# Economics of Water

## *2014 Texas Water Summit:*

***Securing Our Economic Future – Austin, May 19, 2014***

***Academy of Medicine, Engineering and Science of Texas***

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Michelsen – Rio Grande

TEXAS A&M AGRILIFE RESEARCH

# Economics Is

- Not synonymous with money or gold.
- Not the stock market.
- Not accounting.
- Not just about business profits or markets.
- Water resource economics is the intersection of physical, cultural and social conditions, scientific information, policy, law and institutions.

# Economics is used to:

- Forecast water demand and user responses to changes in price and other factors.
- Estimate resource values where markets do not exist.
- Analyze economic impacts of alternative laws, policies and institutions.
- Estimate benefits/damages of water quality.
- Estimate benefits & costs of water projects such as storage reservoirs, new treatment methods, importation and efficiency improvements.

# Economics is used to:

- Evaluate the damages of drought and benefits of water supply reliability.
- Estimate the economic affects of climate change.
- Understand price/subsidy effects as well as behavioral responses to water management incentive systems.
- Conduct economic risk assessments.
- Understand and quantify distribution (allocation) and equity impacts.

# Why Water Resource Economics?

Important to recognize we don’t manage water for water’s sake, we allocate and manage water for the services (values) it provides.

- Water is essential for life.
- Water for production of goods (for profit).
- Water is required for food and fiber.
- Water contributes to the quality of life.
- Water provides ecosystem services.

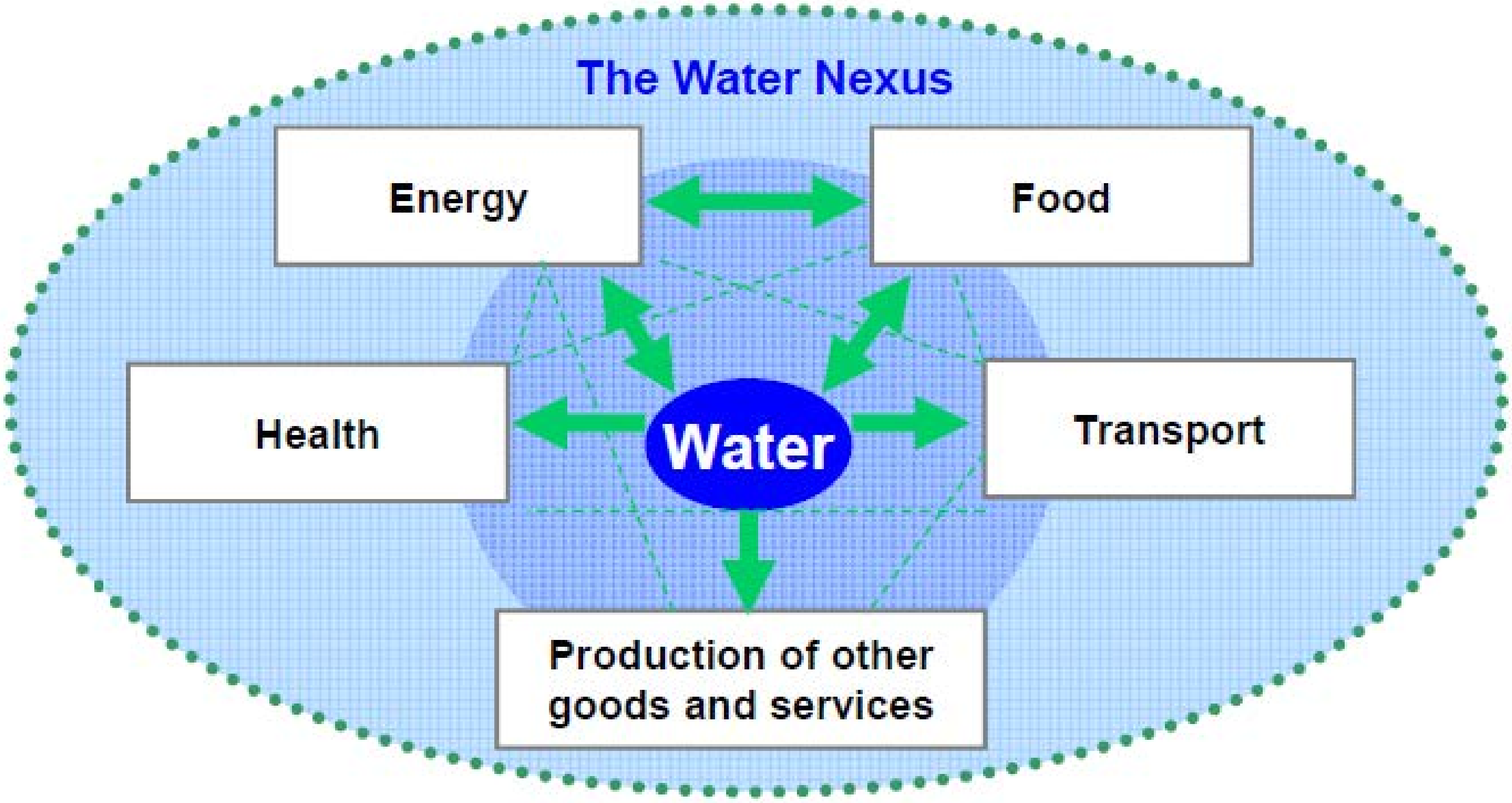
- Economics applied to understand these values

# Water as an Economic Good

…Past failure to recognize the economic value of water has led to wasteful and environmentally damaging uses of the resource. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources. (*Principle 4, The Dublin Statement on Water and Sustainable Development, UN Conference, 1992)*

**Water has an economic value in all its competing uses and should be recognized as an economic good**. *Source: R.A. Young, 1995.*

# Water & Economic Interdependencies




Source: Facing the Future, IBM, 2012

# Popular Solution

- Simply need to price water at what it's worth.
  - Worth to whom?  Used in what purpose?
  - Water's value during flood or drought conditions?
  - Who sets the price?
- Markets will solve these issues, won't they?
  - In many/most cases markets, if left to themselves, will not allocate or price water efficiently.
  - Because of the characteristics of water, markets for water resources and related services often do not reflect the full value of water resources or are absent.

# Important to Recognize Water Price < Value

- Economic incentives (missing)
- Market failures (few buyers/sellers)
- Laws, regulations, policies
- Water right ownership issues
- Water has public good characteristics

    e.g. non-market, ecosystem services

# Issues are State, Regional, Local, National and Global

# Virtual Water Balance by Country and Direction of Gross Flows

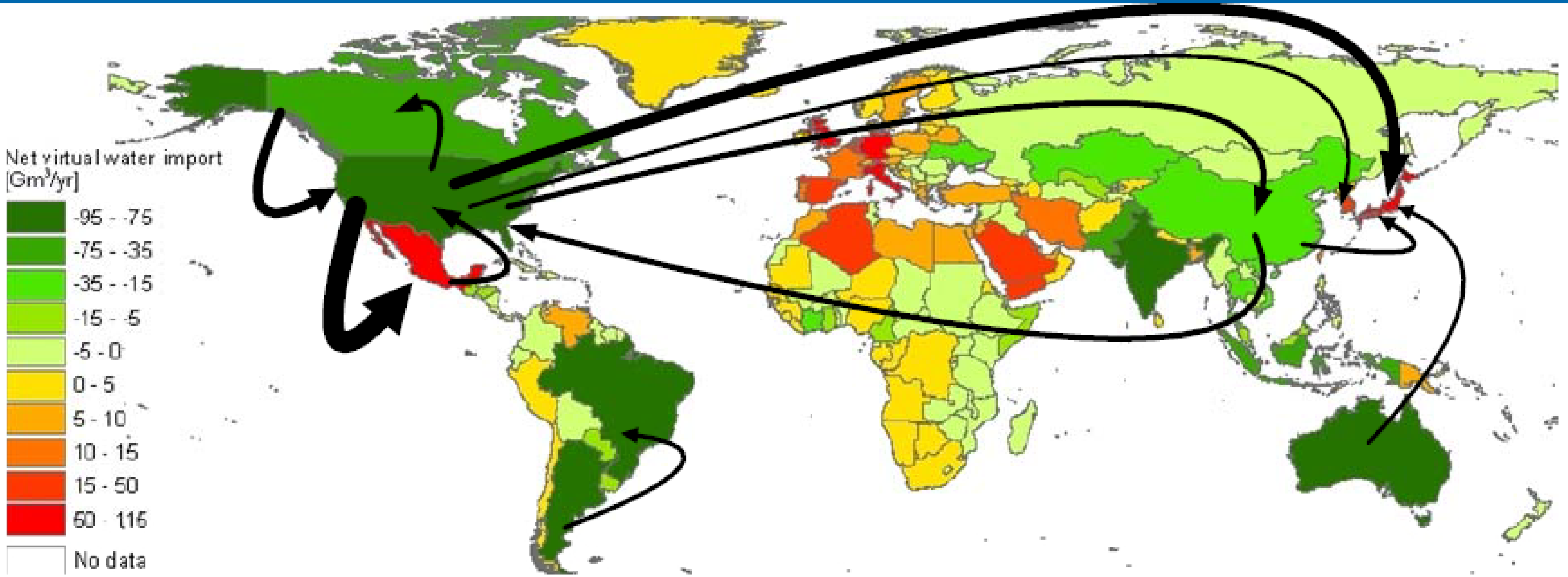



*Figure 4. Virtual water balance per country and direction of gross virtual water flows related to trade in agricultural and industrial products over the period 1996-2005. Only the biggest gross flows (> 15 $Gm^3$/yr) are shown; the fatter the arrow, the bigger the virtual water flow.*

Source: National Water Footprint Accounts: Volume 1, M.M. Mekonnen and A.Y. Hoekstra, May, 2011. Research Report No. 50, UNESCO-IHE.

# Vulnerabilities of Water Resources

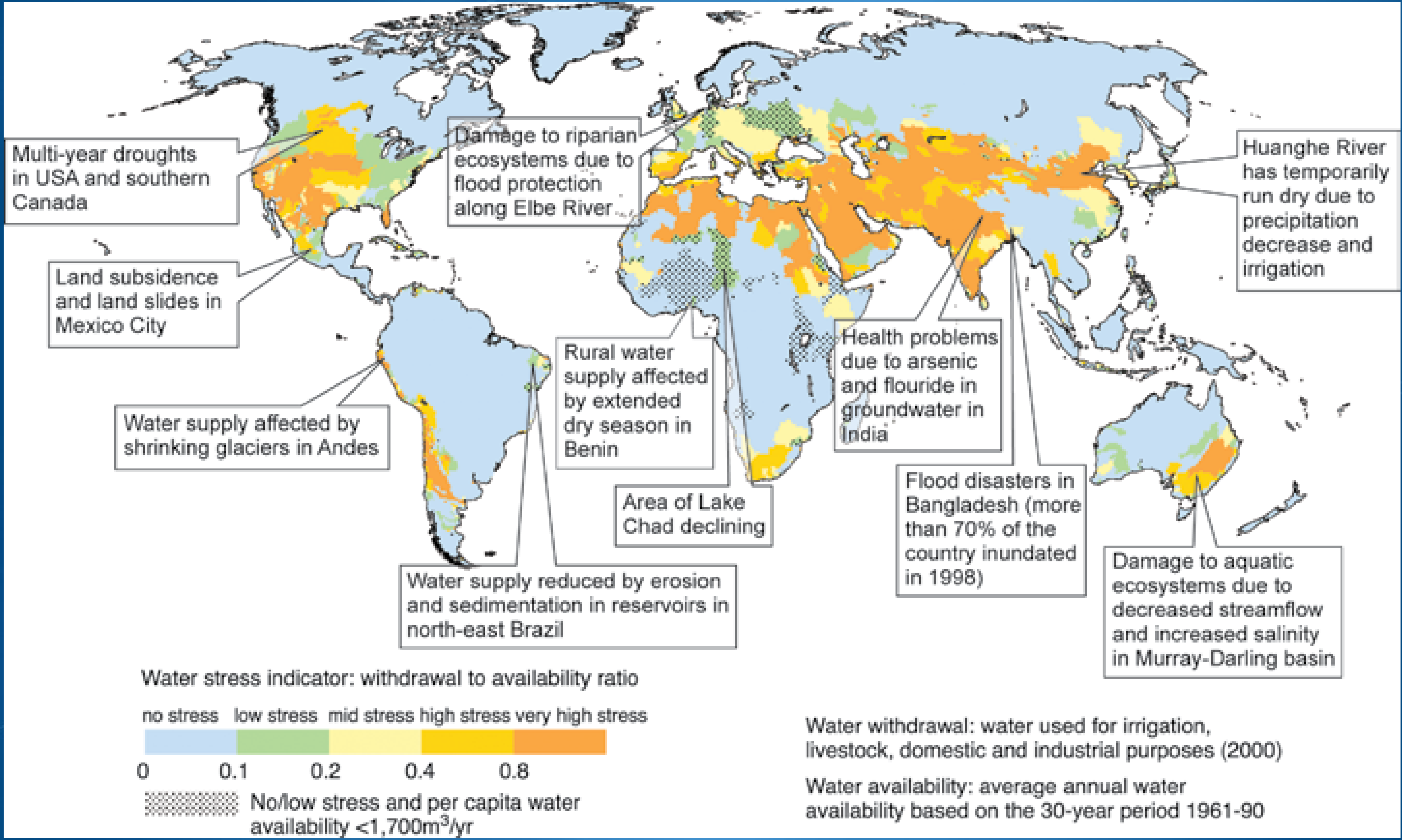
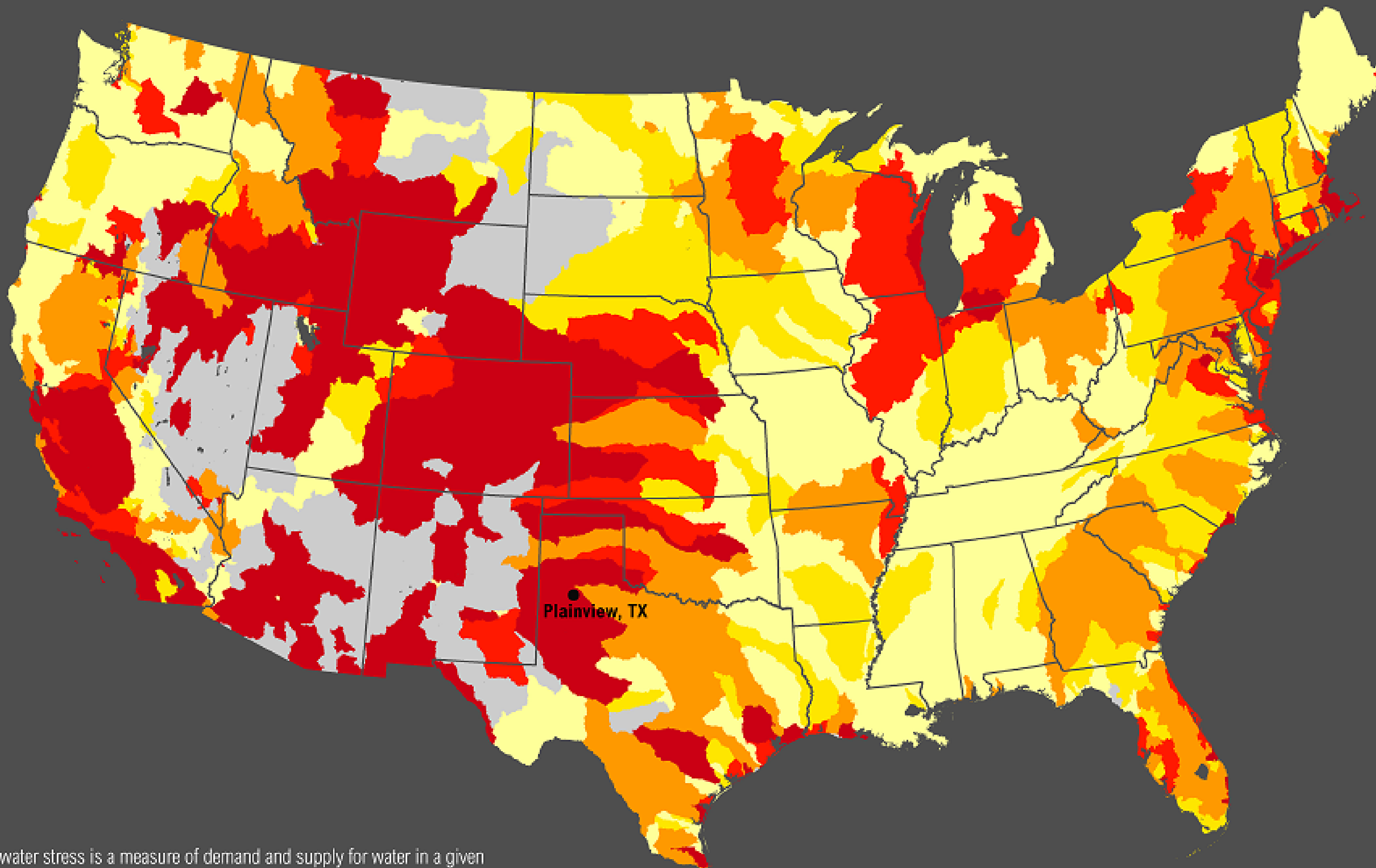



***Figure 1.1:** Examples of current vulnerabilities of freshwater resources and their management; in the background, a water stress map based on WaterGAP (Alcamo et al., 2003a). See text for relation to climate change. [WGII Figure 3.2]*


Reference: Alcamo, J., P. Döll, T. Henrichs, F. Kaspar, B. Lehner, T. Rösch and S. Siebert, 2003a: Development and testing of the WaterGAP 2 global model of water use and availability. *Hydrol. Sci. J.*, ***48, 317–338.***

# **WATER STRESS** IN THE UNITED STATES

AQUEDUCT




**NOTE**

1. Baseline water stress is a measure of demand and supply for water in a given area, and is calculated as the ratio of local water withdrawal over renewable water supply.

**REFERENCES**

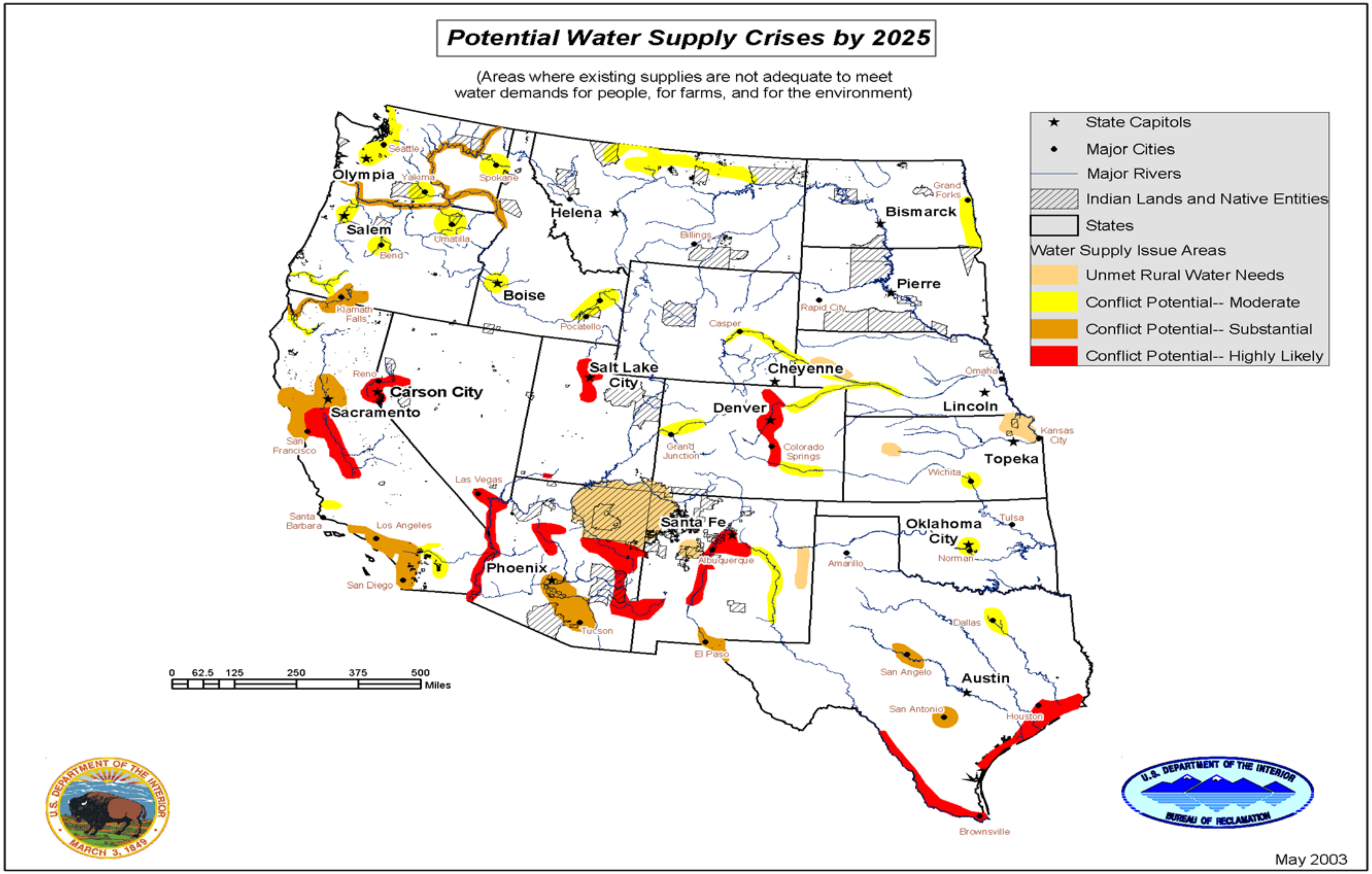
*Aqueduct methodology:* *aqueduct.wri.org*

Water woes are magnified when drought strikes places like Plainview, Texas, where baseline water stress is **extremely high**.

WORLD RESOURCES INSTITUTE

| Arid & low water use | Low | Low to medium | Medium to high | High | Extremely high |
|---|---|---|---|---|---|
| (Ratio: withdrawals/supply) | < 10% | 10% - 20% | 20% - 40% | 40% - 80% | > 80% |

# USBR - Reality Number 2: Existing Water Supplies are Inadequate

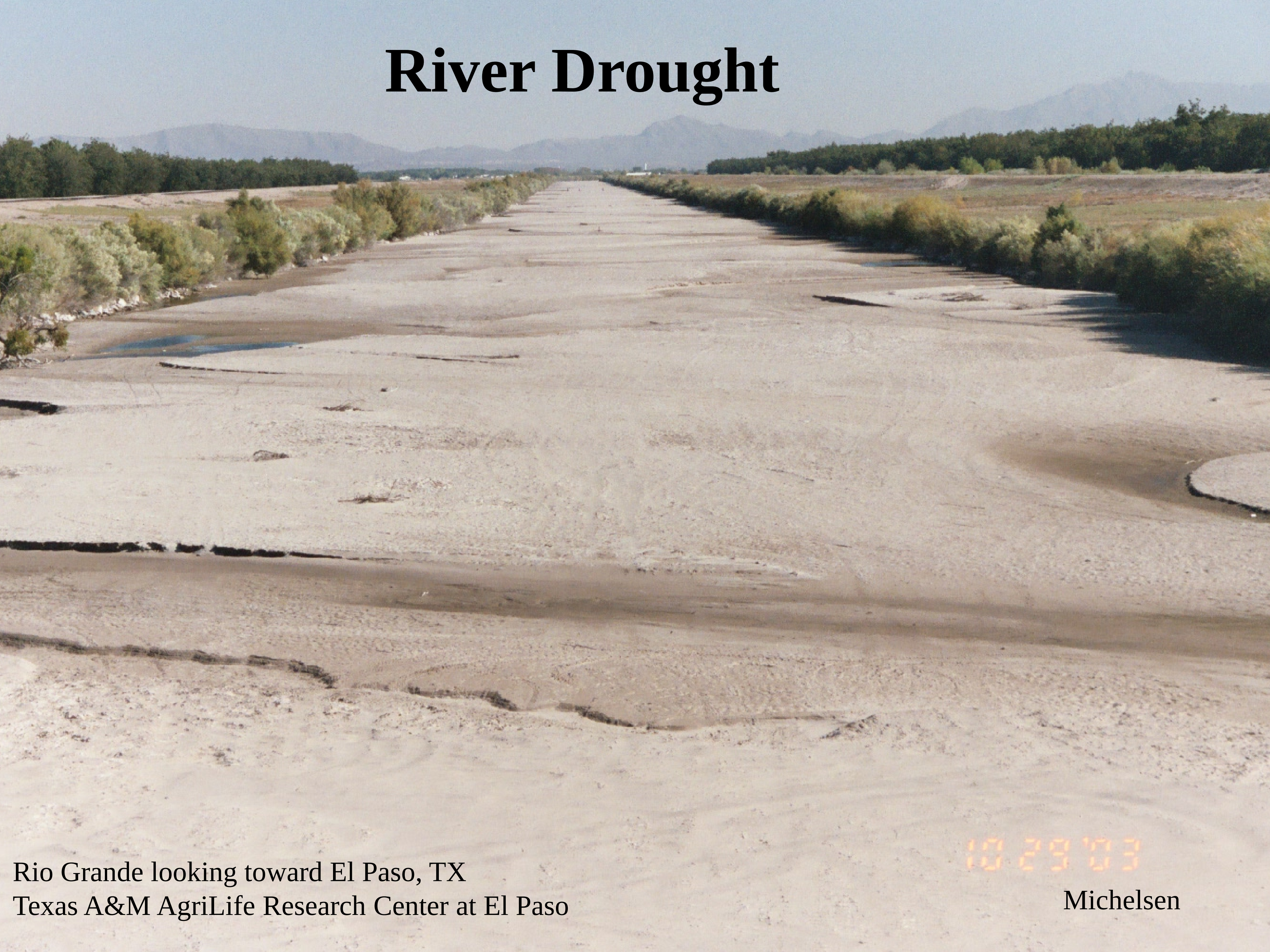


## Lake Meredith: Texas High Plains
## 0% full
**Once served as an important water resource for Amarillo and Lubbock, TX**


From Travis Miller


Elephant Butte Reservoir
below 20% storage capacity- Michelsen

# River Drought




Rio Grande looking toward El Paso, TX
Texas A&M AgriLife Research Center at El Paso

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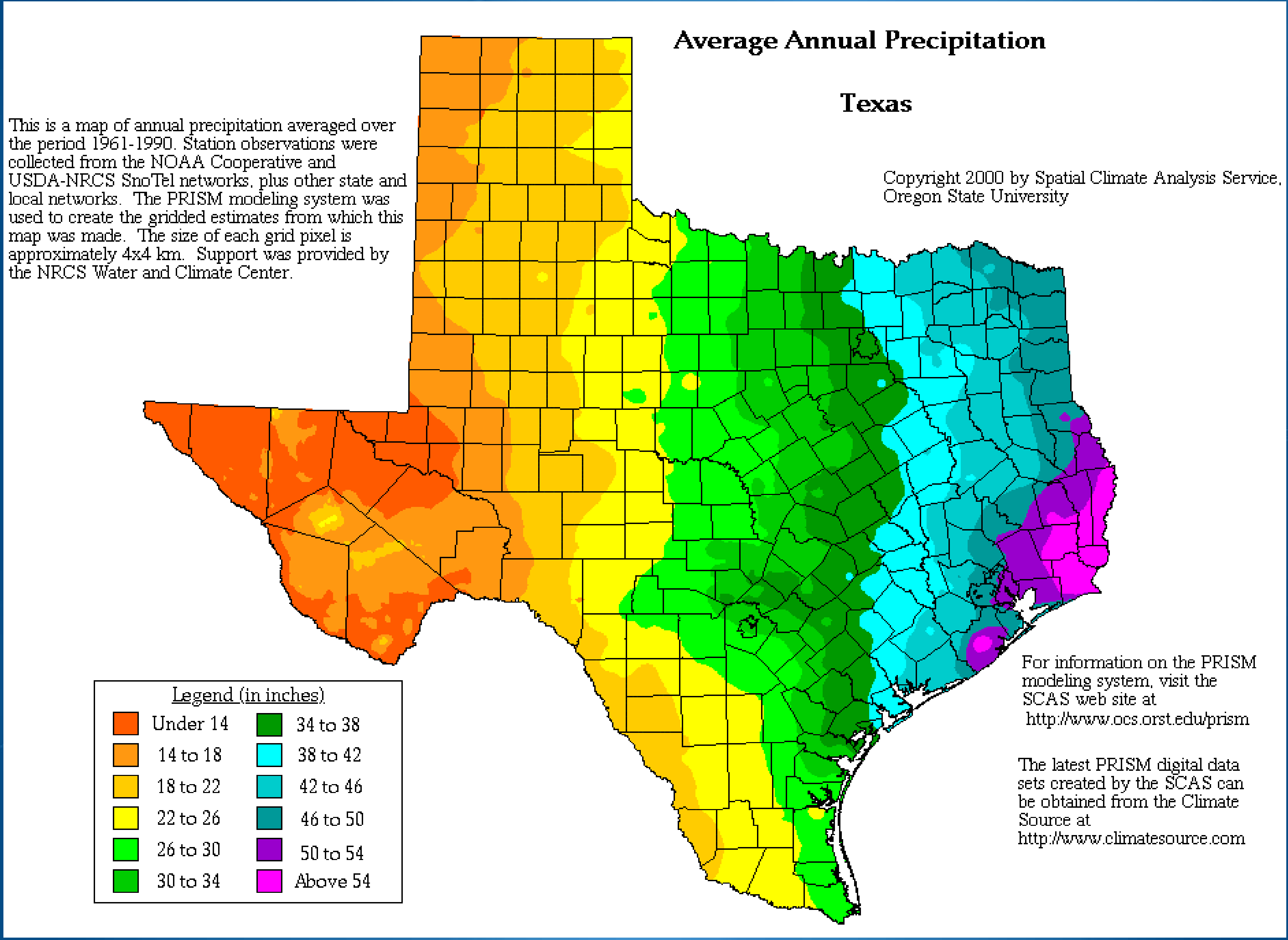
# Scenes from recent Texas droughts

From Travis Miller


Average Annual Precipitation
Texas
This is a map of annual precipitation averaged over the period 1961-1990. Station observations were collected from the NOAA Cooperative and USDA-NRCS SnoTel networks, plus other state and local networks. The PRISM modeling system was used to create the gridded estimates from which this map was made. The size of each grid pixel is approximately 4x4 km. Support was provided by the NRCS Water and Climate Center.
Copyright 2000 by Spatial Climate Analysis Service, Oregon State University
Legend (in inches)
Under 14
14 to 18
18 to 22
22 to 26
26 to 30
30 to 34
34 to 38
38 to 42
42 to 46
46 to 50
50 to 54
Above 54
For information on the PRISM modeling system, visit the SCAS web site at http://www.ocs.orst.edu/prism
The latest PRISM digital data sets created by the SCAS can be obtained from the Climate Source at http://www.climatesource.com

# Agricultural Water Savings and Costs Drought & Full Supply Conditions

| BMP Strategy | Water Savings (af) | | Annual Cost ($) | | Unit Cost ($/af) | |
|---|---|---|---|---|---|---|
| | Drought | Full | Drought | Full | Drought | Full |
| Scheduling | 1,740 | 5,070 | 96,000 | 122,400 | **55.17** | **24.14** |
| Pipelines for District Canals* | 25,000 | 50,000 | 8,487,434 | 8,487,434 | **339** | **170** |
| Tailwater Reuse | 1,723 | 6,274 | 910,800 | 1,161,270 | **529** | **185** |

*Present value of annual cost including capital cost and annual operating and maintenance (discount rate of 5.5% over 30 year life expectancy), using 206 miles of canals.

| BMP Strategy | Water Savings (af) | | Annual Cost ($) | | Unit Cost ($/af) | |
|---|---|---|---|---|---|---|
| | Drought | Full | Drought | Full | Drought | Full |
| Scheduling | | | | | | |
| Pivot/sprinkler | 2,357 | 7,453 | 202,920 | 202,920 | **83** | **27** |
| Surface irrigation | 1,178 | 3,726 | 67,650 | 37,650 | **57** | **18** |
| Tailwater Reuse | | | | | | |
| Surface irrigation | 589 | 1,863 | 194,063 | 194,063 | **329** | **104** |

Source: Michelsen et al. Evaluation of Irrigation Efficiency Strategies for Far West Texas: Feasibility, Water Savings and Cost Considerations, 2009. Texas Water Resources Institute, Texas A&M AgriLife Research for TWDB.

# Estimated Water Use Values – **Marginal Values**, $/acre foot

*Table 5.3* *Marginal water values from crop-water production functions, 1980 (dollars per acre foot)*

| Crop | Value | | | | | |
|---|---|---|---|---|---|---|
| | Idaho | Washington | California | Arizona | New Mexico | Texas |
| Grain sorghum | | | | <15 | | 113 |
| Wheat | | $59 | | 22 | | 35 |
| Alfalfa | | | | 25 | 25 | |
| Cotton | | | 71–129 | 56 | 61 | |
| Corn | | | | | 52 | 57 |
| Sugarbeets | | 144 | | | | |
| Potatoes | | | | | | |
| Tomatoes | 698 | 282 | 390 | | | |

*Source:* Gibbons (1986, chapter 2, table 2.2), based on various studies done by Harry Ayer, Paul Hoyt, Jane Prentzel, Sharon Kelly, David Miller, Mark Lynham, and T.S. Longley.

Source: Shaw, W. Douglass. Water Resource Economics and Policy: an Introduction. 2005.

# Economic Impact of MX Treaty Non-delivery

**Table 4. Incremental Farm Gate Marginal Valuation of Strict Treaty Compliance (End-of-Cycle Debt Repayment in Acre-Feet)**

| | Quantity Demanded | | Marginal | Incremental |
|---|---|---|---|---|
| Year | Reservoir [a] | Farm Gate | Value | Value, Farm Gate |
| 1998 | 100,000 | 46,165 | $50.60 | $ 2,335,929 |
| | 200,000 | 92,329 | $48.50 | $ 2,238,983 |
| | 300,000 | 138,494 | $30.60 | $ 1,412,637 |
| | 400,000 | 184,658 | $22.40 | $ 1,034,087 |
| | 500,000 | 230,823 | $7.70 | $ 355,467 |
| | 550,000 | 253,905 | $0.02 | $ 392 |
| | | | TOTAL | $ 7,377,495 |
| 1999 | 100,000 | 26,938 | $62.70 | $ 1,688,995 |
| | 200,000 | 53,875 | $57.60 | $ 1,551,612 |
| | 300,000 | 80,813 | $50.60 | $ 1,363,048 |
| | 400,000 | 107,751 | $50.60 | $ 1,363,048 |
| | 473,849 | 127,644 | $48.20 | $ 958,854 |
| | | | TOTAL | $ 6,925,558 |
| 2003 | 100,000 | 31,822 | $49.00 | $ 1,559,288 |
| | 200,000 | 63,644 | $31.50 | $ 1,002,399 |
| | 280,000 | 89,102 | $1.60 | $ 40,732 |
| | | | TOTAL: | $ 2,602,420 |
| 2004 | 25000 | 6,966 | $6.60 | $ 45,976 |
| | 50,000 [c] | 13,932 | $2.70 | $ 18,808 |
| | | | TOTAL: | $ 64,784 |

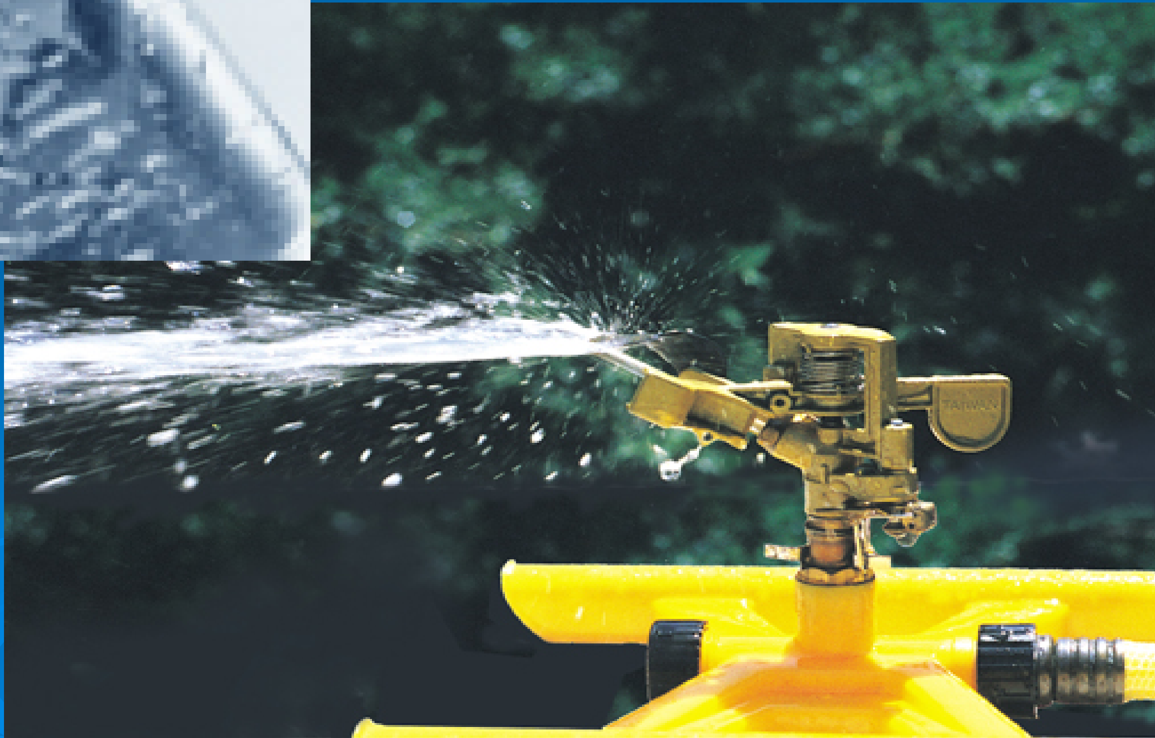
Robinson, Michelsen and Gollehon. Mitigating Water Shortages in a Multiple Risk Environment. 2009.

# Droughts over the last fifteen years have cost Texas agriculture $20.7 billion

**Direct farm gate drought loss estimated by year**

Dean McCorkle, Dept.
Agricultural Economics, TAMU

* * 2011 – $7.62 billion
* * 2009 – $3.6 billion
* * 2008 – $1.4 billion
* * 2006 – $4.1 billion
* * 2002 – $0.31 billion
* * 2000 – $1.1 billion
* * 1999 – $0.22 billion
* * 1998 – $2.4 billion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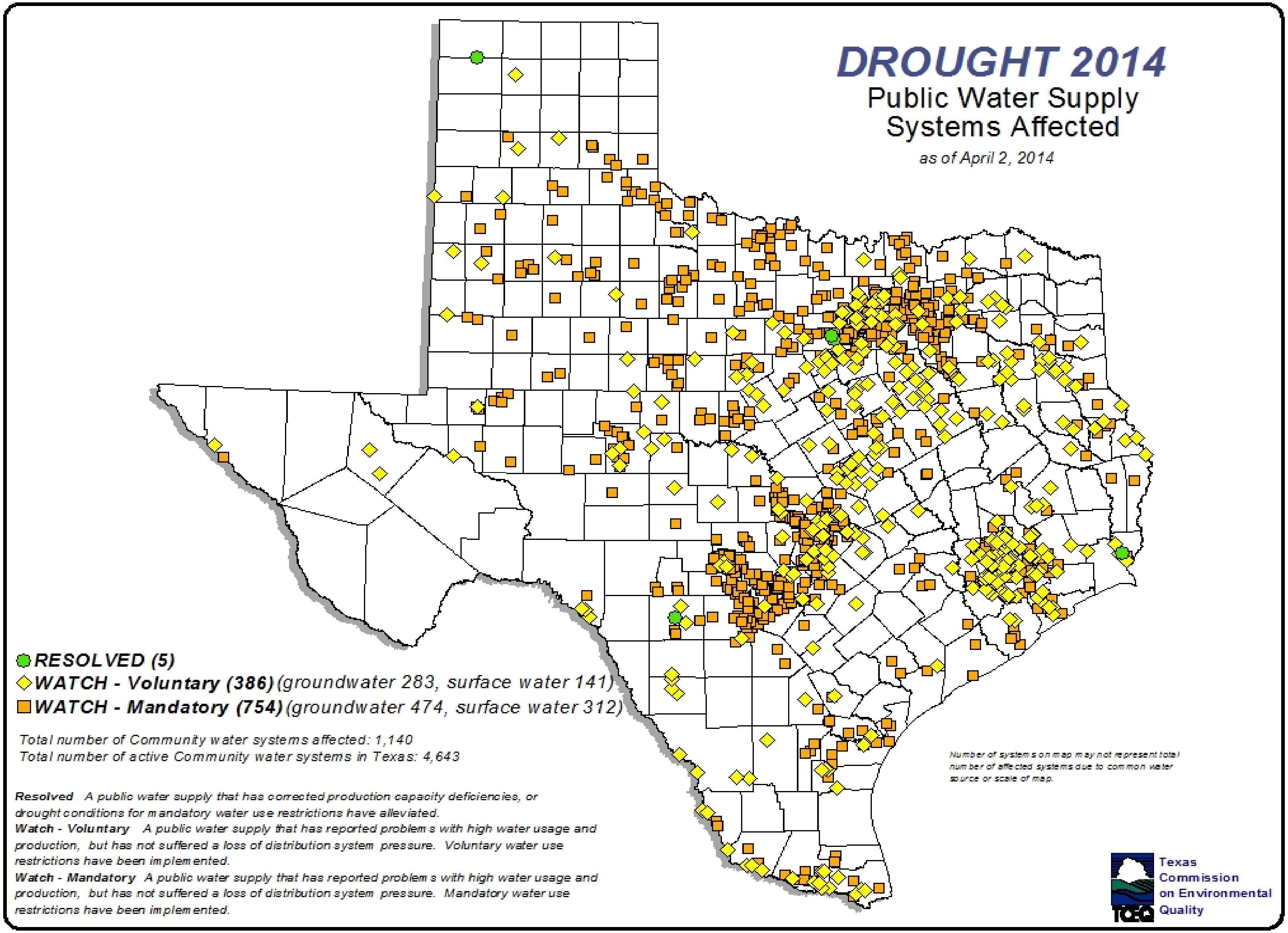
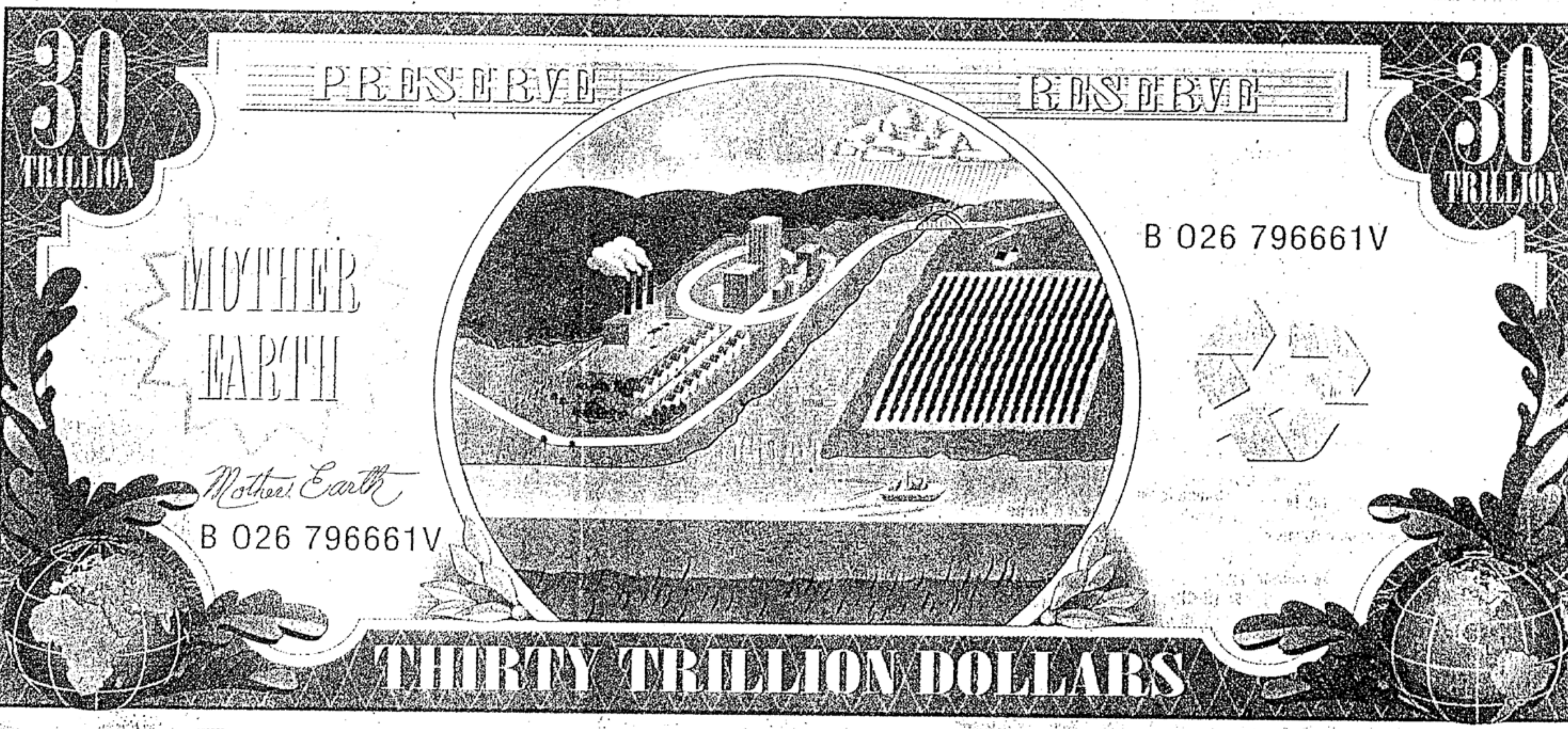
## On April 2, 2014 there were 1,140 of 4,642 public water systems on drought warning or watch or 24.6% of all public water systems on drought contingency plans




From Travis Miller

# Putting a Price on
# Mother Nature




DAN AGUAYO/The Oregonian

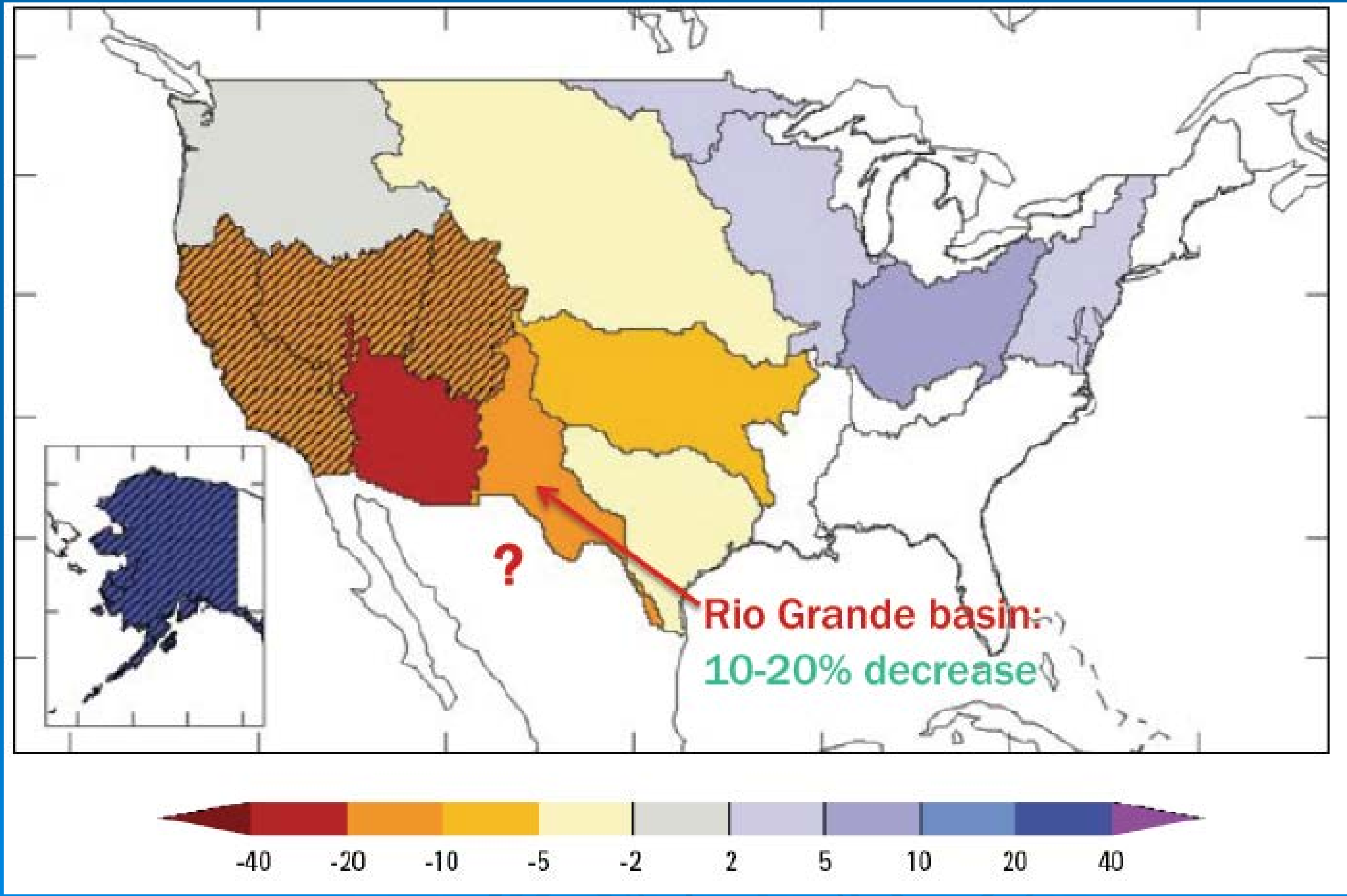
*The Earth's free services are worth trillions of dollars, but environmental scientists warn that humans are depleting and undermining those resources at an alarming rate — and losing them will be costly*

Michelsen, North Park, CO

Michelsen

# Projected Streamflow Changes

mid-21st Century projection, relative to 20th Century baseline




Source: Milly et al. 2005 from D. Gutzler, Binational Border Water Summit, Sept. 2012


Texas A&M AgriLife Research Center at El Paso

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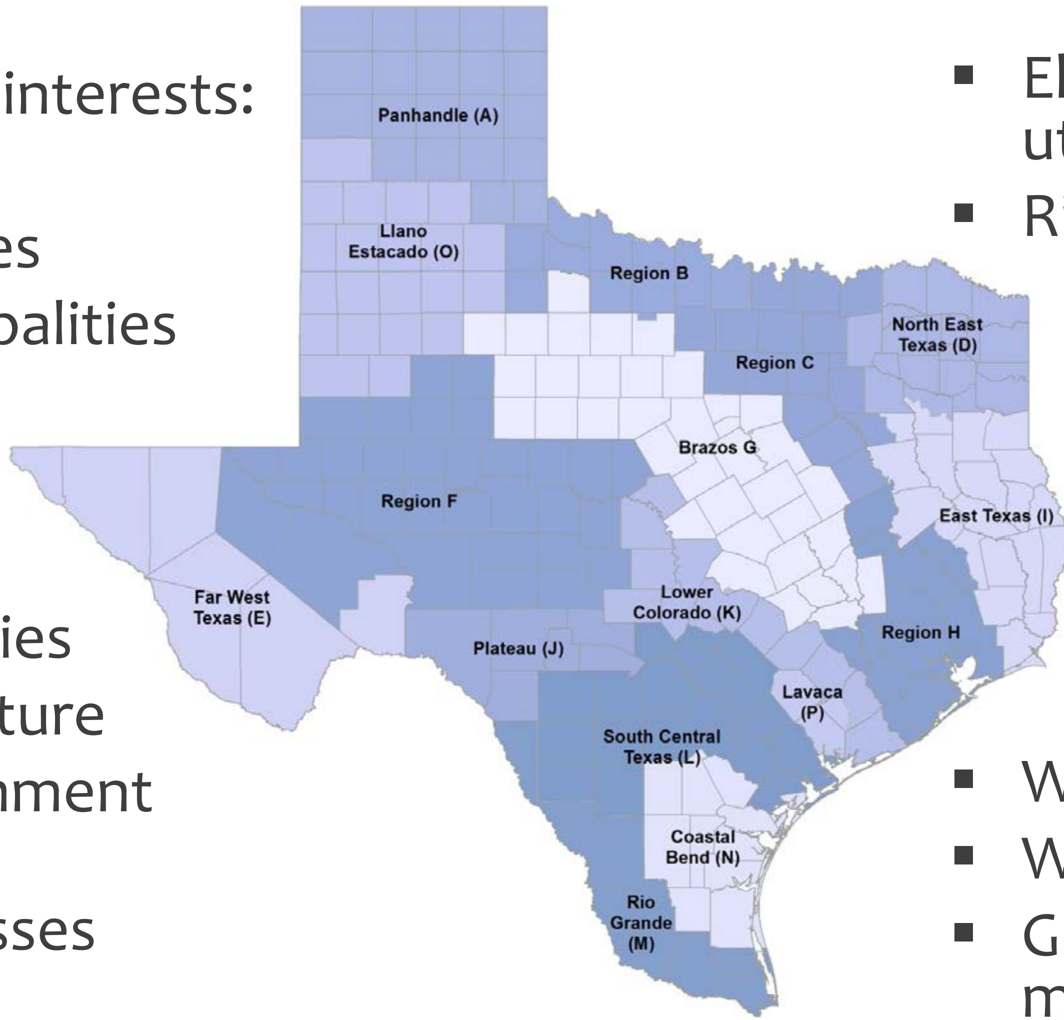
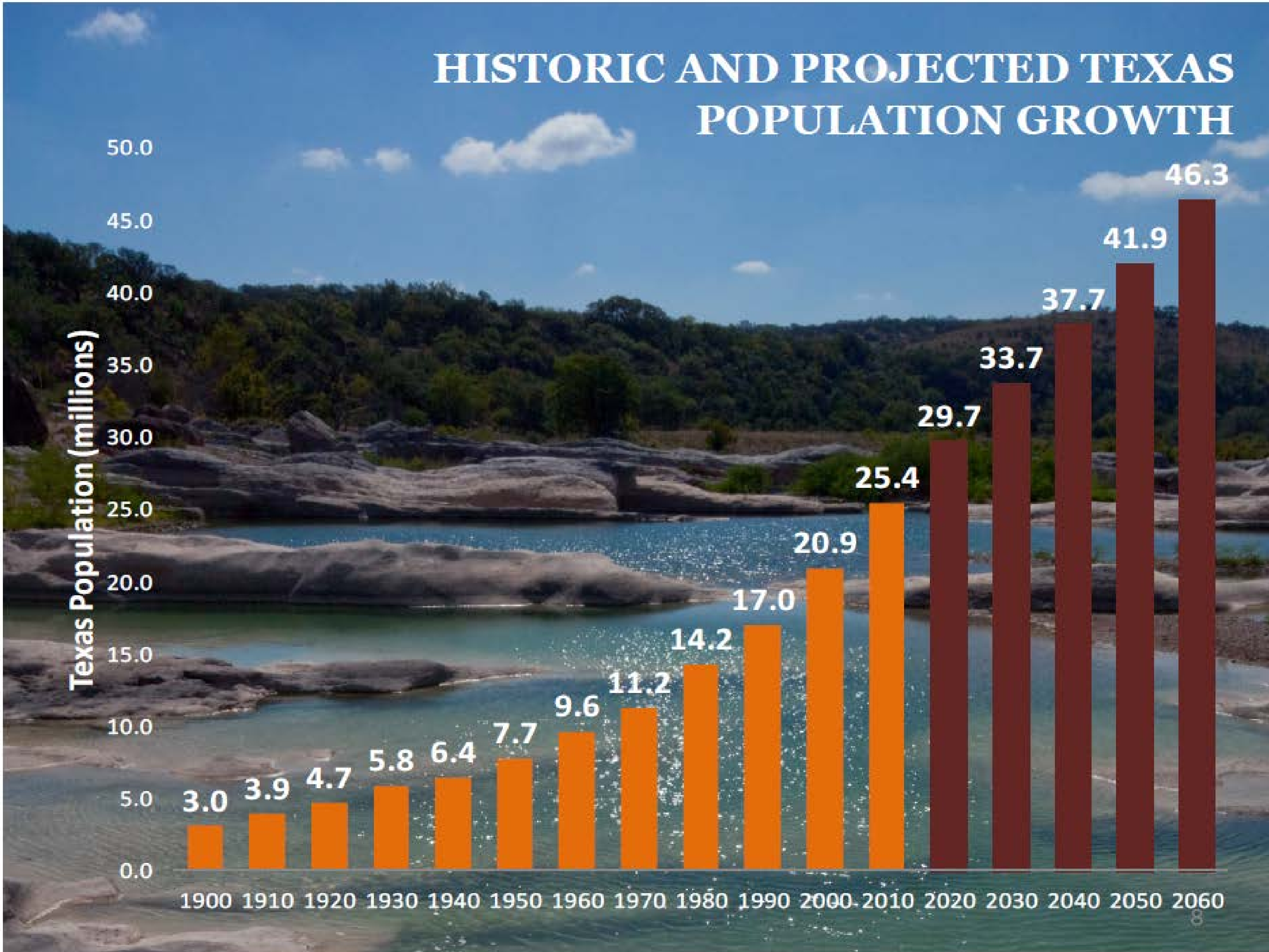
# Regional Water Planning

Statutory interests:

- Public
- Counties
- Municipalities
- Industries
- Agriculture
- Environment
- Small businesses

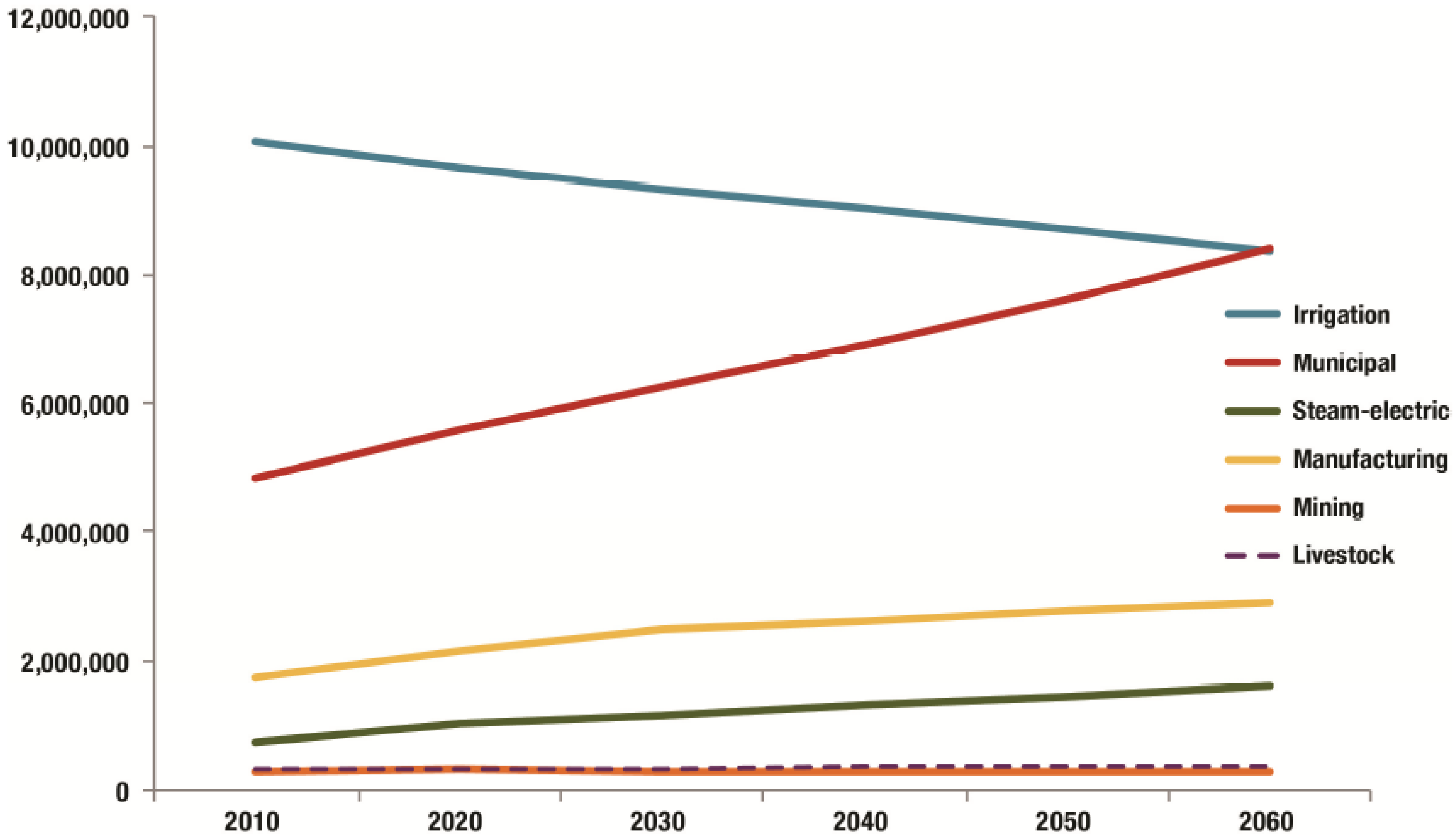



- Electric-generating utilities
- River authorities
- Water districts
- Water utilities
- Groundwater management areas



HISTORIC AND PROJECTED TEXAS POPULATION GROWTH
Texas Population (millions)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
3.0
3.9
4.7
5.8
6.4
7.7
9.6
11.2
14.2
17.0
20.9
25.4
29.7
33.7
37.7
41.9
46.3
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050 2060

# TX STATE WATER PLAN -- WATER DEMAND PROJECTIONS



# Evolution of water withdrawals in the US, 1950-2005

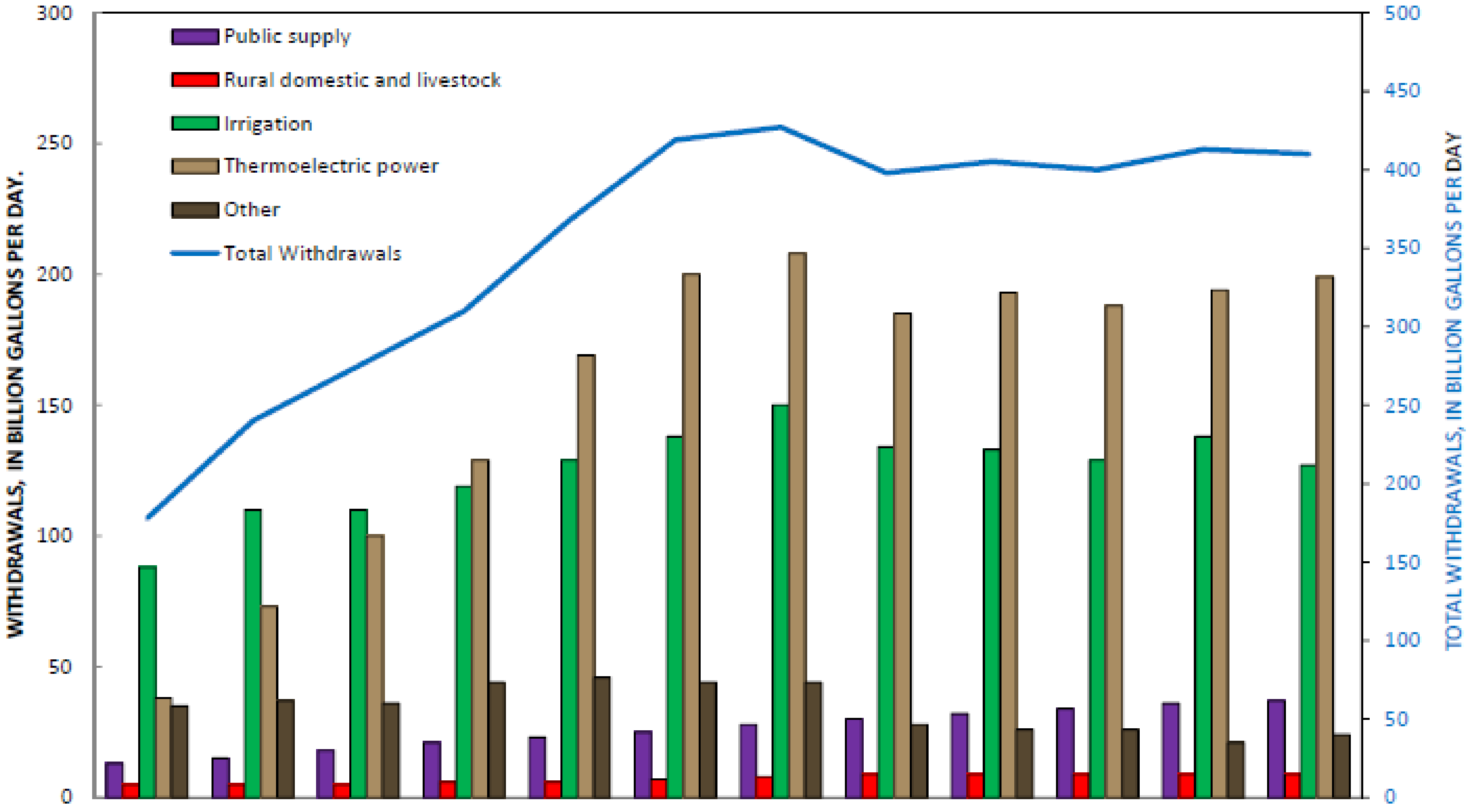
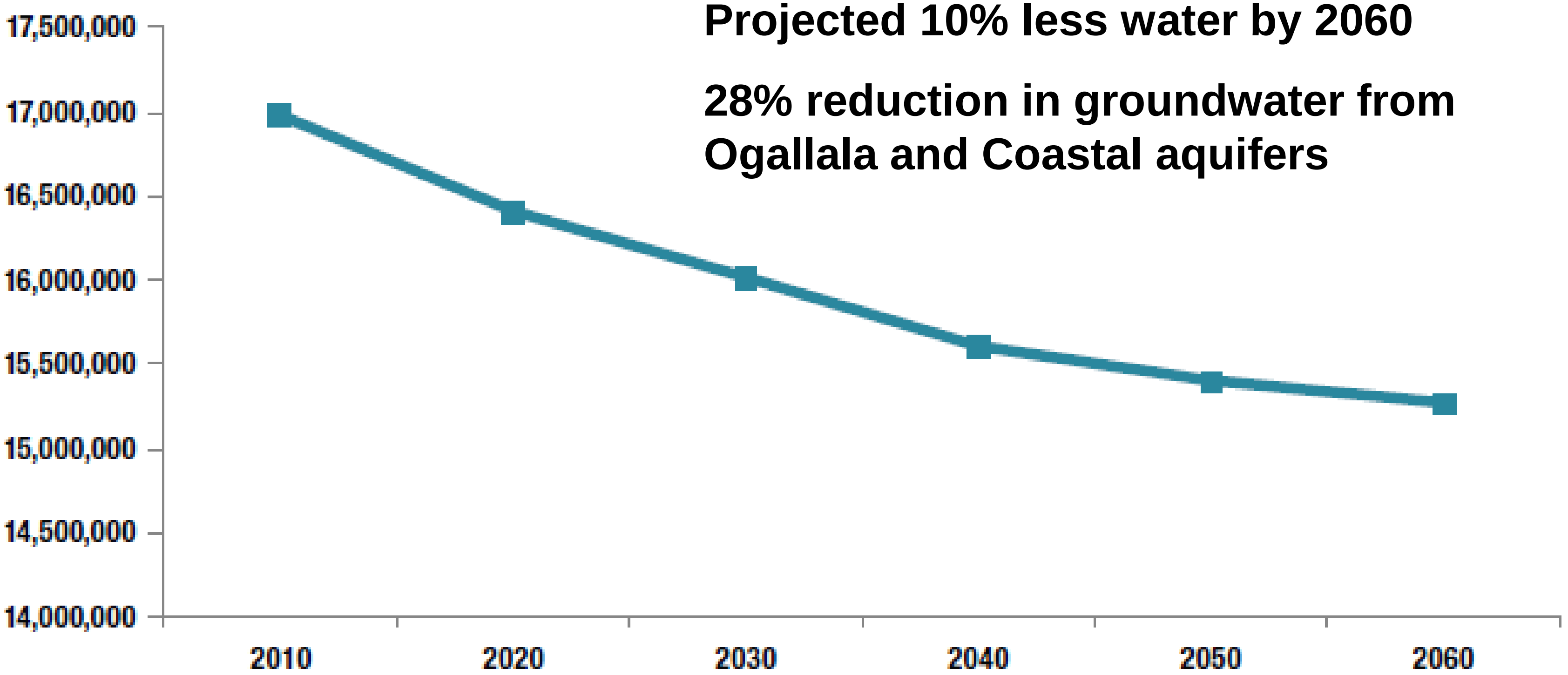



Figure 14. Trends in total water withdrawals by water-use category, 1950-2005.

# Projected Existing Water Supplies
(acre-feet per year)

**Projected 10% less water by 2060**

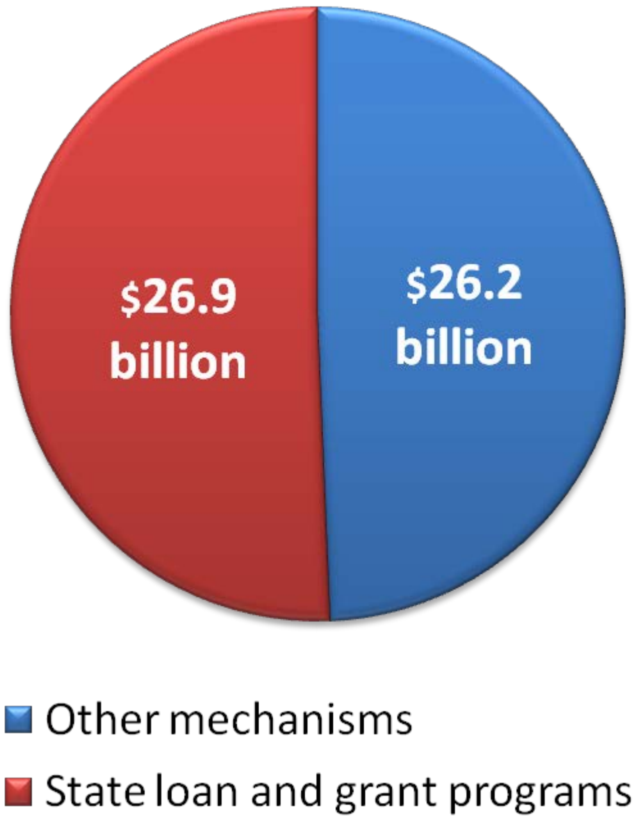
**28% reduction in groundwater from Ogallala and Coastal aquifers**



# 2012 State Water Plan Costs of the 562 Recommended Strategies Needed by 2060

- $53.1 billion to implement
- Project sponsors need access to $26.9 billion of project capital costs through state assistance
- This does not include operating costs of these drought strategies

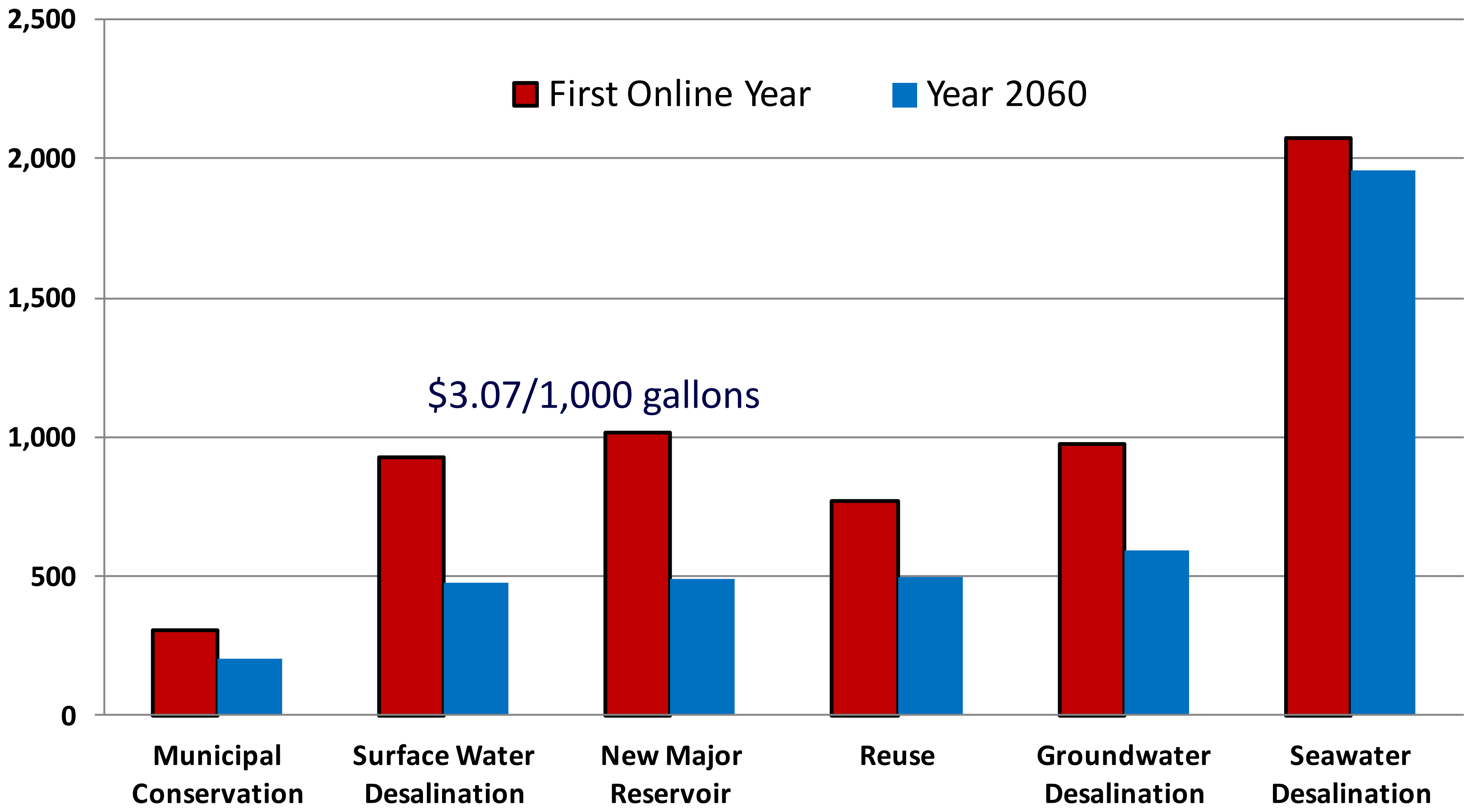
## Financing State Water Plan Projects



# Economic Issues

- Do the economic benefits of each of the SWP strategies to provide full supplies during drought of record conditions exceed the costs?
- How do they compare in cost?
- These supplies may be surplus in other years.
- Can the State afford and is it willing to provide $26.9 billion or about half of total capital cost?
- How will municipalities/communities raise the other $26.2 billion?
- Increases in taxes and/or water rates?

# Annual Average Unit Costs of Water Management Strategy Categories, 2012 State Water Plan (dollars per acre-foot)



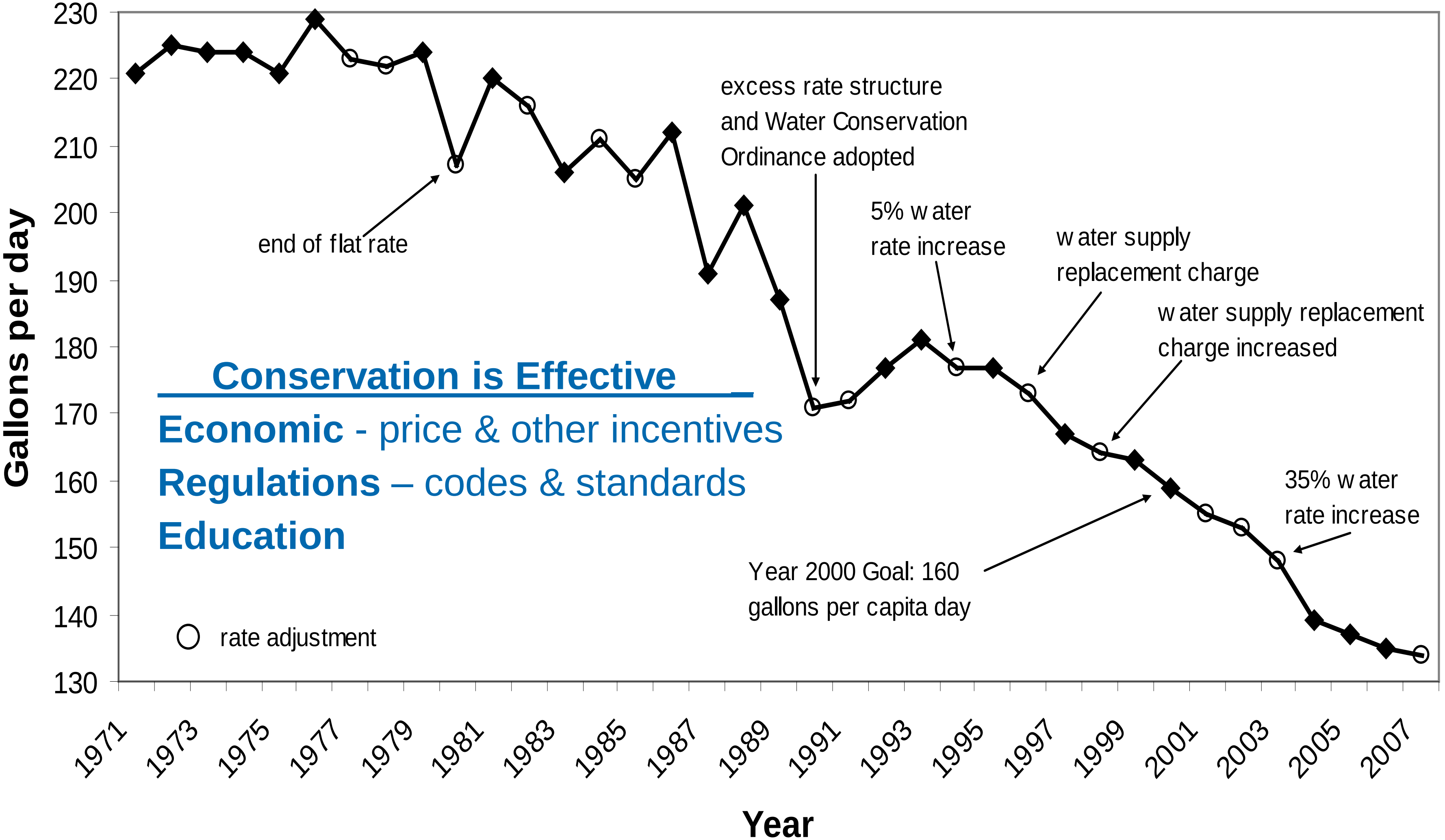

**Unit costs are higher in early years and fall significantly once debt on construction costs are paid .**
**TWDB 2012**

# How Much Water Does Each Person Use?

(gallons/person/day, all uses)

| | | |
|---|---|---|
| **Dallas:** | **238** | |
| **Albuquerque:** | **193** | (250 in 1995) |
| **Las Cruces:** | **194** | |
| **El Paso:** | **134** | |
| **Juarez:** | **104** | |
| **National average** | **160** | |

# Per Capita Consumption All EPWU Customers

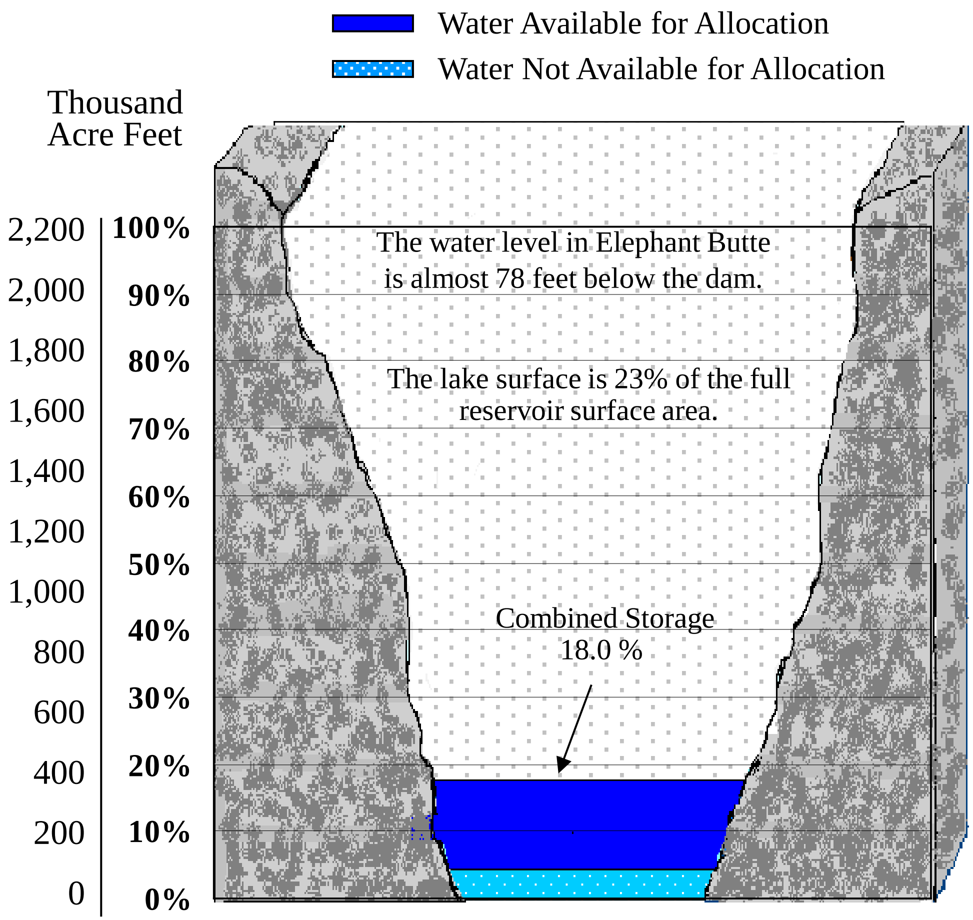



Texas A&M AgriLife Research Center at El Paso

Data Source: El Paso Water Utilities

# Drought Watch on the Rio Grande
# Surface Water Supply Conditions April 21, 2014

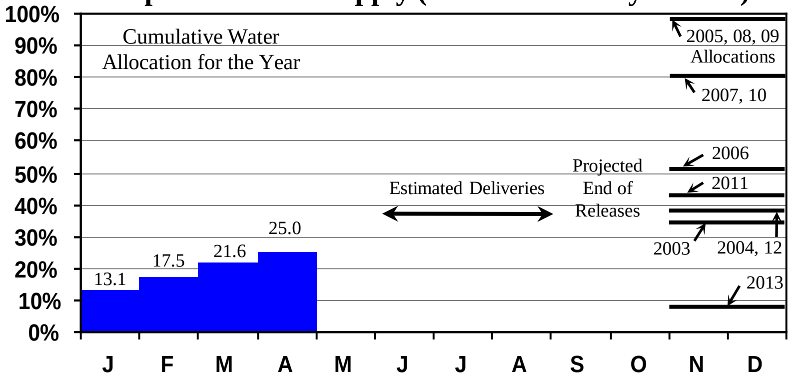
## Combined Elephant Butte and Caballo Reservoir Storage




## Water Supply Conditions & Forecasts

- **Water in Storage** is 402,778 acre-feet or **18.0%** of the combined reservoir capacity of 2.23 million acre-feet. Of this 100,000 acre-feet of the amount in storage is Rio Grande Compact and San Juan-Chama credit water which is not available for use, leaving 13.6% of capacity or 302,000 acre-feet available.
- **Spring snowpack runoff into Elephant Butte Reservoir is forecast to be only 8% of average.** This is one of the lowest in the almost 100 year history of Rio Grande Project. The Climate Prediction Center three-month forecast calls for above normal temperatures and average chances of precipitation. The forecast is for drought to persist or intensify.
- **The 2014 Rio Grande Project water allocation to-date is 25% of a full supply**. The 2013 water allocation was 6.1% of a full supply.

**Water allocation to agricultural and urban users as a percent of full supply (amount varies by district)**

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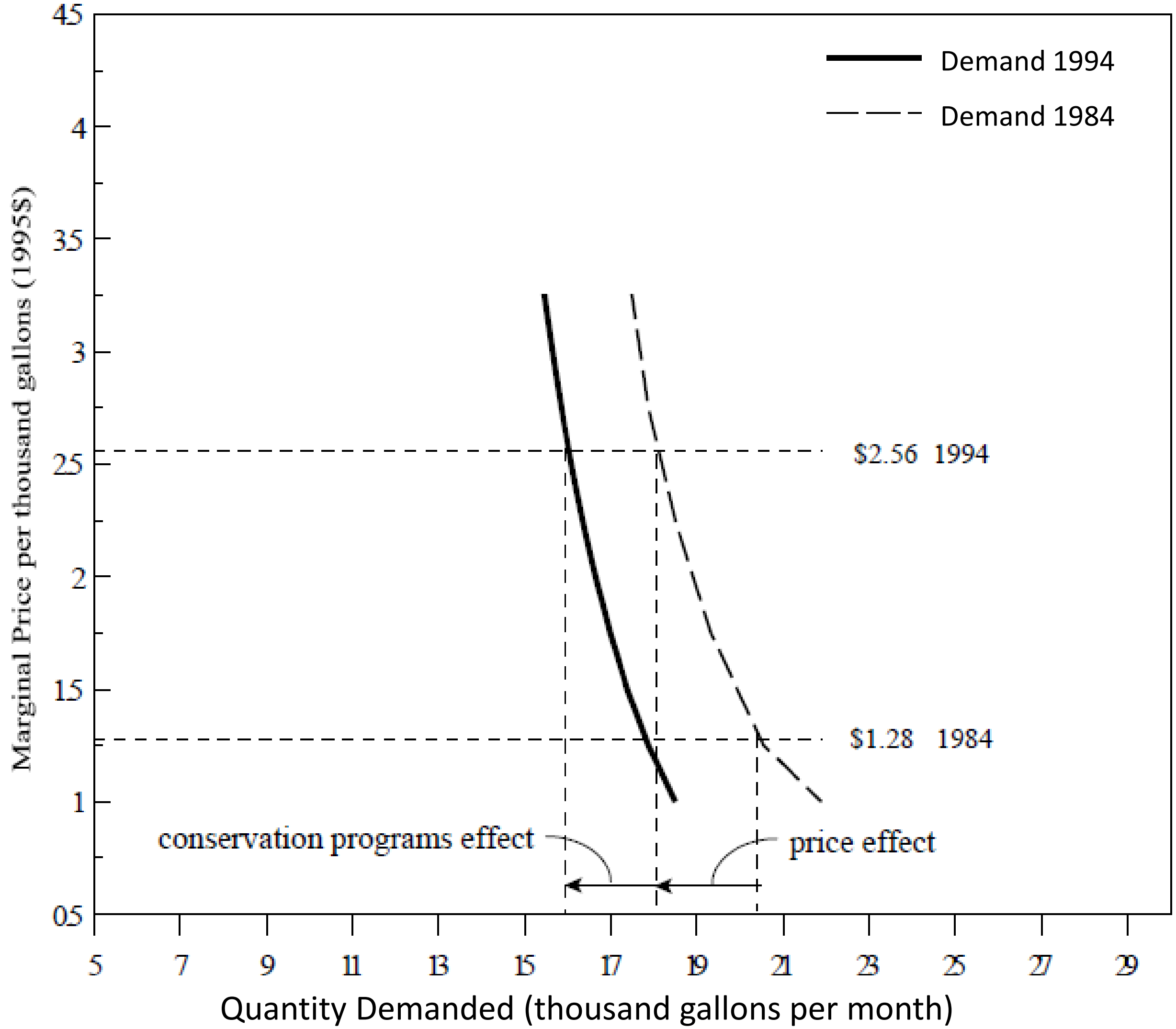
For additional information: http://elpaso.tamu.edu/research
http://elpaso.uc.usbr.gov

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

# Los Angeles Water Demand 1984 and 1994: Response to Marginal Price and Nonprice Conservation Programs




Source: Michelsen, McGuckin and Stumpf. Effectiveness of Residential Water Conservation Price and Nonprice Programs. 1998.

# Cost of Not Implementing Plan Recommendations

- **$12 billion** lost income - 2010
- **$116 billion** lost income – 2060

- State/local business taxes lost: $1 billion – 2010
- State/local business taxes lost: $10 billion – 2060

- **Lost jobs : 115,000** – 2010
- **Lost jobs: 1 million** – 2060

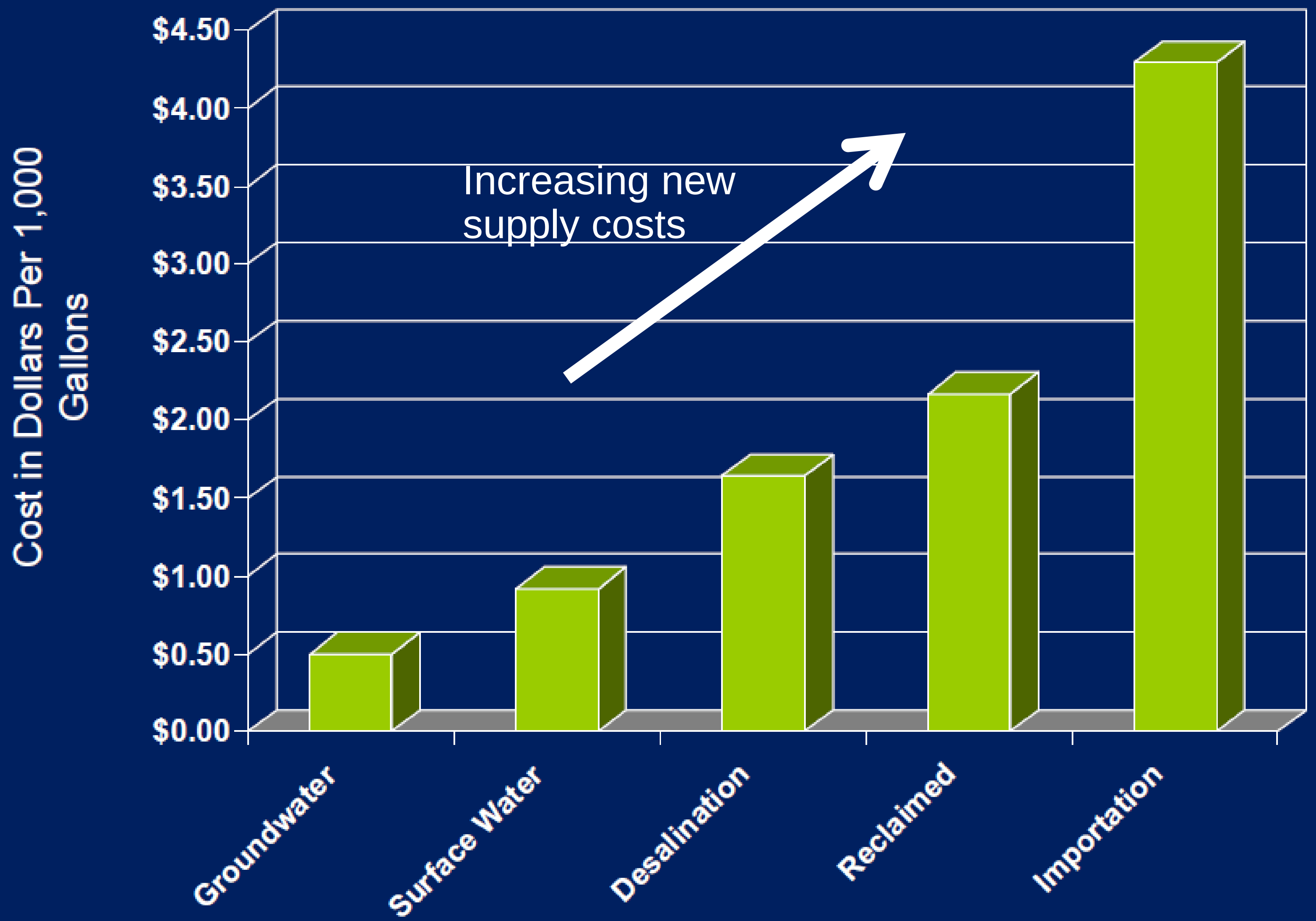
- Lost population growth: 1.4 million - 2060


**El Paso Desalination Plant**
(largest inland desalination plant in world)

Michelsen

# El Paso Water Utilities Strategies by Source

## Cost Comparison

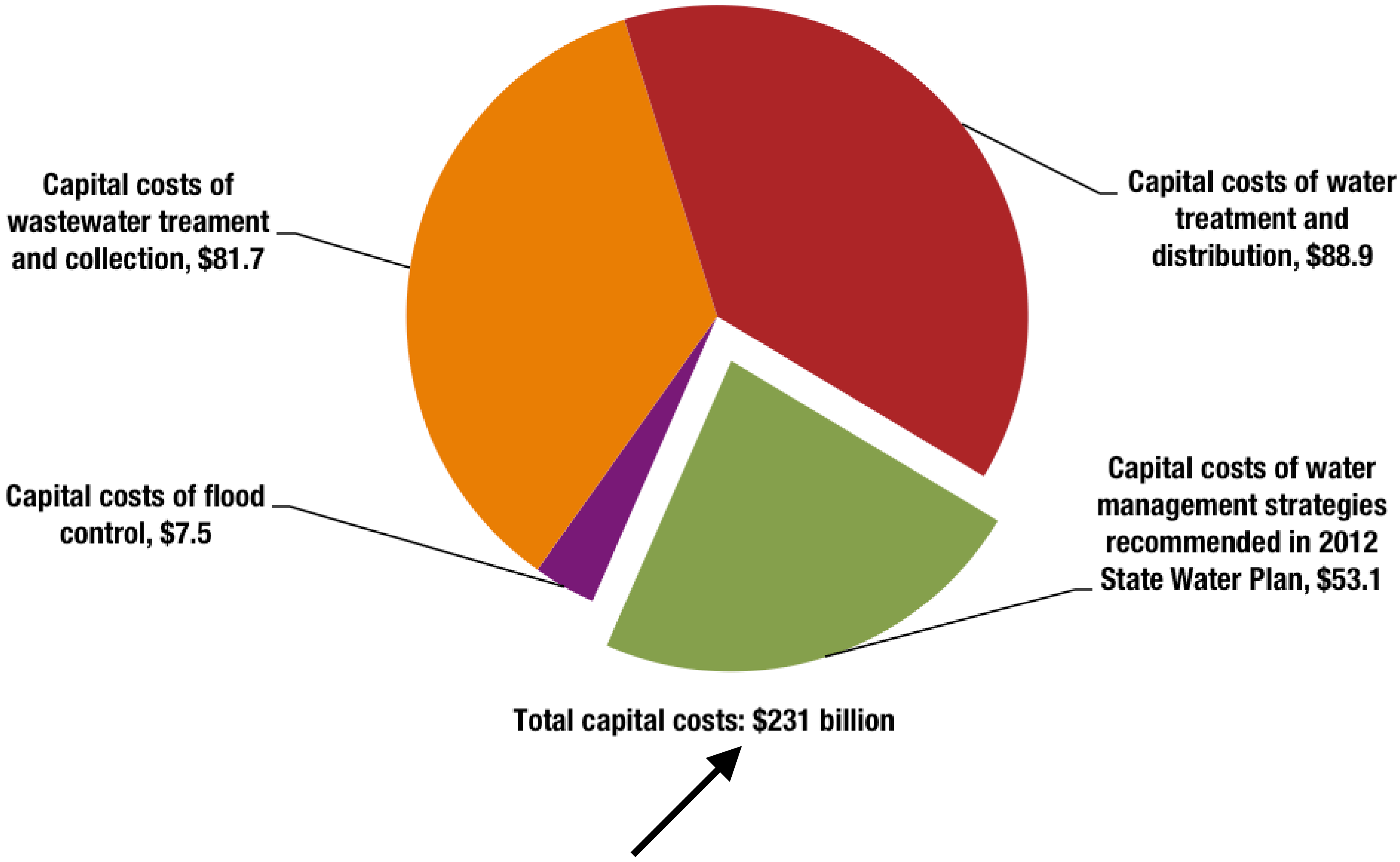


# Additional Water Supply Costs

- **Aging infrastructure** – Nationally an estimated $1 trillion in infrastructure work is required by 2035 to maintain & meet drinking water needs
- **Compliance costs** to meet federal clean water regulations
- **Treatment of emerging water contaminants** (pharmaceuticals)
- **Interdependency of energy, water** & chemical costs to treat and supply water and treat wastewater
- **Increased security costs** for water systems since 9/11
- **Bonds/price increases will be needed** to fund costs of repairs and upgrades of existing systems

# SWP Supply Costs Plus Other Additional TX Municipal Capital Costs Total $231 billion

## *Q: Ability and Willingness to Pay? Who?*



# Texas Municipal Infrastructure Funding

- Over the previous decade over one billion dollars was provided in financial assistance to build or upgrade existing water infrastructure from the State Drinking Water Revolving Fund (from federal appropriations matched with state dollars).
- SWIFT program created in 2013 with $2 billion
- Compare this to estimated costs of $231 billion needed over the next five decades.
- Much higher levels of investment needed just to meet existing infrastructure and water demand

# TX A&M AgriLife Water Research Examples

- Policy changes could reduce drought impacts 30%
- IBWC levees: $500M benefits (avoided flood damages)
- Out of 20 Conservation strategies only 3 feasible
  - Most cost efficient practices already implemented
  - Other practices too expensive for agriculture
- Salinity damages of $10+M/yr in Upper Rio Grande
  - Could be reduced by half with 200mg/l improvement

# TX A&M AgriLife Water Research Examples

- Lining 10 miles of canal could supply water 8,000 homes
- US-MX Transboundary Aquifer Assessment Program
  - Collaboration TWRI-Research-NMWRRI-USGS-Mexico
  - Extent, quality and use of transboundary aquifers
- Water value in hydraulic fracturing avg. $115,000/af
  - Wide range in value depending natural gas prices

# Economic Opportunities Include

- Assessing user willingness and ability to pay
- New technologies in urban and agricultural water use
- Application of Integrated Water Resources Management (IWRM) methods
- Assistance in water market development
- Multi-disciplinary modeling and evaluation
- Economic, policy and institutional analyses

# Texas A&M AgriLife Research

## 13 Regional Research Centers Statewide