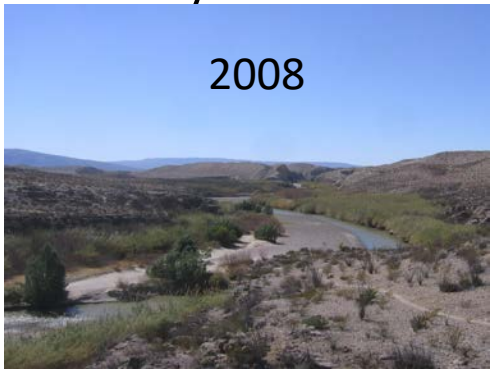


Environmental Challenges

- Flow regime alteration (timing, magnitude, frequency, duration)
- Highly diverted and managed river
- Water quality degradation
- Sediment imbalance
- Endangered species
- Proliferation of invasive species
- Hydraulic fracking
- River disconnected also from society

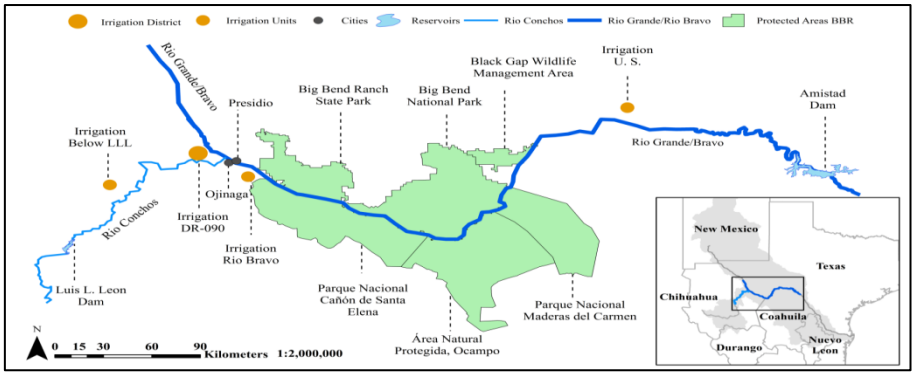


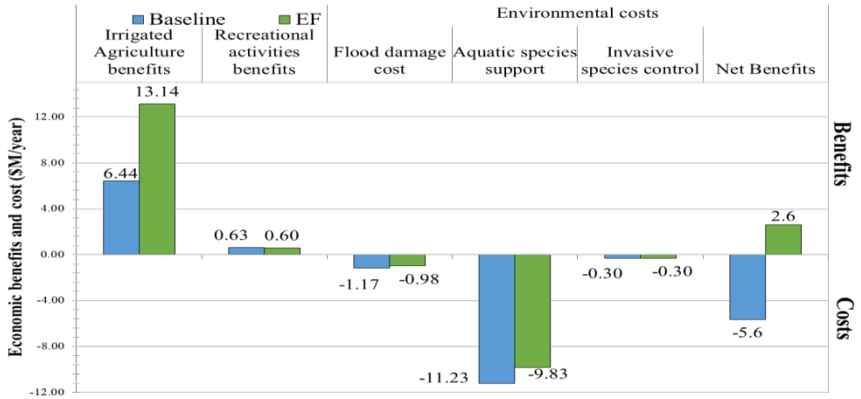




Environmental Opportunities

- Reintroduction of End. Species
- “El dia del Rio” – Rio Conchos
- **Impossible going back– we get to decide**
- Hyd. feasibility of e-flows in Rio Conchos
- Hyd. & economic feasibility in Big Bend
- Env. Restoration: (a) Amistad & Falcon, and (b) Lower RGB Valley
- Recreation





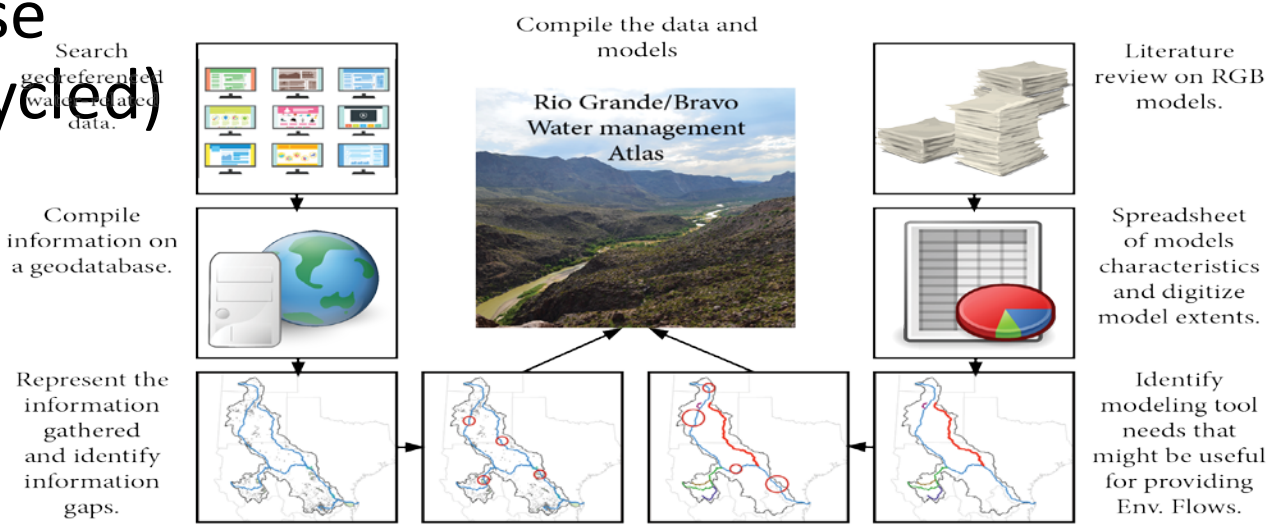
Ortiz-Partida et. Al. (2016). Economic Effects of Reservoir Re-operation Policy in the Rio Grande/Bravo for Integrated Human and Environmental Water Management. J. of Hydrology: Regional Studies.

Water Resources Challenges

- It is a desert!!!
- Highly variable and water scarce basin
- Over-allocated SW and GW resources
- Aging infrastructure and outdated operation
- Fragmented Water Resources Management
- Non-existing GW and Env. Management
- Flood management

Water Resources Opportunities

- Water conservation and Irrig. Efficiency
- Reservoir Re-op & update the operation's manuals
- Conjunctive use (SW+GW+Recycled)
- GW Banking
- Water Education
- Rio Grande/Rio Bravo Water Atlas



Ortiz-Partida et al. (2017). Assessing the State of Water Resource Knowledge and Tools for Future Planning in the Rio Grande-Rio Bravo Basin. United States Geological Survey. South Central Climate Science Center. https://doi.org/10.21429/C9BC7D.

Food for thought …

- Impossible turning back time, we have the opportunity to decide
- It is possible to agree in difficult political times
- We gotta be ready …
- **Develop a practical scientific agenda**
- From fragmented to integrated … From binational to whole basin

THANK YOU

GRACIAS

OBRIGADO

GRAZIE

MERCI

SHUKRAN

XIE XIE

samsandoval@ucdavis.edu

http://watermanagement.ucdavis.edu

Social Perspectives of the Rio Grande/Bravo

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(Univ. of Oklahoma, Center for Applied Social Research)

Stephanie Paladino, Ph.D.
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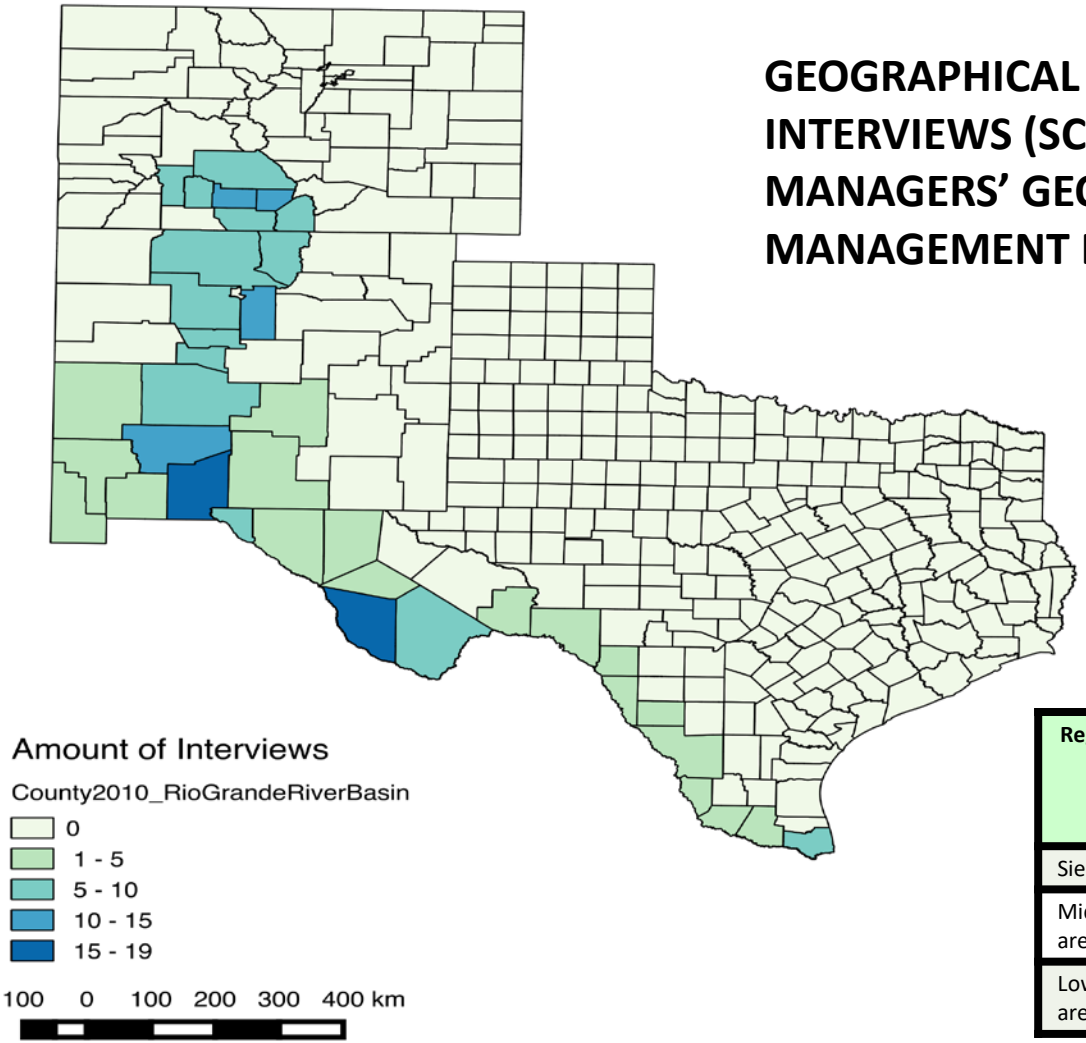
What is the Rio Grande/Bravo?

*"…. **It's really three rivers**. There's the river above Elephant Butte Dam, and you can call that the Rio Grande. There's the Rio Grande Project, which is from Elephant Butte Dam down to Little Box Canyon down here…Fort Quitman. And then that river that runs into the gulf at Brownsville is not the Rio Grande at all. That's Rio Conchos. And the Rio Grande is an occasional tributary. But, I mean, it hasn't been a tributary for some years now, so it's really occasional. So that's a completely different river system."*

Study Design & Methodology

- Fifteen months of ethnographic fieldwork in the Rio Grande basin, including in Mexico's Rio Conchos basin
- Over 120 water managers from Colorado to the Gulf of Mexico
- Included:
  - Municipal Managers
  - Federal Managers
  - Irrigation Districts
  - Farmers
  - Recreation
  - Tribal
- Interviews & Participant Observation (~4-8 hours, on average spent with each interviewee)

GEOGRAPHICAL SCOPE OF U.S. INTERVIEWS (SCALE OF WATER MANAGERS' GEOGRAPHICAL MANAGEMENT DOMAINS)



Conchos Region Interviews

Region of Conchos	Group Interviews (Total Interviewees)	Individual Interviews
Sierra	3 (11)	1
Middle (Delicias area)	0	6
Lower (Ojinaga area)	0	3

Why should we care about the social context in the Rio Grande/Bravo?

- Ecological and hydrological problems in the RGB can be documented with good science, BUT solutions to these problems demand human decision-making and action
- Formal legal/governance structures are only part of the social context of water management
- “Regular people” and institutions feel impacts, manage water, demand changes in different ways to meet different needs, objectives
- What are the spaces that allow for identifying, understanding, and weighing trade-offs?

Formal Governance: Fragmented or Connected?

- Jurisdictional fragmentation (8 states, 2 countries)
  - Federal (Mex/US) and state (US) water laws
  - Interstate water agreements
  - International water agreements (U.S. & Mexico)
- However, these agreements ALSO are among the few contexts that knit the basin together “socially”: force knowledge exchange, interaction, negotiation, collaboration, and possible future reimaginings of the system
- In addition: different properties of river/water system management distributed among many agencies, institutions, organizations

Actor Typologies

GOVERNMENT	
Bi-national	especially, IBWC/ CILA, each part of respective state departments-counterparts
Federal Gov't	directly involved in management of water infrastructure anindirectly through management of basin lands
State Gov't	includes state agencies, but also Commissioners to Rio Grande Compact Commission
County Gov't	
Municipal	municipal water suppliers
Rural-municipal	(water suppliers for unincorporated settlements, rural residents)

IRRIGATION	
Water Conservation Districts (county-based)	
Multi-county water districts	incl districts w/ a variety of mostly surface or surface and groundwater management responsibilities
Irrigation districts	can cross county jurisdictions or be within a county; intermediaries between water sources (reservoirs) and irrigators-
Multi-county groundwater management areas	NM- declares certain GW basins, applies rules; TX
Ditch/canal organizations: 'companies' and	
Community ditches/acequias	
Well-users' associations	

OTHER ACTORS	
Ag and ranching - individual land owners/managers	
NGOs	Land trusts
Collaborative projects	usually restoration focused- or multiple objectives (environment, landowner, recreation) multiple players: ngo, public, private, academia
River/water recreation	
Ag & hydrology engineering	
Farm insurance/risk management programs	
Environmental restoration business	

Is "New" River Thinking Possible? Perspectives from the Conchos

- **Institutional water management relatively centralized** (CONAGUA):
  - Build broader basin knowledge that integrates multiple scales & levels of information and management within one institution.
  - Consejo de Cuenca/RGB Basin Council
- **One institution balancing local, regional, national water interests**
- **Experiments:** Improve irrigation efficiency in exchange for farmers giving up water rights
- **Base of relatively decentralized local actors** (irrigator organizations and independents, uneven resource base)
- **Limited knowledge exchange across and within water sectors, outside of formal governance?**
- **Borderlands: broader geographic and historical perspectives on the RGB, including up through New Mexico and down to Gulf.**
- **Binational projects**

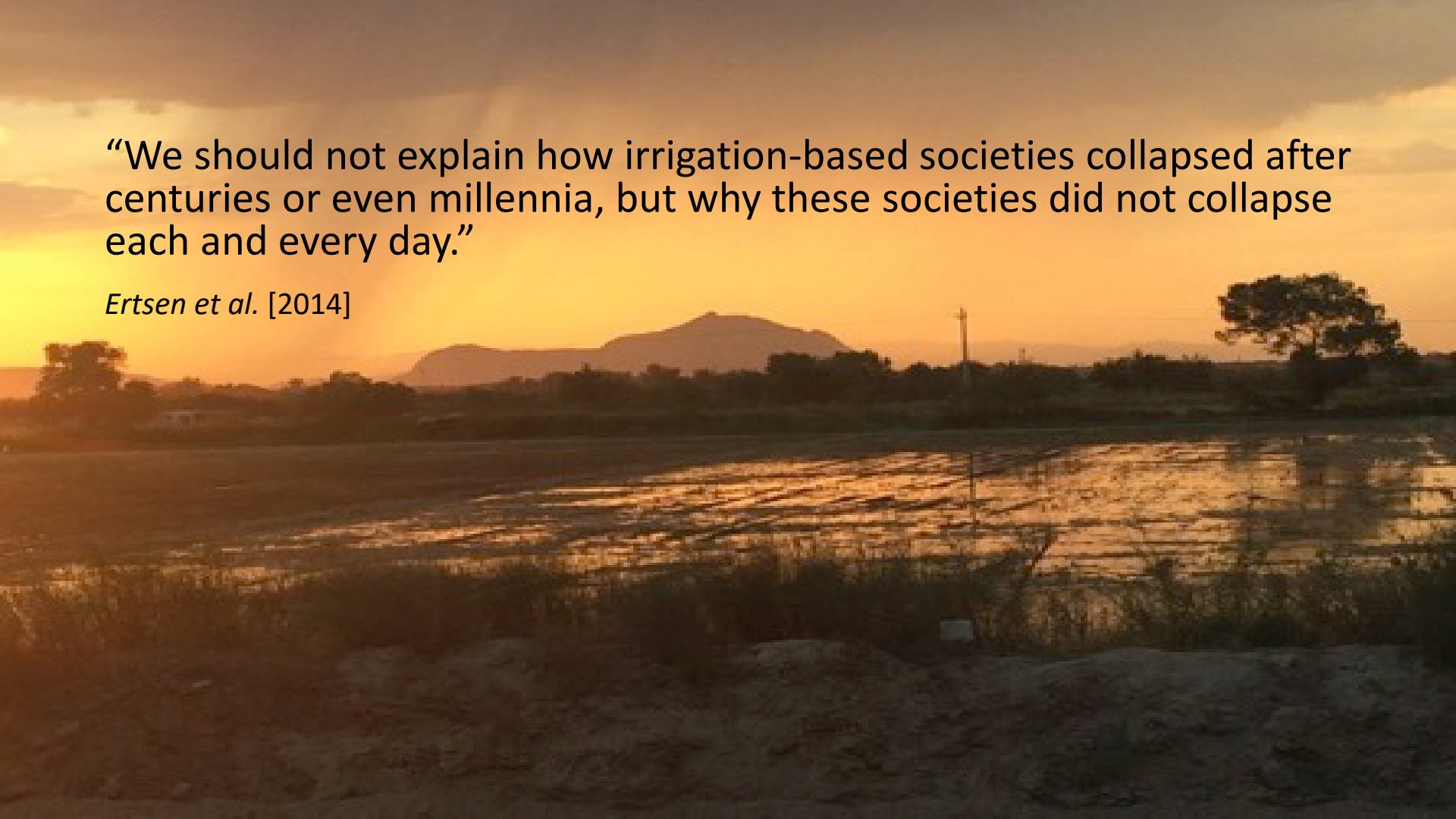
Is "New" River Thinking Possible? Perspectives from the U.S.

- **Water management is relatively decentralized and distributed** among many agencies and actors, which can **reinforce overly regionalized or localized perspectives**. *"We actually know more about the other rivers in our state than we do about the rest of the RG basin"* (southern Colorado interviewee).
- **But, increasing experiments at regional scales (sub-basin)** in water management:

  --between irrigation districts;

  -- multiple water use sectors;

  -- groundwater and surface water
- **"Lateral" networks/exchanges within and across sectors outside of formal governance**. More "average" people.
- **Strong networks of "water people" and water organizations pushing ideas**


“We should not explain how irrigation-based societies collapsed after centuries or even millennia, but why these societies did not collapse each and every day.”
Ertsen et al. [2014]

Acknowledgments

- Funding for this research was provided by the United State Geological Service and the South Central Climate Science Center (“Improving Resilience for the Rio Grande Coupled Human-Natural System.” PI Jack Friedman. G15AP00132.)

- Thanks to my Co-PIs Jennifer Koch and Jadwiga Ziolkowska, both from the University of Oklahoma’s Department of Geography and Environmental Sustainability.

- Thank you to all of the water managers and others who have given their time throughout this research. Thank you, especially, to World Wildlife Fund-Chihuahua and CONAGUA for the assistance that they provided.

CONTEXT OF THE RIO BRAVO BASIN: Basic socio-economics

Rio Grande / Río Bravo Binational Forum

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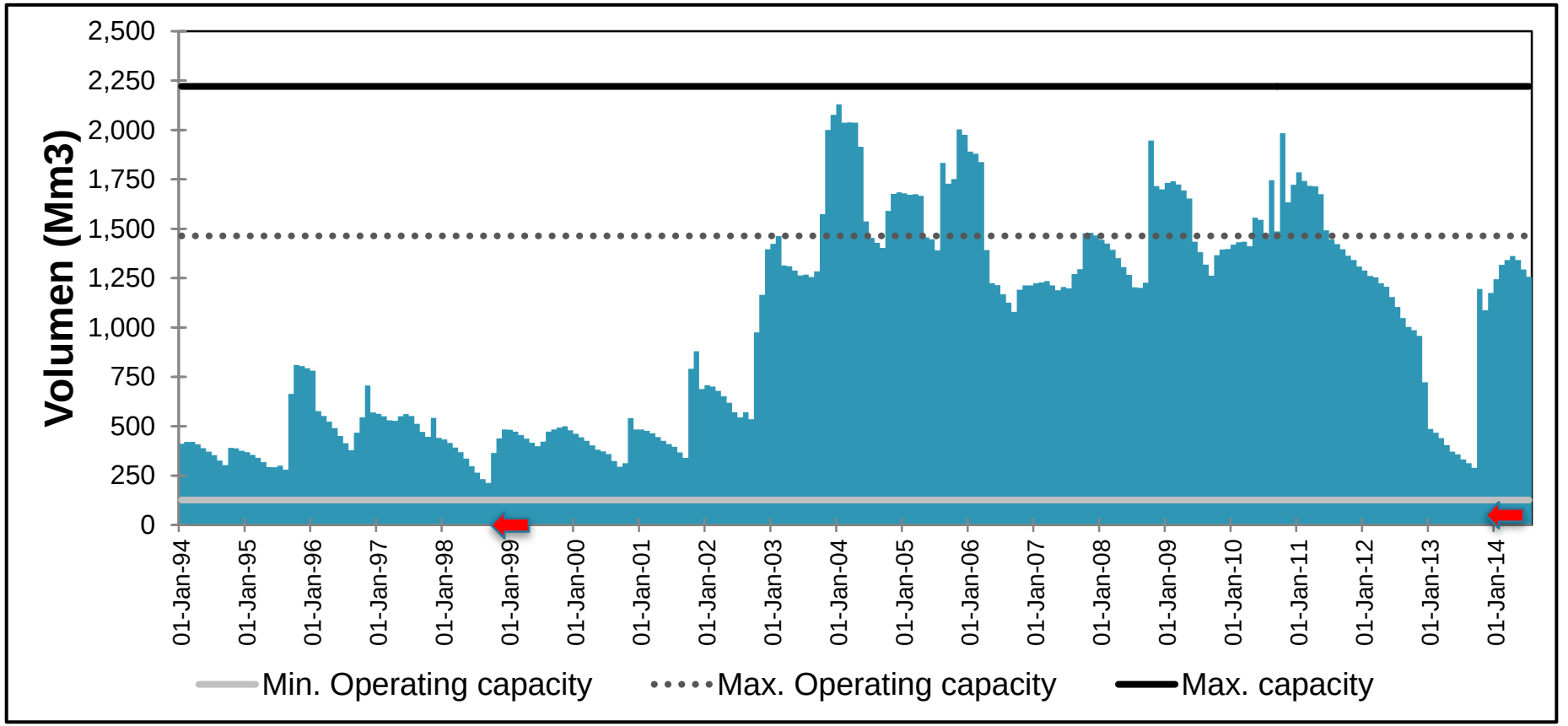
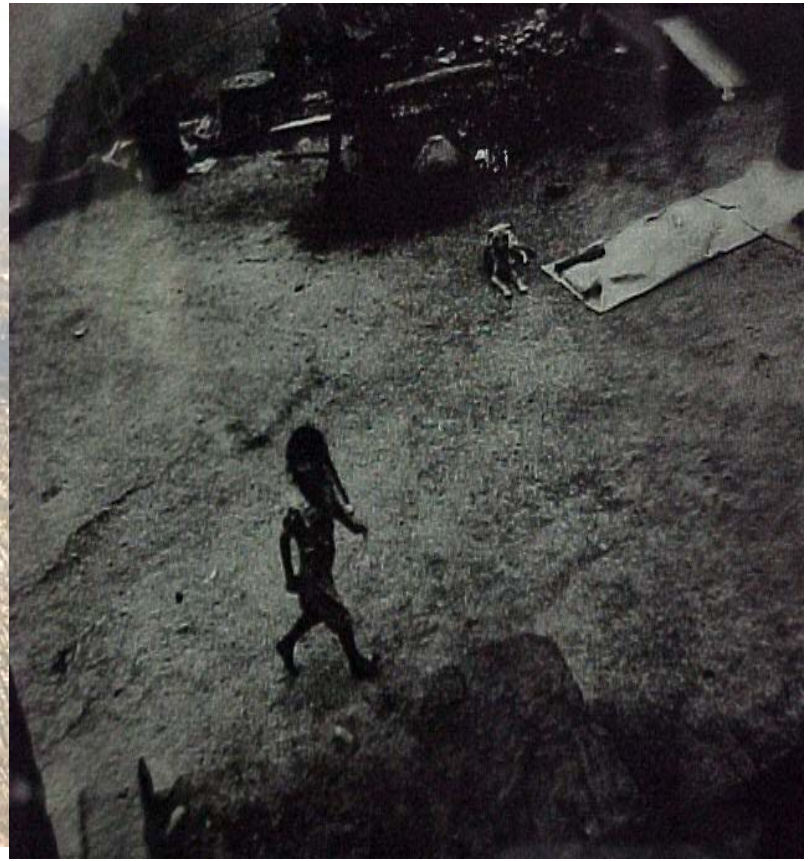
Natural Resources Journal

Coping with Scarcity in the Río Grande/ Río Bravo Drainage Basin: Lessons to be Learned from the Droughts of 1993 - 1996

Combined storage of Monterrey's surface sources of water (La Boca, Cerro Prieto and El Cuchillo Dams)





Metropolitan concentration of Rio Bravo Basin population, 2015

1 Monterrey	**4,535,185**
2 Cd. Juárez	**1,391,180**
3 Chihuahua	878,062
4 Saltillo	809,537
5 Reynosa	646,202
6 Matamoros	520,367
7 Nuevo Laredo	399,431
Subtotal Urban	**9,179,964**
TOTAL BASIN	12,095,967

In 2010 there were around 700,000 people living in rural settlements (approximately 45% in Chihuahua).

From 34 to 44% in places with fewer than 100 inhabitants.

Between 2010 and 2015 immigrated 355,500 people.

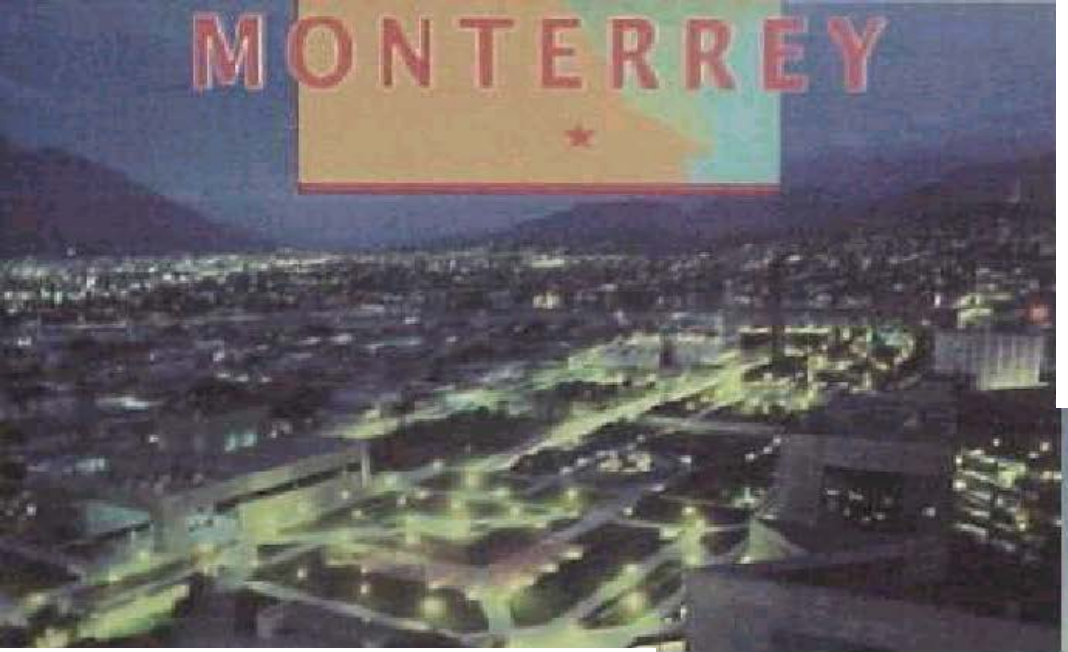
Projection for the basin in 2030**: 14.3 millones**

The future: climate change

Projections for the basin suggest that climate will be:

1. Dryer.
2. More unstable (and probably more extreme).

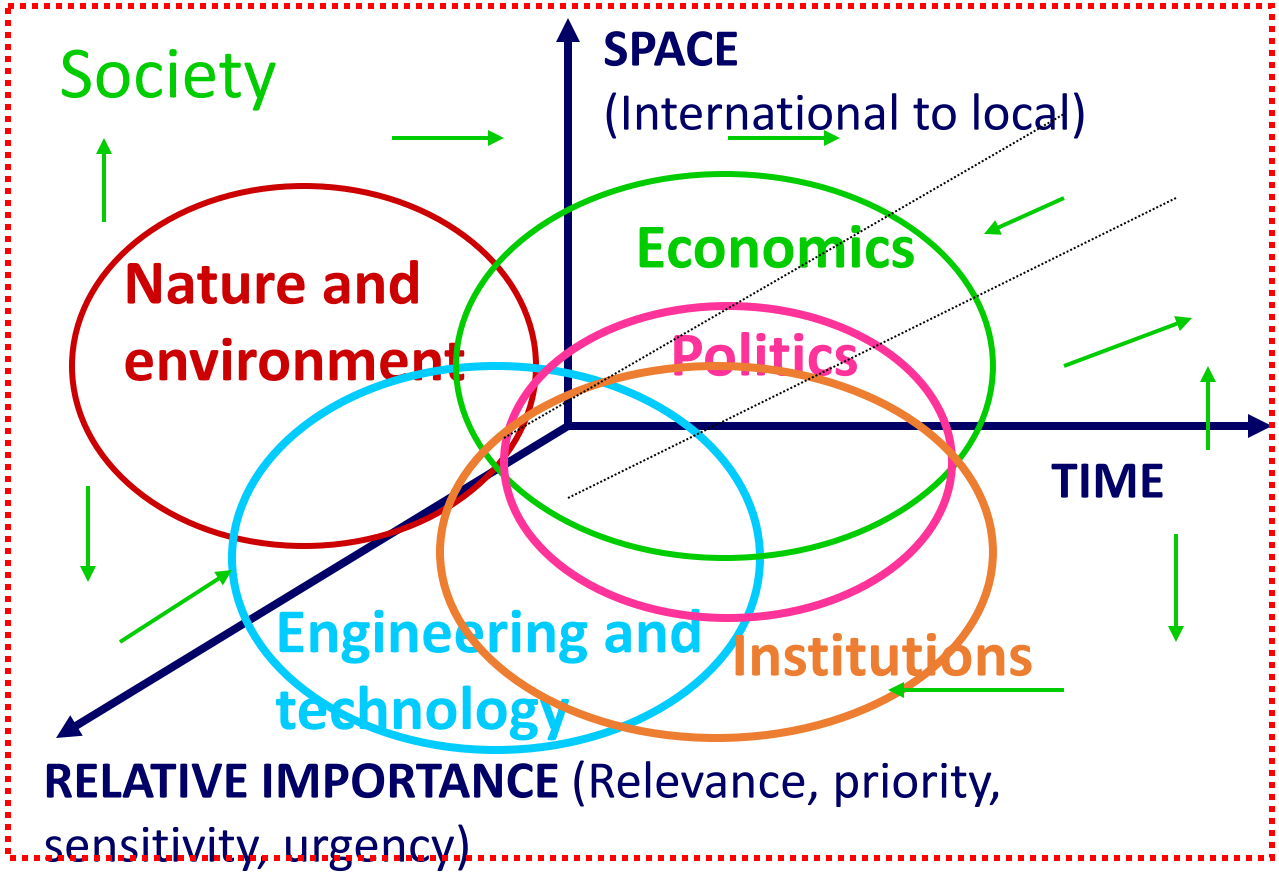
- **With and without climate change, the necessity for adaptation is clear and urgent.** Climate change scenarios suggest that this necessity will be more acute than historic records show.



Urban-rural contexts …

… in interregional transfers of water

Multidimensional framework



*Competencies
*Responsibility *Moral
*Social initiatives
* Interests
*Conflicts
*Culture
*History
*Personal factors
* Plausible events
*Cooperation
*Flexibility
*Creativity
Willingness / *Political obligation

Acting Forces

Economic Perspective on Water Issues and Possible Solutions in the Rio Grande Basin

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Rio Grande/Rio Bravo Forum 2017

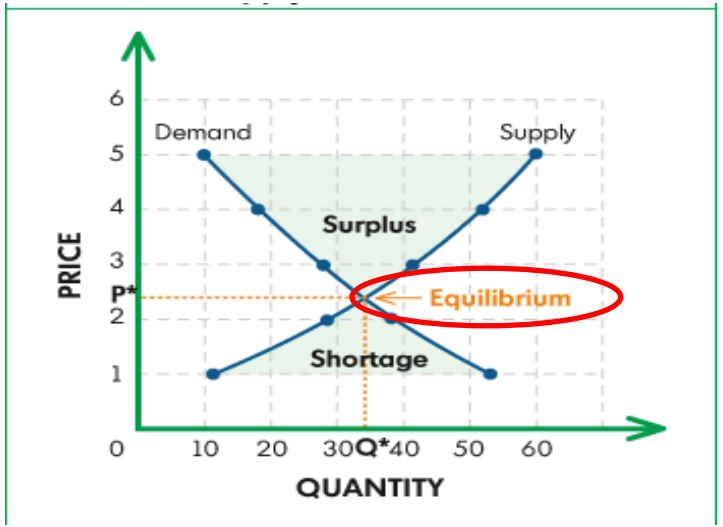
El Paso, Texas
November, 7-8, 2017

Major economic issue – $ values

Drivers of water problems in the Rio Grande:

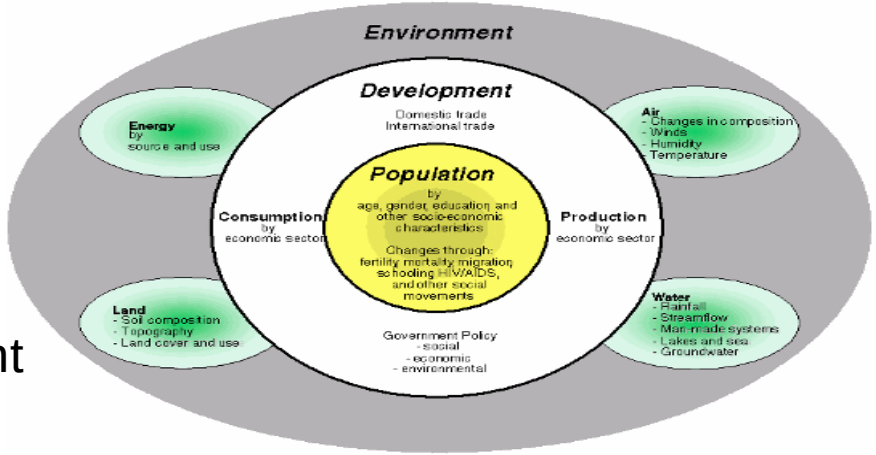
1. Growing population
2. Frequent (and long-term droughts)
3. Sectoral water (over)use (agricultural production)

=> Impact on: water demand, supply, water rates and costs



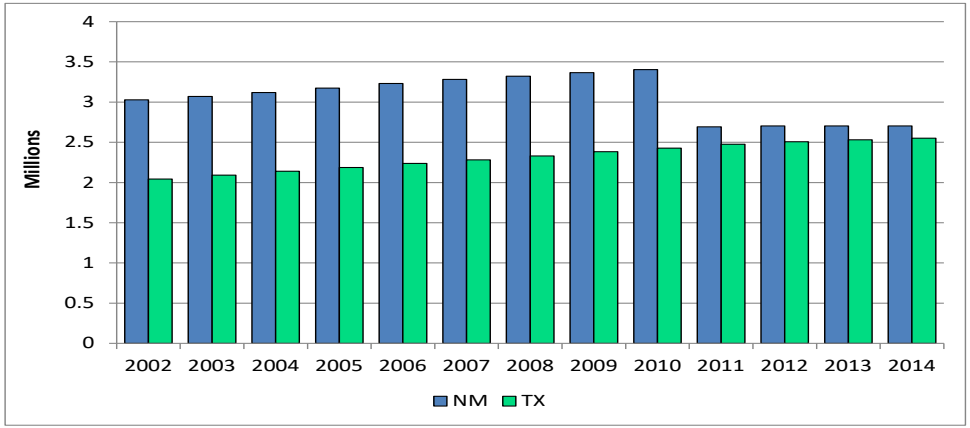
Water issues in the RG Basin are not unusual

- Water is a 'common good' → *tragedy of the commons*
  => No well-established water markets
  => Economic value of water unknown (i.e., shadow price)
- No clear boundaries in surface and groundwater use (implications of weather variability on water withdrawals)
- No consistent pricing system for water use across sectors (over time)
- Consistent water use monitoring missing
- Imbalance in the economy-environment system (competition for water)

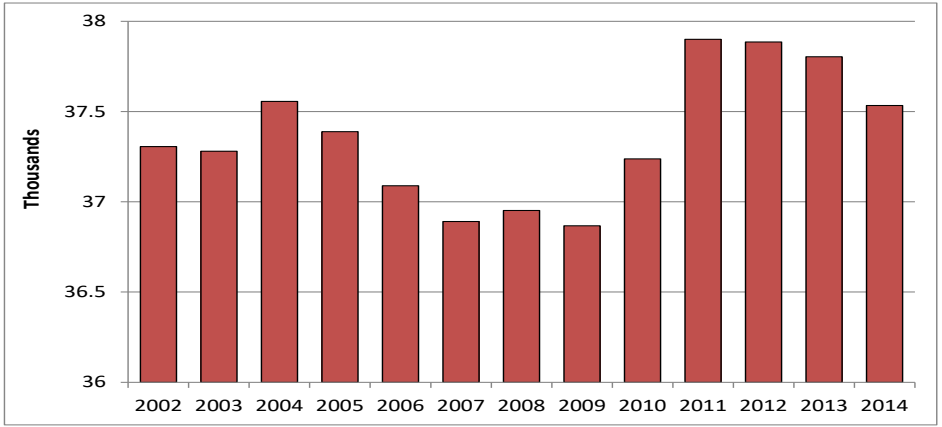


Population in RG adjacent counties

NM and TX



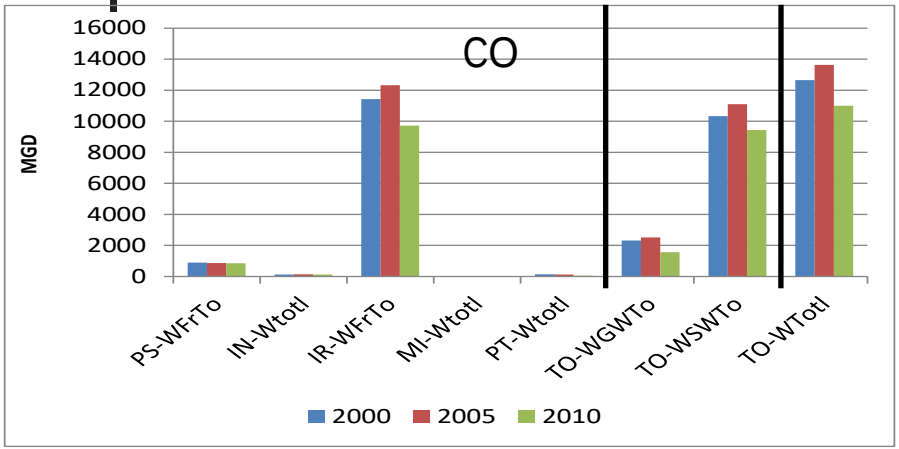
CO

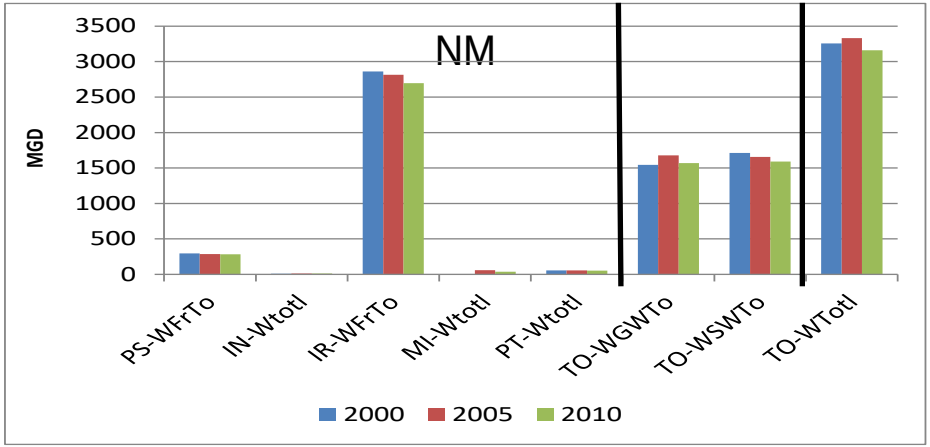


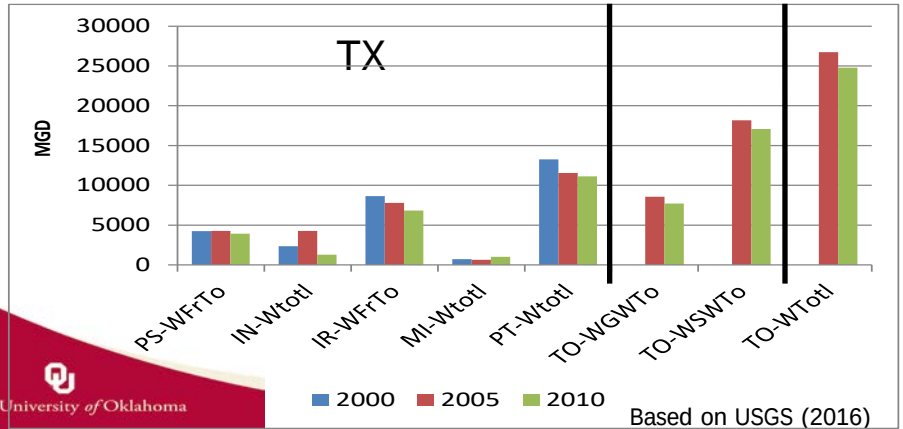
NM - 10% population decline between 2002 and 2014
TX - 24% population increase between 2002 and 2014
CO - Slight variations but no significant change

User (sector) specific measures needed

Water withdrawals by users, source & totals – all counties







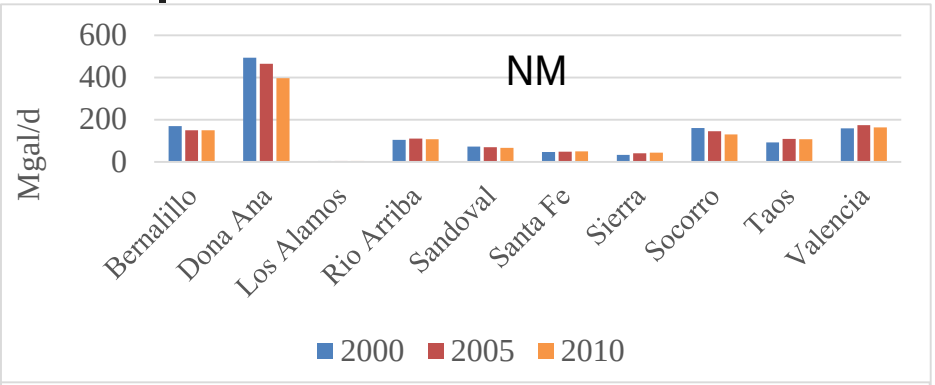
Based on USGS (2016)

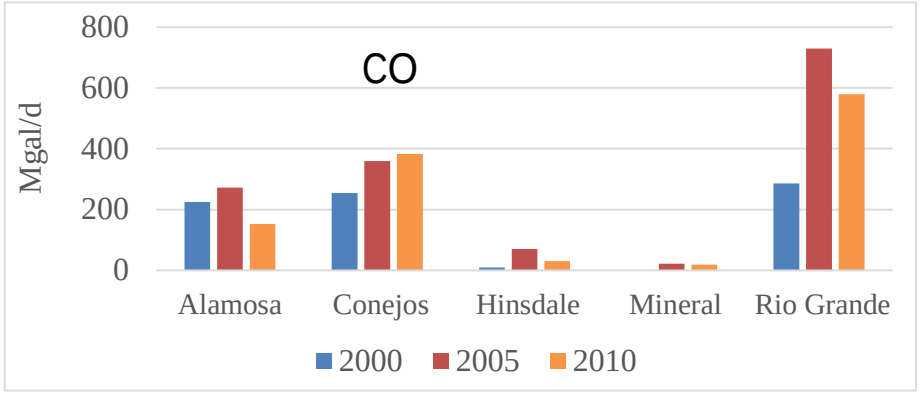
Sector specific measures needed
→ irrigation vs. other sectors

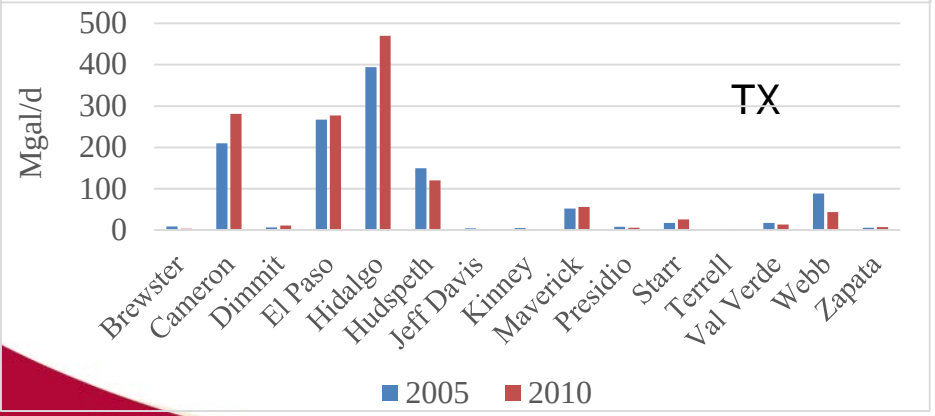
State specific measures needed
→ water consumption volumes

Temporal success (2000-2010)
→ impacts of conservation measures?

Total water withdrawals – only RG adjacent counties



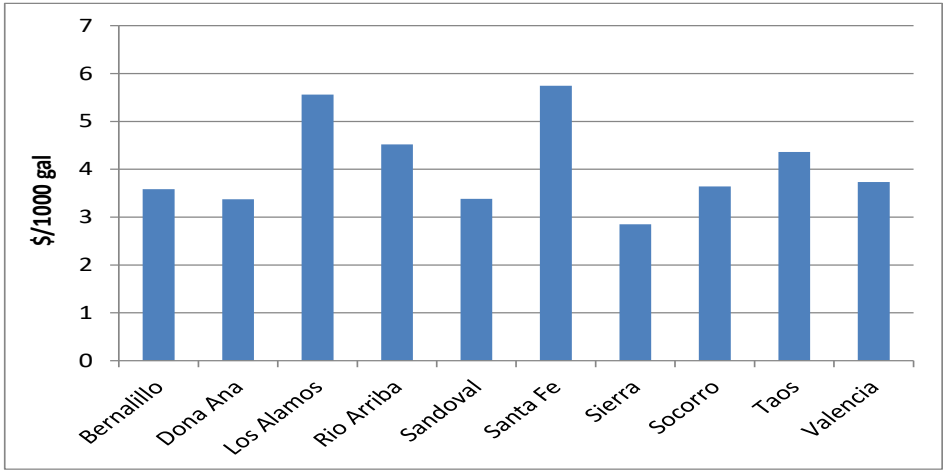




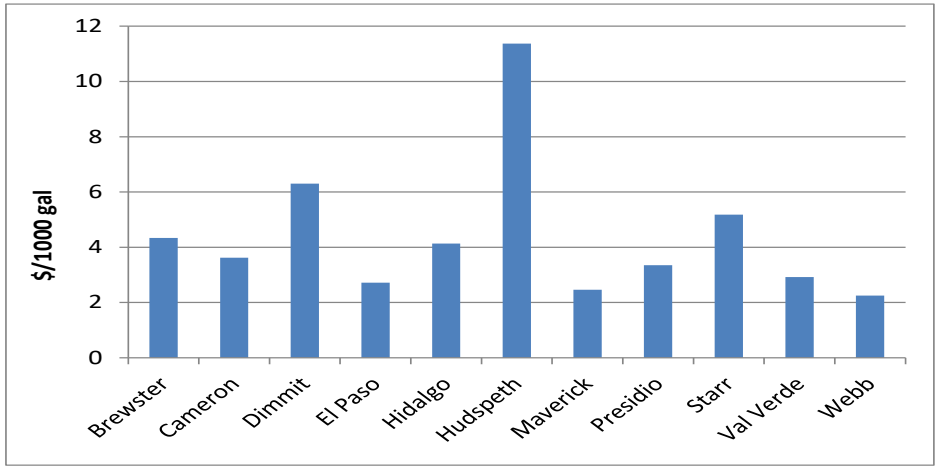
Region and county specific measures needed
→ water consumption measures

Water rates in TX and MX (average 2002-2016)

NM



TX



CO data not archived – data consistency challenge

Demand/Supply specific measures needed both at regional/county level and for different users (commercial vs residential rates)

Possible water management approaches

Demand management

1. Economic incentives and taxes on water consumption
   - Water pricing
   - Subsidies for water conservation (ag. sector, household use)
2. Water conservation technologies (agriculture, municipal use)

Supply management

1. Economic incentives for new supply mechanisms, approaches and sources
   - Water markets
   - Cap and trade system for water
   - Payments for watershed services
2. New infrastructure (dams, levees, canals)
3. New technologies (rainwater harvesting, ASR, desalination - Kay Bailey Hutchison Desalination Plant in El Paso, TX; Southmost Regional Water Authority Desalination Plant in Brownsville, TX)

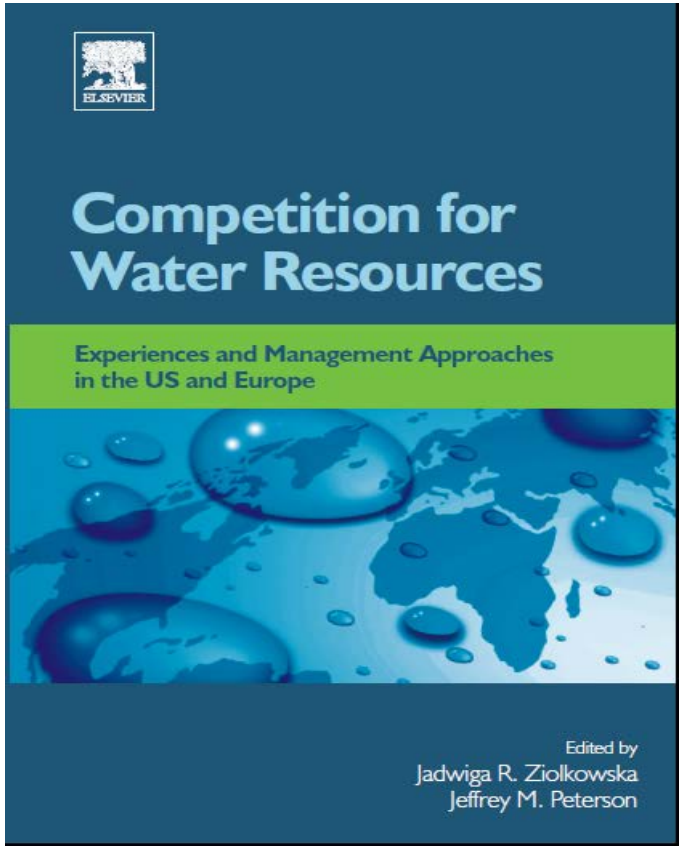
Possible water management approaches

Governance

- Establishing property rights
- River Basin organizations and transboundary management
- Cross-state and cross-border regulations

Practical actions needed:

Improve consistency of water use monitoring across the RG Basin to tack progress over time



New book on water resources

edited by

Dr. Jad Ziolkowska & Dr. Jeff Peterson

KEY FEATURES

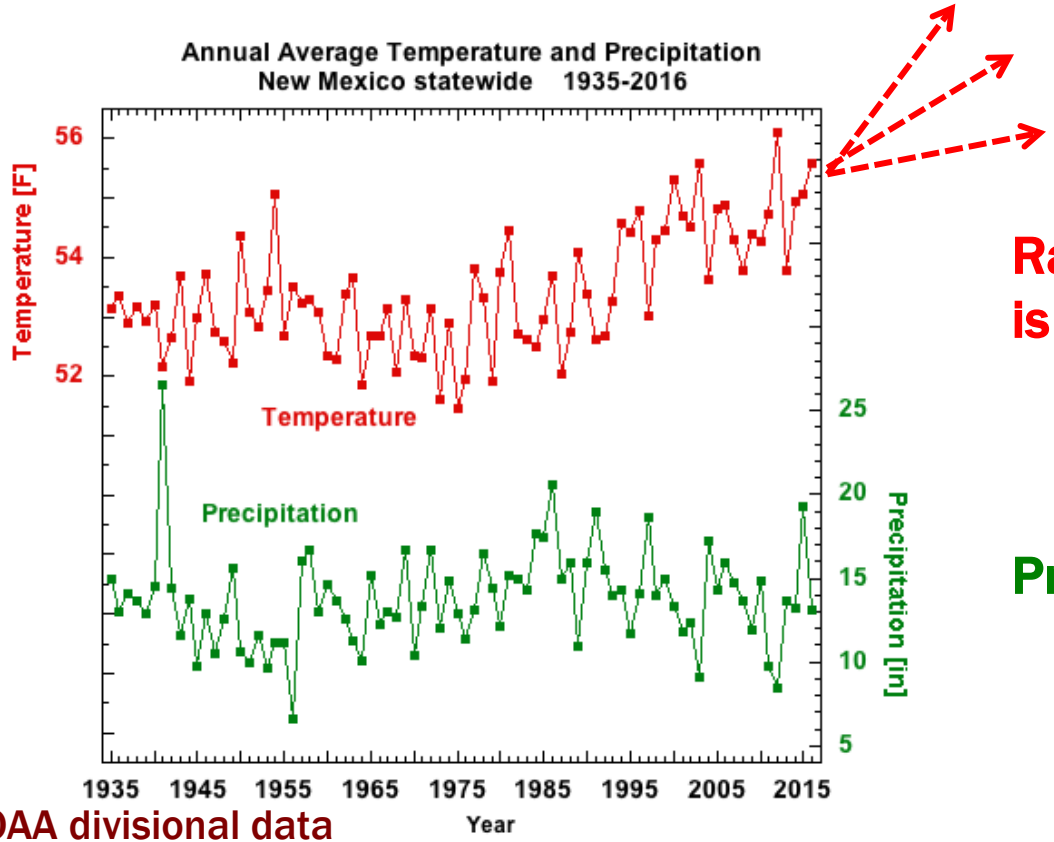
- Provides a national and regional perspective through the use of country specific case study examples
- Includes a comparative analysis between the US and Europe, illustrating experiences in water management from two sides of the Atlantic
- Covers interdisciplinary topics related to water, such as agriculture and energy

International perspective on water scarcity problems and useful management methods and best practices in the US and Europe

Context of the Basin
Contexto de la Cuenca

David Gutzler
University of New Mexico

Observed climate variability in New Mexico



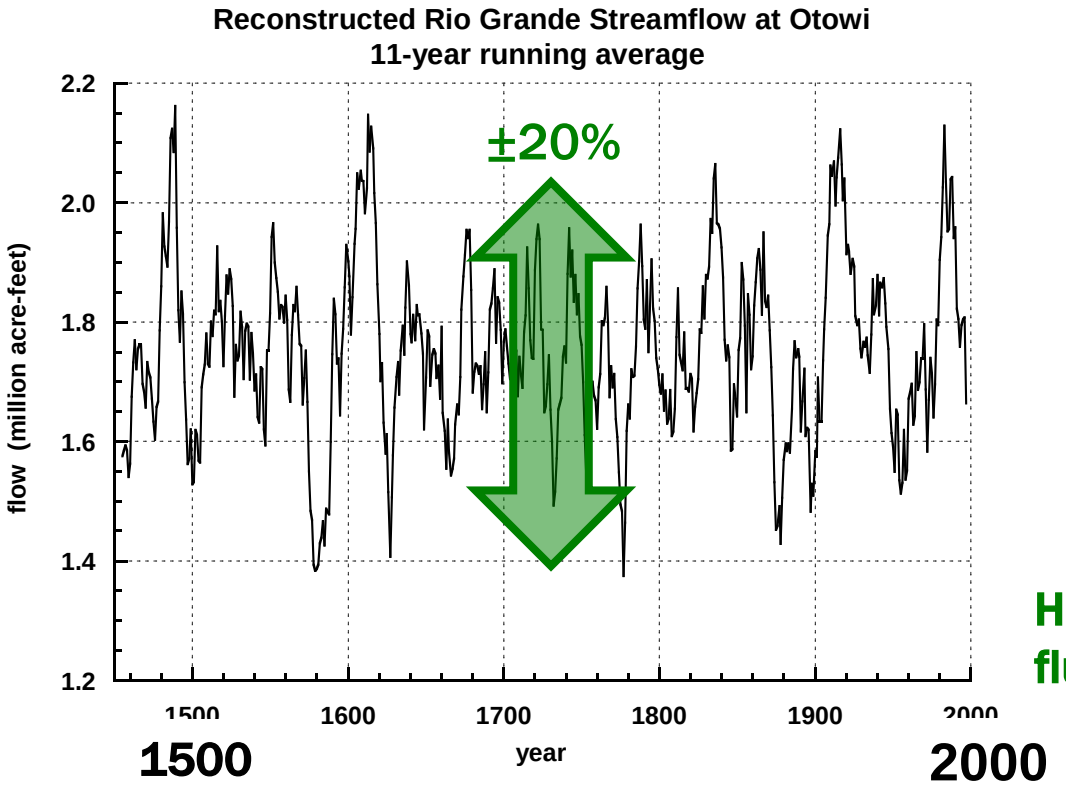
NOAA divisional data

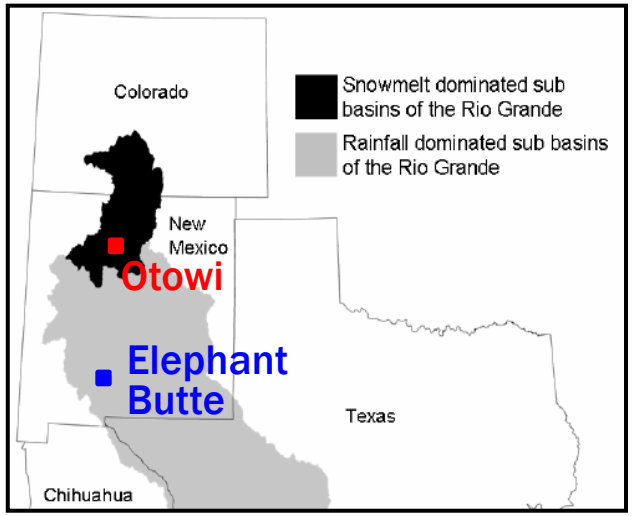
?

Rapid temperature change is happening now

Precipitation: Extreme variability

Reconstructed upper Rio Grande streamflow

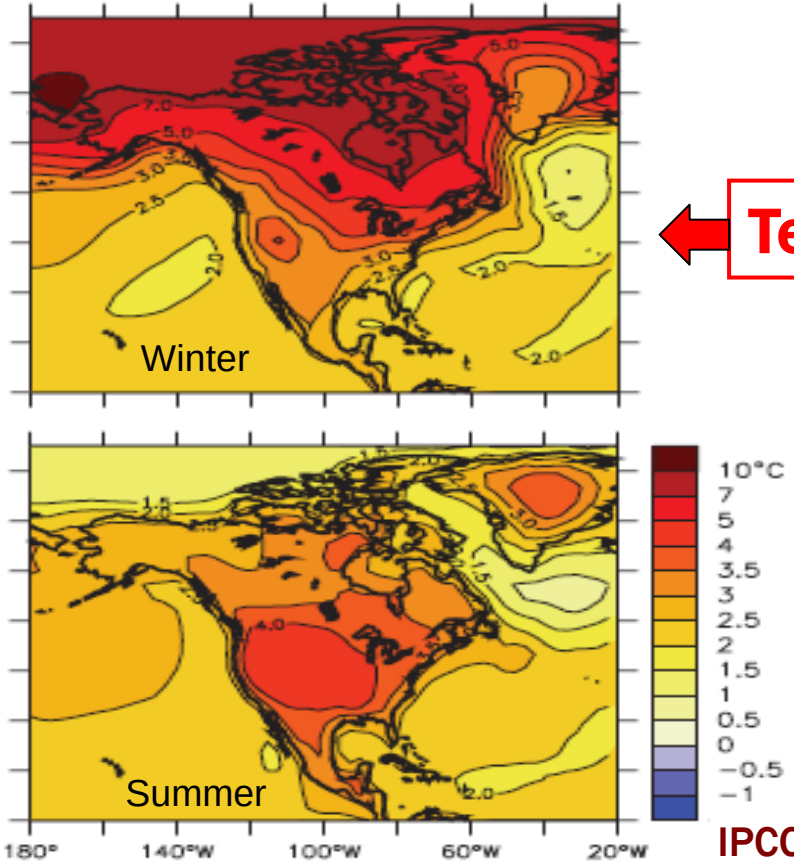




Huge, natural multidecadal fluctuations in upper Rio Grande flow

treeflow.org
Gutzler (2012)

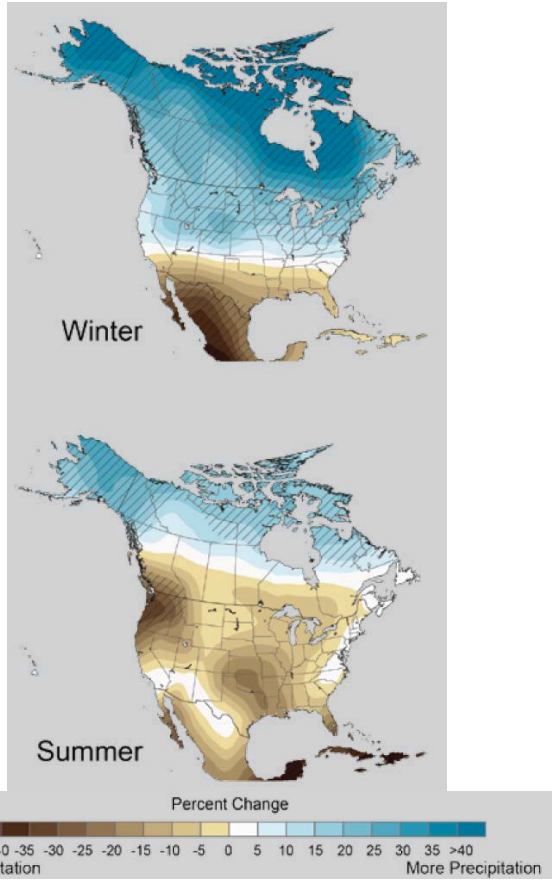
Projected climate change



IPCC AR4

Temperature

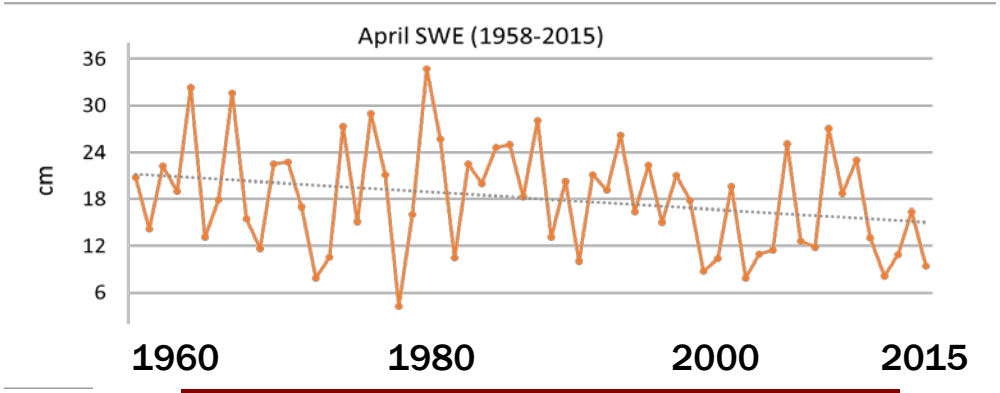
Precipitation



US GCRP

Decreasing snowpack

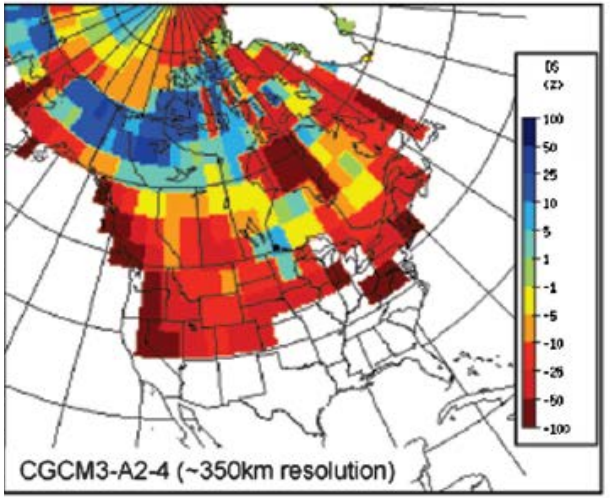
Observed Snowpack
Upper Rio Grande Basin



25% decrease since late 1950s

Chavarria & Gutzler (2017)

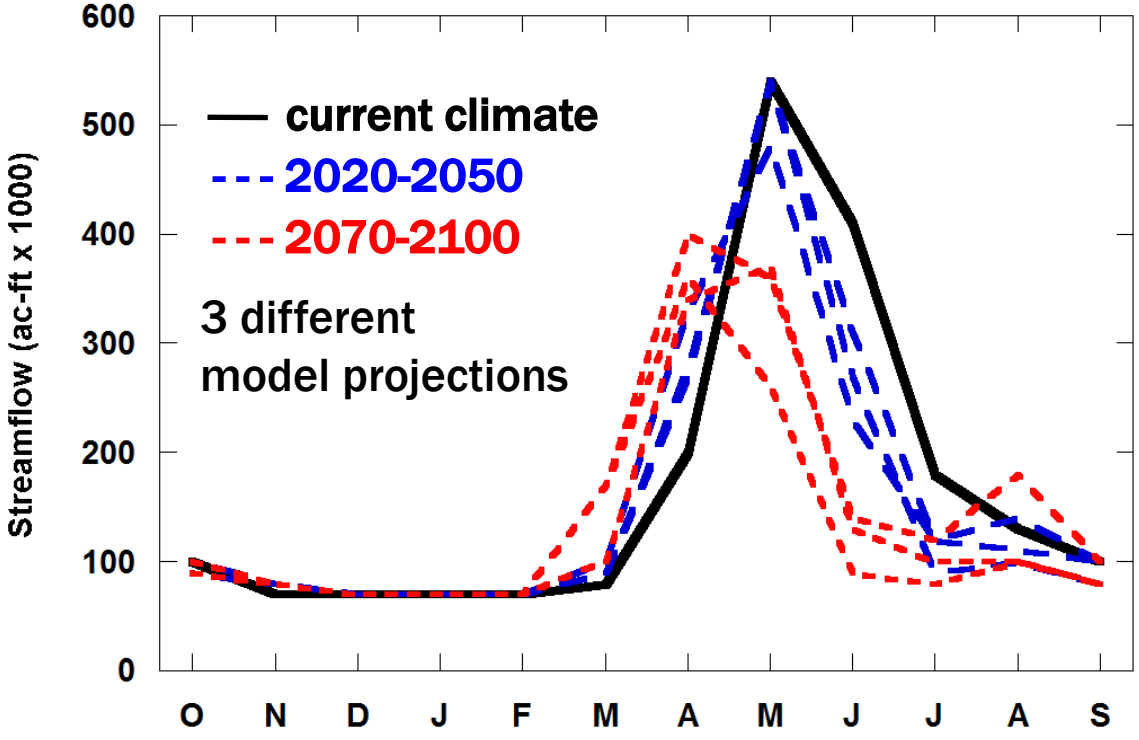
21st Century Projected Snowpack



Brown & Mote (2009)

Decrease in snowpack is happening now … and projected to diminish further

Projected Upper Rio Grande Streamflow



Hurd and Coonrod (2012)

In the future (warmer) climate:

Earlier & weaker snowmelt runoff peak

Reduced total streamflow, especially in late spring / early summer

Climate Change in the Rio Grande Basin

1) It's already happening!

2) Big projected temperature change
(continuation of observed trend)
Huge ongoing decline in snowpack

Rio Grande at Otowi

3) Significant trend toward aridity
... continued variability of precipitation
... droughts, when they occur, will be worse than before
... stressing water resources throughout the basin

4) Global warming adds to existing environmental stresses
(such as groundwater depletion and habitat destruction)

The ecological context of flow-related issues in the Rio Grande/Rio Bravo:

Rio Grande Forum November 2017

Phaedra Budy*

Demitra Blythe

Bryan Maloney

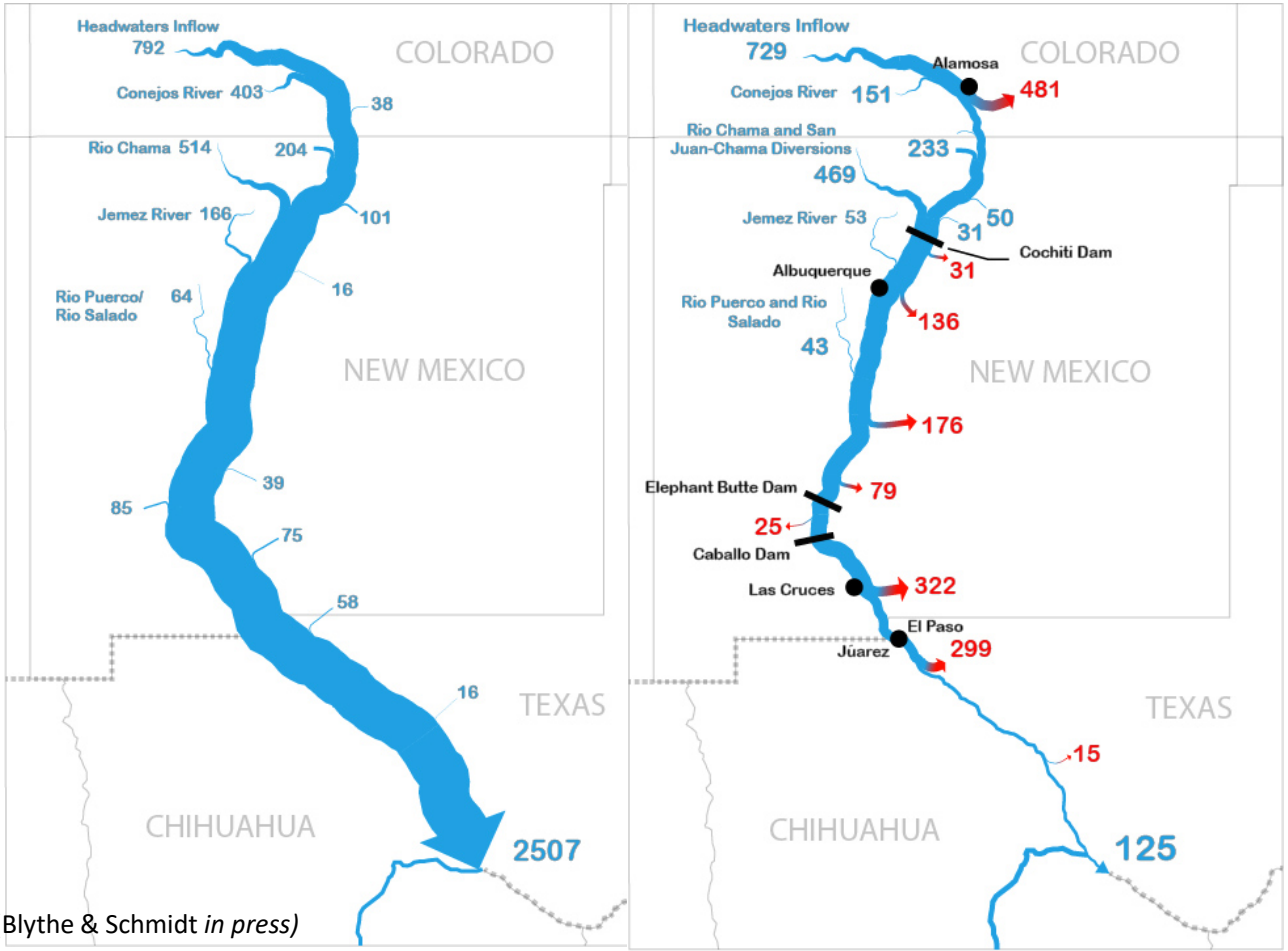
Jack Schmidt

Todd Blythe

***US Geological Survey – Utah Cooperative Fish ad Wildlife Research Unit**

Utah State University

Dramatic Reduction in Flow



(Blythe & Schmidt *in press)*

- Total annual flow of the northern branch = 95% lower
- The greatest <u>cumulative</u> depletions are at the far downstream end
- Current 2-year flood = decreased by > 60%
- Natural sediment flux has been reduced from the 3rd largest in US to 0 (zero).

DIRECT EFFECT

INDIRECT EFFECT

--FLOW

Fragmentation
Flood Protection
Pumping

Spring Flood
- Magnitude
- Duration
- Timing

Base Flow
- Magnitude
- Duration
- Timing

Water Temperature

Surface ground water interactions

Decreased sediment transport = Sediment (+OM) accumulation

Reduction in channel width and complexity Altered bed grain size

Intermittent River drying

Impaired water quality

Reduced Floodplain connection & inundation

Non-native fish invasion & establishment

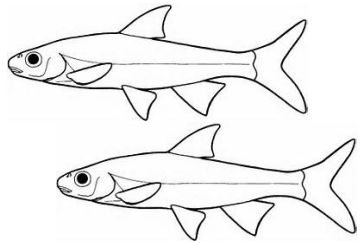
Reduction in quantity and quality of aquatic in-stream and riparian habitat

Altered primary and secondary productivity (algae & bugs)

Non-native plant invasion & Establishment

Native vegetation, meadow and wetland loss and conversion

Ecosystem Health
- Fish and Invertebrate (e.g., mussels)
  - Abundance
  - Persistence
  - Diversity
- Nutrient processing
- Riparian plant and animal communities



Middle Rio Grande in New Mexico

DIRECT EFFECT

INDIRECT EFFECT

--FLOW

Spring Flood
- Magnitude
- Duration
- Timing

Base Flow
- Magnitude
- Duration
- Timing

Water Temperature

Surface ground water interactions

Decreased sediment transport = Sediment (+OM) accumulation

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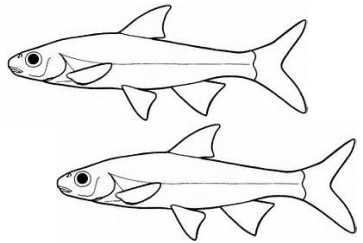

DIRECT EFFECT

INDIRECT EFFECT

Big Bend region of lower Rio Grande

--FLOW

Spring Flood
- Magnitude
- Duration
- Timing

Base Flow
- Magnitude
- Duration
- Timing

Water Temperature

Surface ground water interactions

Decreased sediment transport = Sediment (+OM) accumulation

Reduction in channel width and complexity Altered bed grain size

Intermittent River drying

Impaired water quality

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Ecosystem Health
- Fish and Invertebrate (e.g., mussels)
  - Abundance
  - Persistence
  - Diversity
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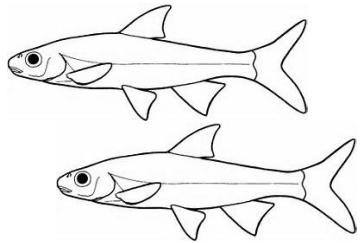
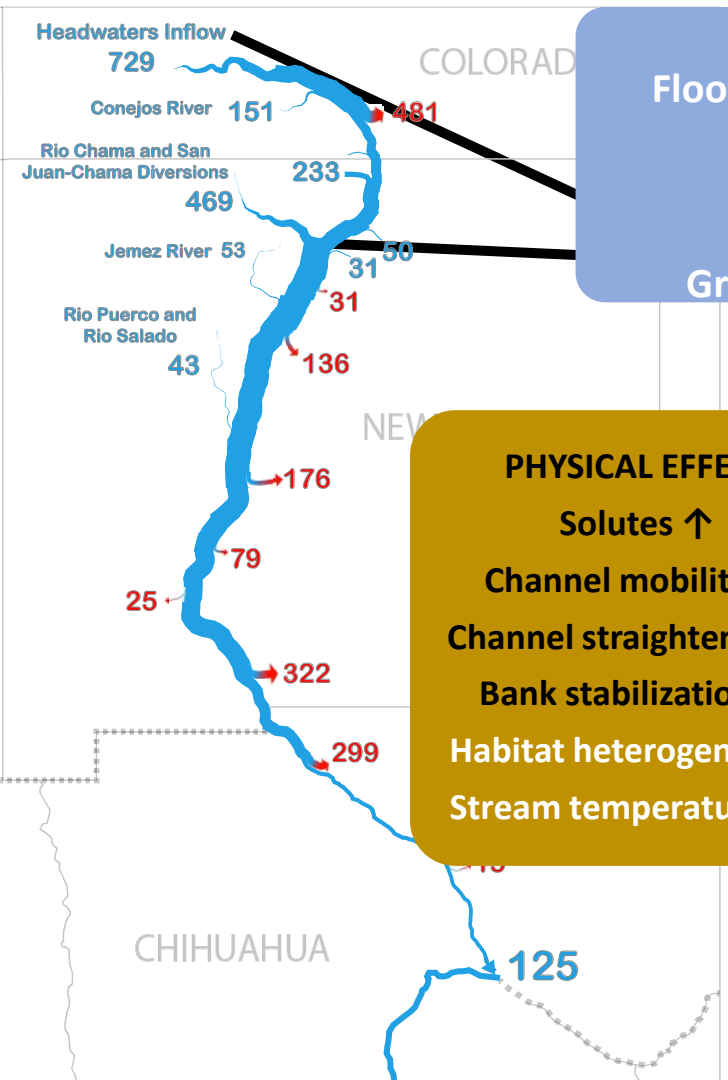


Upper Rio Grande



CAUSE

Flood magnitude (70% smaller)

& duration ↓

Baseflow magnitude ↓

Groundwater extractions ↑

PHYSICAL EFFECT

Solutes ↑

Channel mobility ↓

Channel straightening ↑

Bank stabilization ↑

Habitat heterogeneity↓

Stream temperature ↑?

BIOLOGICAL EFFECT

Native fishes ↓

(e.g., extirpation/extinction of ALL endemic fishes from mainstem)

Non-native fishes (>85%) ↑

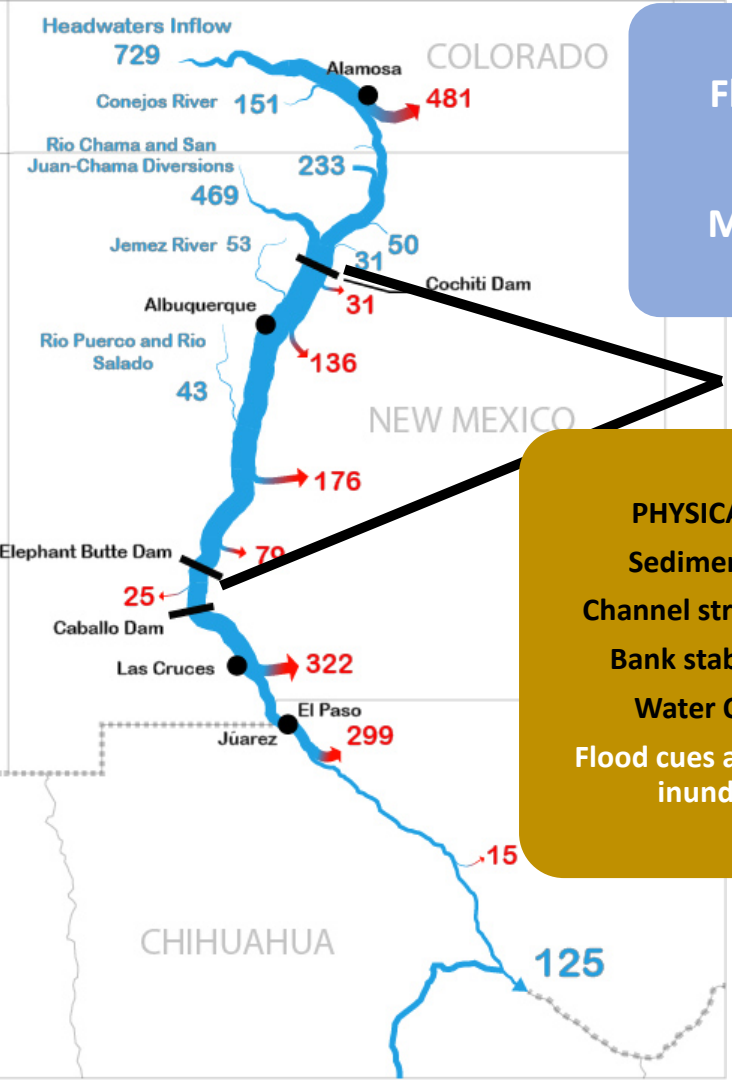
Native vegetation ↓

Non-native vegetation ↑

Wildlife species ↓

Other 'non-flow' related issues that matter (to ecosystem health):
Non-native fishes (trout)

Middle Rio Grande in New Mexico



CAUSE

Flood magnitude (75% smaller) & duration

Monsoon flood ~ > spring flood

Water table ↓

PHYSICAL EFFECT

Sediment Load ↓

Channel straightening ↑

Bank stabilization ↑

Water Quality ↓

Flood cues and floodplain inundation ↓

BIOLOGICAL EFFECT

Native vegetation ↓

Non-native vegetation ↑

Conversion of "meadow" to ag. & desert tolerant plants ↑

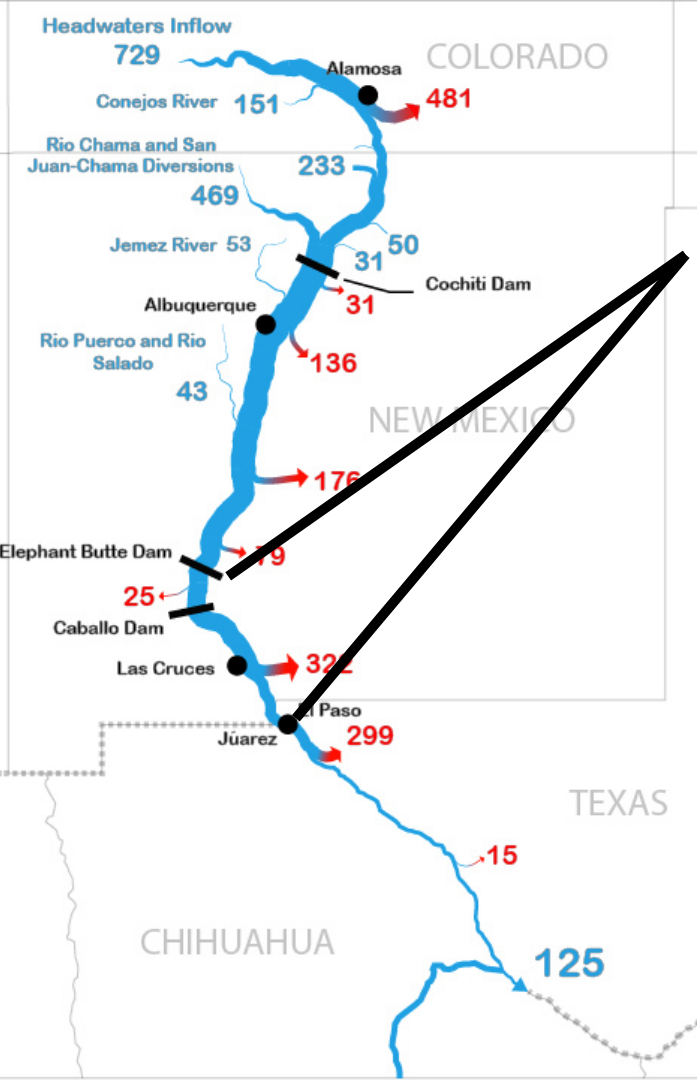
Eutrophication ↑ & Ecosystem Health ↓

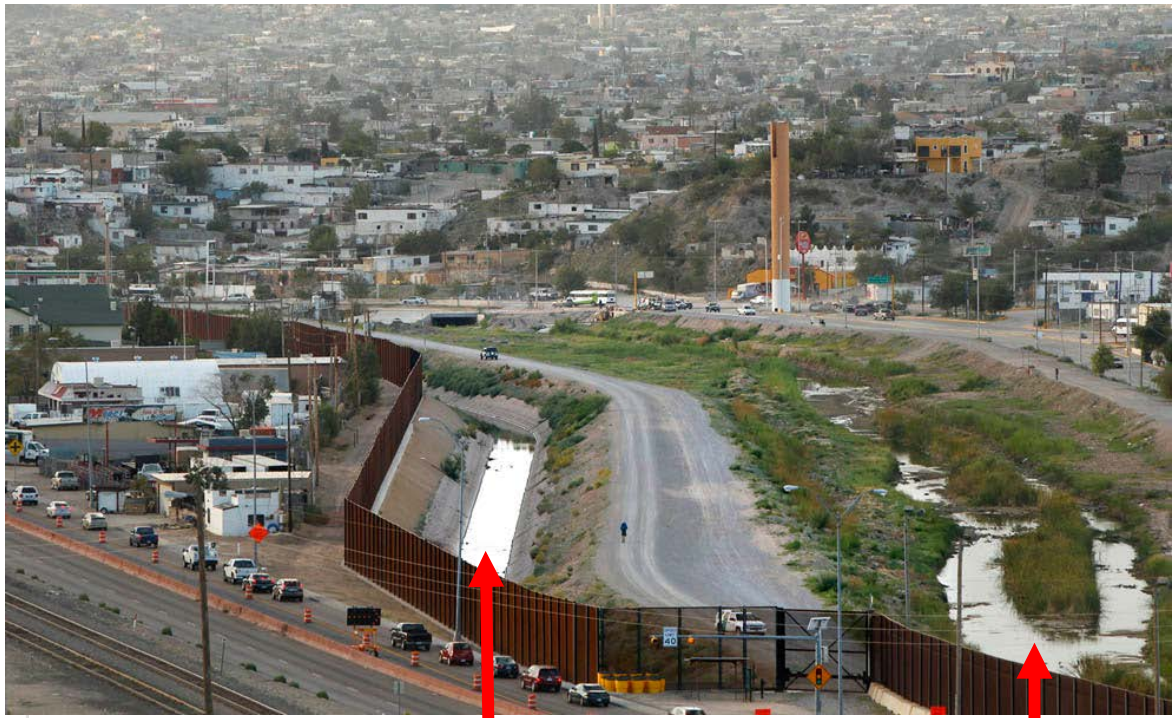
Plant, Wildlife & Fish species ↓

(e.g., ESA RGSM recruitment success and survival ↓)

Other 'non-flow' related issues that matter (to ecosystem health):
Increased nutrient loading, non-native fishes

Northern branch in southern New Mexico and El Paso/Juarez Valley

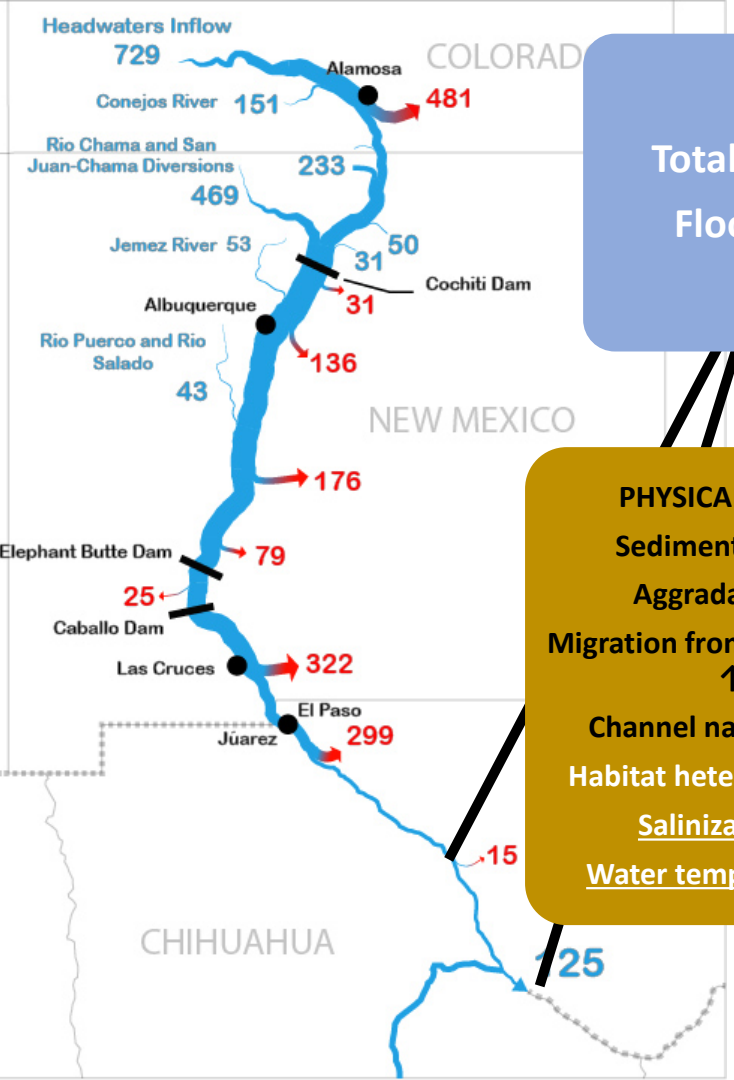




American canal where nearly all the Rio Grande flows are diverted

Where the river would be naturally

Forgotten Reach



CAUSE

Total annual volume ↓ (largely dewatered)

Flood magnitude, frequency, duration ↓

~~Annual spring flood~~

PHYSICAL EFFECT

Sediment Load ↑

Aggradation ↑

Migration from tributaries ? ↑

Channel narrowing ↑

Habitat heterogeneity ↓

Salinization ↑

Water temperature ↑

BIOLOGICAL EFFECT

Native vegetation ↓

Non-native vegetation ↑

Eutrophication? ↑

Wildlife species ↓

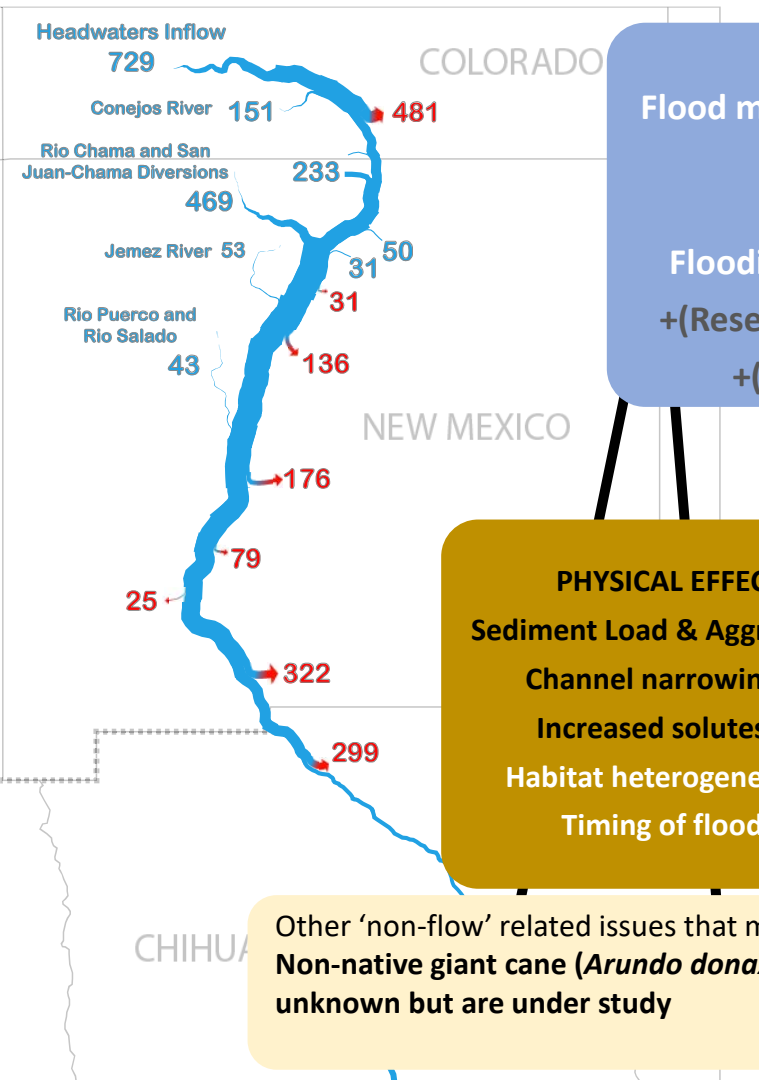
Aquatic species diversity ↓

Tolerant species ↑

Saline-tolerant Red Shiner – *Cyprinella lutrensis*

Other 'non-flow' related issues that matter (to ecosystem health):
E.g., Non-native Asian mussels alter water quality (e.g., XX??)

Big Bend Region of Rio Grande



CAUSE

Flood magnitudes, duration, frequency ↓
"Flood" timing altered

Periods of low flow ↑

Flooding and floodplain inundation ↓

+(Reset floods – occasionally rewidens)

+(Spring-fed portions of river)

PHYSICAL EFFECT

Sediment Load & Aggradation

Channel narrowing ↑

Increased solutes ↑

Habitat heterogeneity ↓

Timing of flood?

BIOLOGICAL EFFECT

Native vegetation ↓

Non-native vegetation ↑

Wildlife species ↓

Aquatic species diversity ↓

ESA RGSM recruitment success ↓

Other 'non-flow' related issues that matter (to ecosystem health):
Non-native giant cane (*Arundo donax*) effects on ecosystem function remain largely unknown but are under study

Ecological Context: Flow is the master variable

- Ecosystem Health and Fish Persistence (for example) requires
  - Adequate base flow
    - No drying
    - Local connectivity
    - Ground water elevation
  - Spring pulse floods
    - Magnitude
    - Duration
    - Floodplain inundation
  - Reset floods of large magnitude and duration
    - Flush sediment
    - Reorganize channel
      - Widen, more complex
  - **Create and maintain habitat and water quality required for healthy biota**

Novel Ecosystem ?

https://therivardreport.com/wp-content/uploads/2014/09/20140830_trcwalk_1066.jpg

> 75 species at risk

Thank you! Acknowledgements

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- The Ecology Center at Utah State University (In kind)
- Big Bend National Park
- Jeff Bennett
- Colleen Caldwell, US Geological Survey – New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University
- Rich Valdez - SWCA


Questions?
¿Pregunatas?
2017 Rio Grande / Río Bravo Binational Forum | Foro Binacional

- What stood out to you from these five presentations?

- ¿Qué se destacó de estas cinco presentaciones?

Discussion Topics / Discusiones informales:

- Challenges you face
- Ways people overcome these challenges
- Favorite pastimes

- Desafíos que enfrenta
- Maneras en que la gente supera estos desafíos
- Pasatiempos favoritos