Economics and Water in the Middle Rio Grande

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University of New Mexico
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Components of Water Resource Management

- Economic Agents; Consumers, Suppliers

  Irrigators, urban centers, species, recreational

- Natural Physical Constraints; Climate

  Precipitation, river and groundwater systems. vegetation

- Manmade Constraints; Physical, Institutional

  Storage, conveyance systems, International, national, state and local institutions: property rights and agreements

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Water Management Policy

"The traditional engineering emphasis in water supply has tended to relegate pricing to a minor role in water policy decision making…. the public has had difficulty in recognizing that water service, even though a necessity, does not have sacred qualities that preclude it from being subjected to economic analysis."

Mellendorf (1983)

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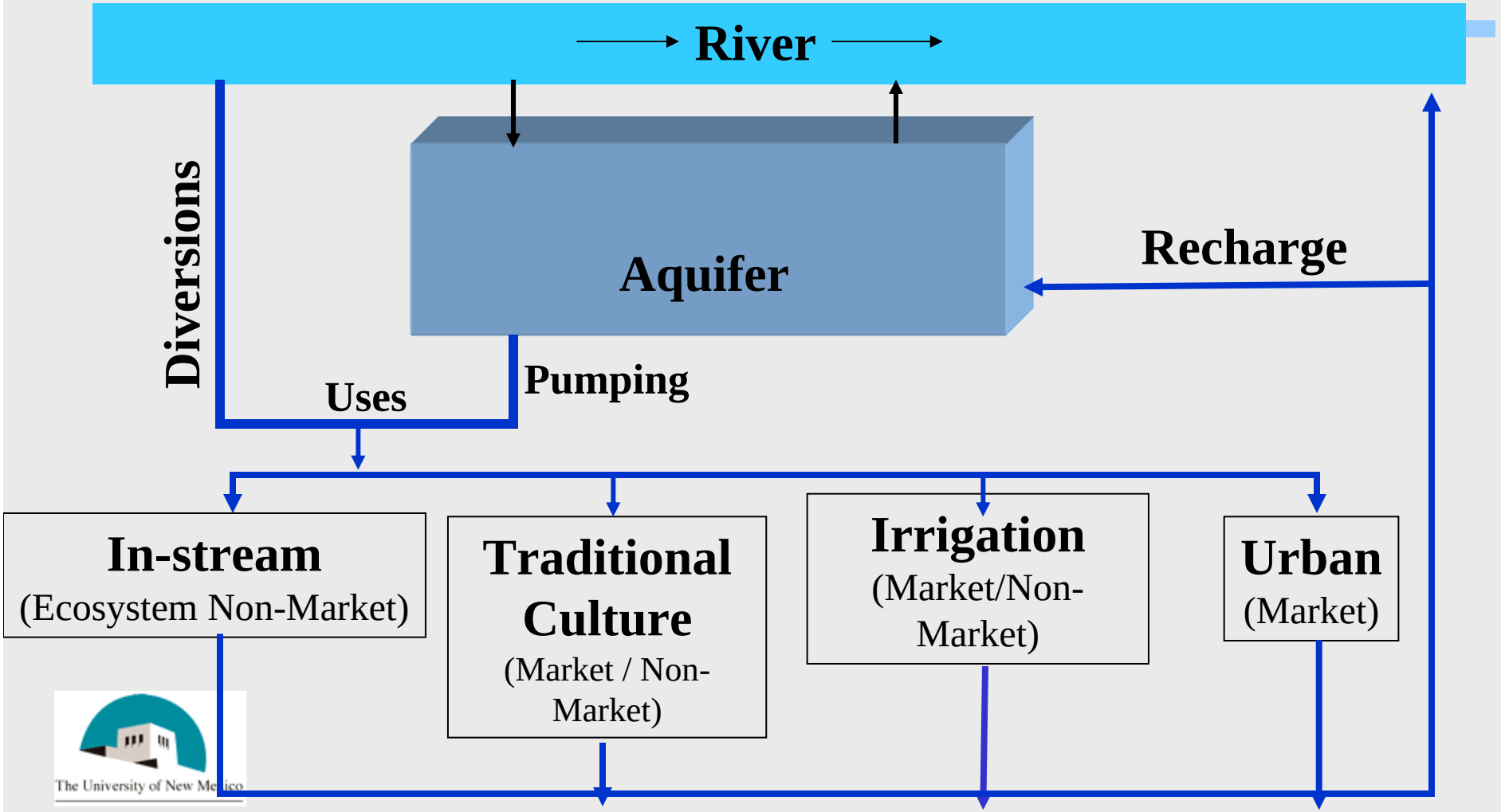
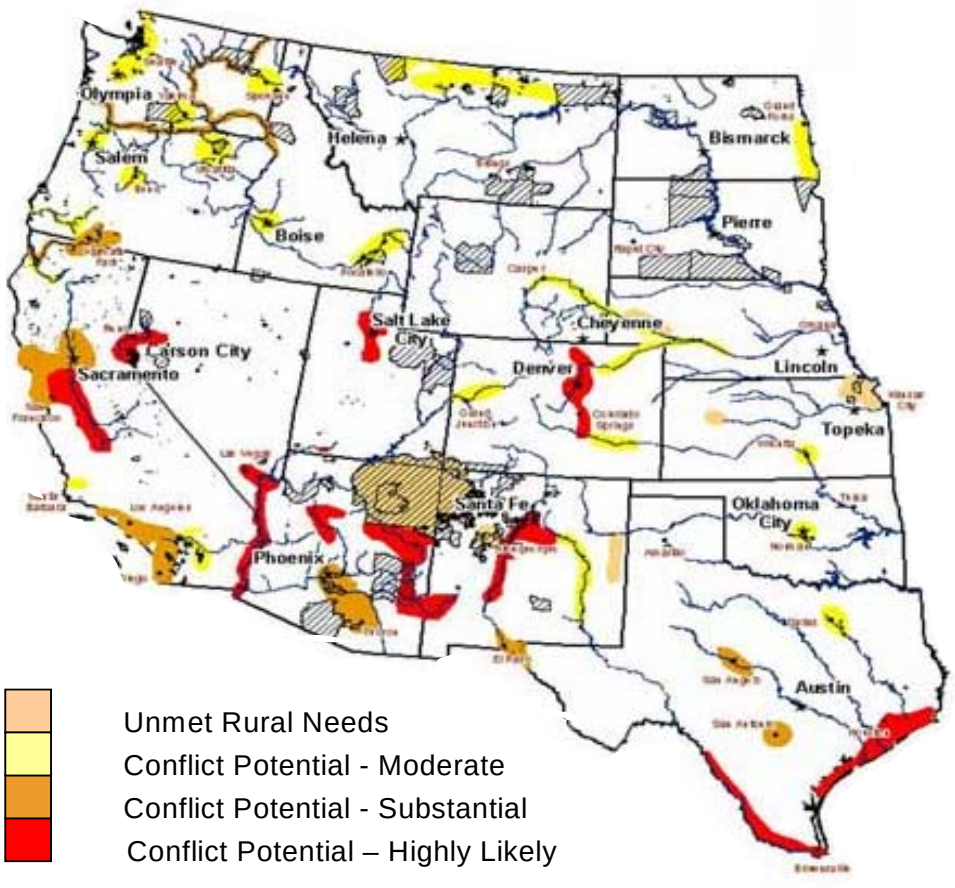
Where Does Economics Fit In?



Water in the West:
Potential Areas of Conflict

DOI (2003)



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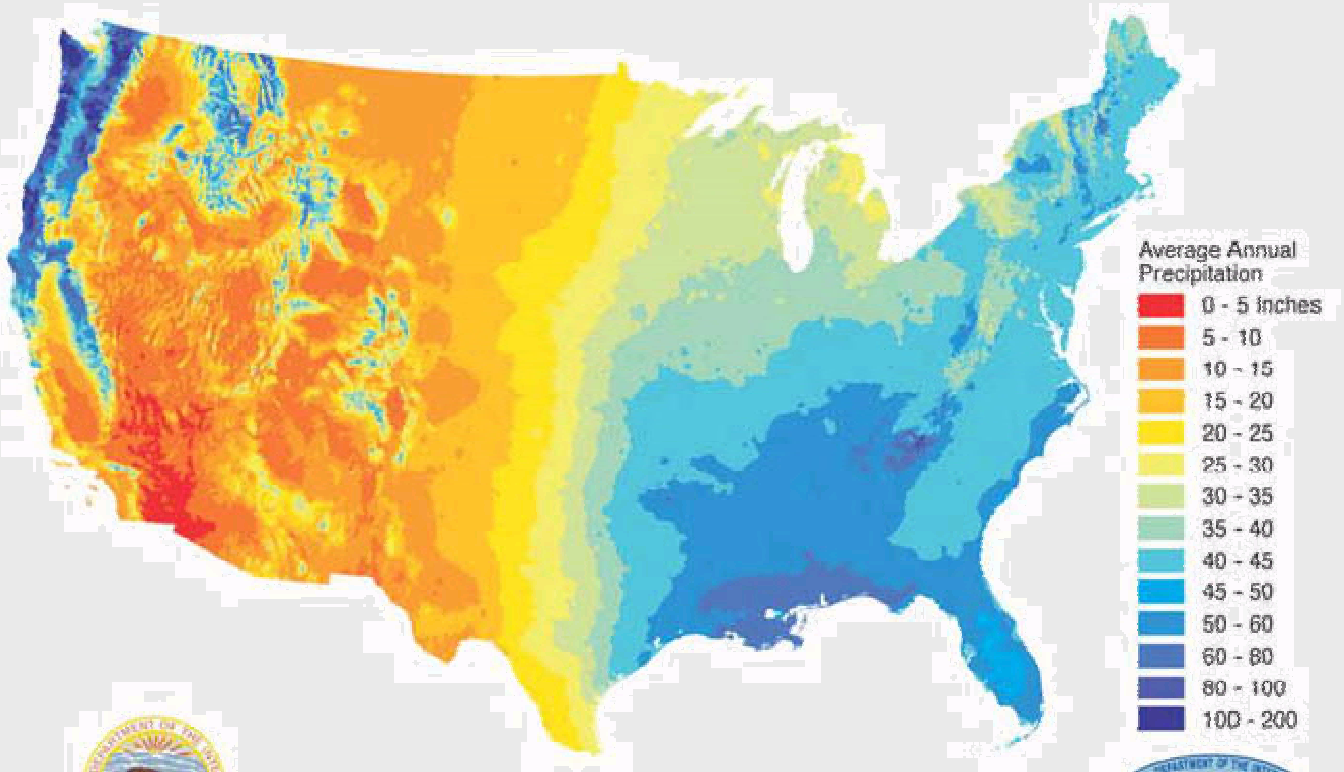
Why?

Southwest Characterized by:

Low Precipitation



Source: USDA-NRCS: http://www.ftw.nrcs.usda.gov/prism.html

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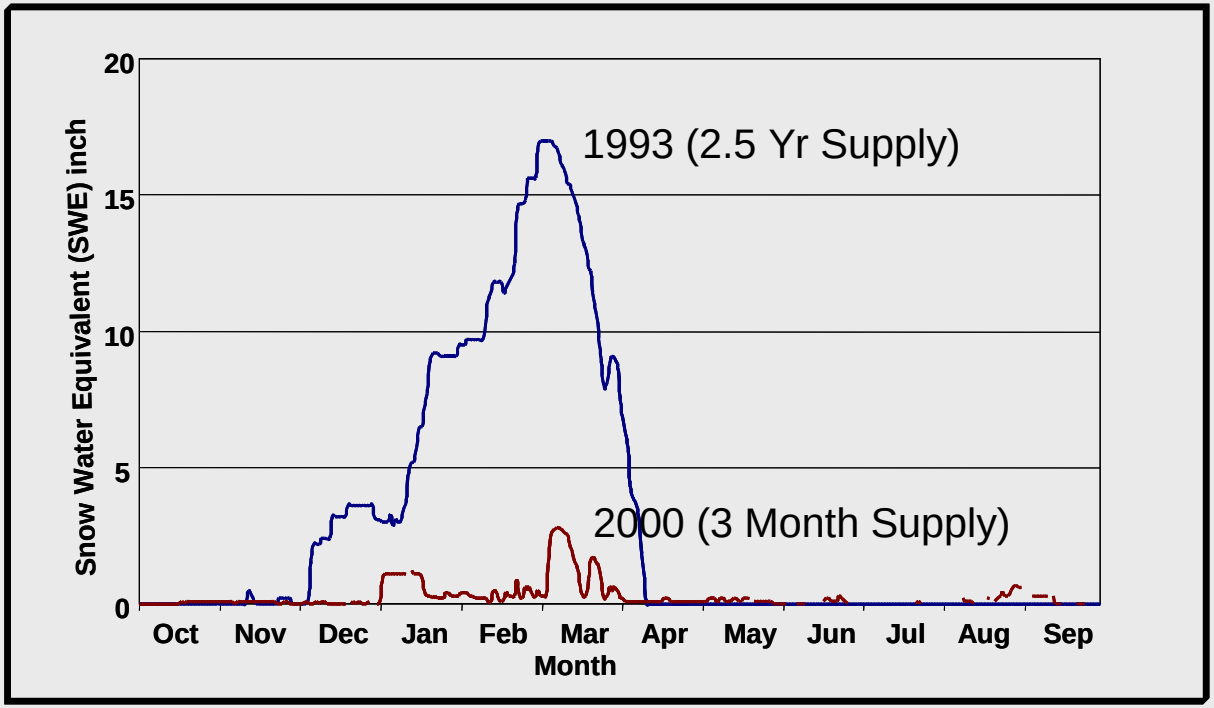
Southwest Characterized by:

Erratic Precipitation



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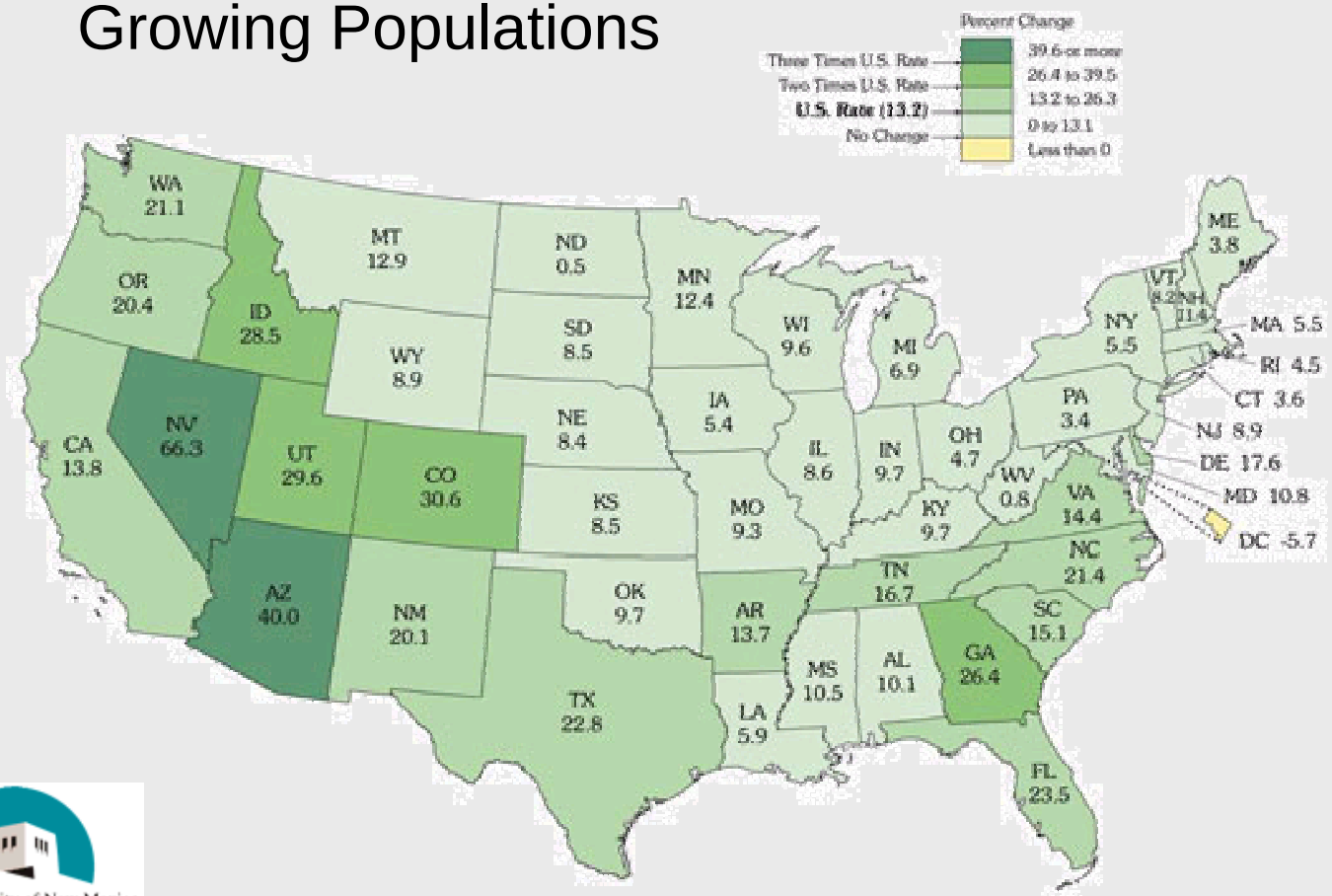
Southwest Characterized by:

Growing Populations



- Darker areas denote faster growth rates.

- Nevada (66%) and Arizona (40%) lead the nation.

- Intermountain states average about 30%.

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Increased Competing Uses

- Agricultural
- In-stream
- Urban
- Native American

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Agriculture

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Agriculture

- Profit Maximizer

$$\max_{\mathbf{x},w} \pi = Pq(\mathbf{x},w) - C(q(\mathbf{x},w))$$

$$s.t.\ \ w \leq \overline{w}$$

- Water is an Input into Production of Crops
- Cost of Water?
- Value of Product?

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Cropping Patterns[1]

CROP	PERCENTAGE OF TOTAL ACRES PLANTED
Alfalfa	53%
Pasture Grass	35%
Corn	4%
Grain	4%
Miscellaneous Vegetables[2]	3%
Chile Peppers	1%

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[1] Chermak et al (Sandia National Laboratories Draft Report 2006).
[2] Includes miscellaneous vegetables (1.9%), grapes (0.1%), melons (0.1%), miscellaneous fruit (0.5%), nursery stock (0.45%), and tree fruit (0.02%).

Crop Information[1]

Crop	Valencia Farm ($ per acre)	Socorro Farm ($ per acre)	Value
Alfalfa (3.5 ton/ac)	$413.60	$541.25	$112-150 per ton
Pasture Grass	---	$238.45	$90-128 per ton
Corn (180 bu/ac)	---	$514.20	$2.50-$3.20 per bushel
Grain		$424.60	$2.70-$3.30 per bushel
Chiles	$2209.90	$1906.72	$24.70-$30.30 per 100 weight

Yield depends on ET or water applied

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[1] From Sandia Draft Report. (Based on NMSU Extension Service Information)

In Stream Values

In-Stream Flow Values

- Non-use: $25 per year per NM household. (Berrens et al 1996).

- Shoreline:$0.02 - $0.10 per cfs: decreases with increasing cfs. (Daubert and Young 1981)

- Birding: $65/day for change from intermittent to perennial, $97 to maintain prime perennial flows (Crandall et al 1992)

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Example: Value of Birding

Value/visitor		$32 ($2003)	$65 (marginal value $2003)
	Avg. monthly visits (1999-2003)	Low-Flow value	Intermittent to perennial
January	19,998	$838,694	$1,703,596
February	19,546	$819,737	$1,665,090
March	11,110	$465,950	$946,461
April	8,878	$372,324	$756,283
May	6,065	$254,381	$516,712
June	4,074	$170,846	$347,030
July	3,838	$160,981	$326,993
August	3,663	$153,634	$312,068
September	4,829	$202,527	$411,383
October	9,972	$418,206	$849,481
November	30,890	$1,295,501	$2,631,486
December	15,390	$645,444	$1,311,058

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Urban

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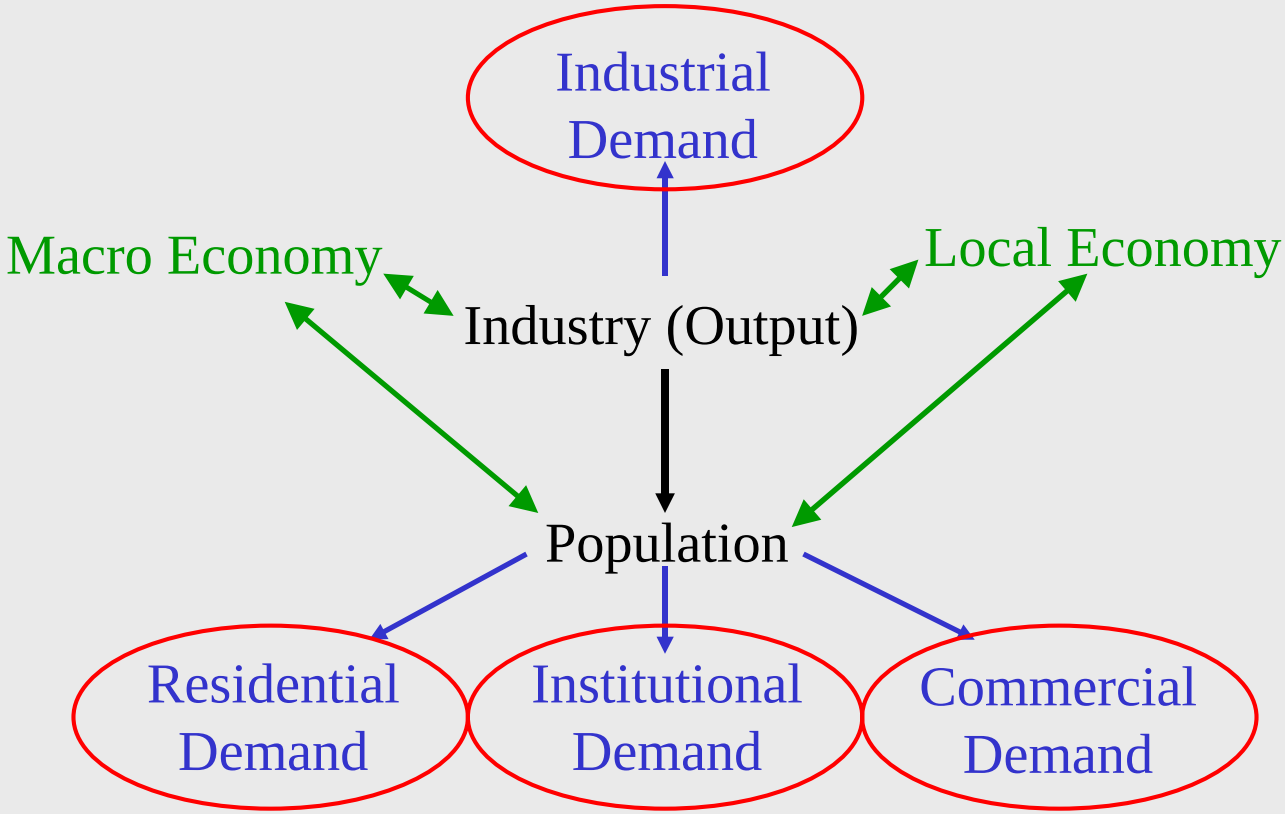
Interactions in NM Economy



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Urban

- Residential
- Commercial
- Industrial
- Institutional

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Commercial, Industrial, Institutional

$$\max_{\mathbf{x},w} \pi = Pq(\mathbf{x},w) - C(q(\mathbf{x},w))$$

$$s.t.\ \ w \leq \bar{w}$$

Production not well studied: water use as a function of employees. May not the as bad an estimate as one might think…

What percentage of Albuquerque's water use is from commercial, industrial, and institutional?

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For a $1 Million Dollar Primary Impact

Activity	Econ. Impact	Employ	Water Use (Mil Gal)	$/Gallon
Copper Mining	1.96	11	8237	0.24
Manufacturing	2.15	21	10481	0.21
Electronics	1.7	20	1790	0.95
Grains	2.02	9	20333	0.10
Golf (amusement/Rec Services)	1.54	23	2637	0.58
Electric Utility	1.67	7	2239	0.75
Dairy	2.7	13	12885	0.21
Semiconductors	1.77	13	8452	0.21
Mattresses and Bedsprings	2.28	20	11093	0.21

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It May Not be Economic Growth

and its impact on water, but the impact of economic growth on population growth.

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Urban Populations (2000)

- Otowi-Cochiti: 62,200
- Cochiti-San Felipe: 0
- San Felipe-Albuquerque: 393,300
- Albuquerque-Bernardo: 147,200
- Bernardo-San Acacia: 300
- San Acacia-San Marcial: 10,300
- San Marcial-Elephant Butte: 0
- TOTAL: 613,400

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Population Growth (2005-2030)
BBER Projections

- NM: 33%
- Bernalillo: 27%
- Dona Ana: 45%
- Santa Fe: 57%
- San Juan: 27%
- Sierra 50%
- Valencia: 68%
- Sandoval: 82%

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From: http://www.unm.edu/~bber/demo/table1.htm (Last accessed 10-17-05)

It May Not be Economic Growth

and its impact on water, but the impact of economic growth on population growth.

And, all consuming households are not created equal…

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Do “Conservation-built” Homes Help?

Consider the following consumer who lives in a house that is equipped with many water savings devices, such as;

Low-flow showerheads
Ultra-low flush toilets
Drip irrigation system

How does this family use water? Are they conservation minded?

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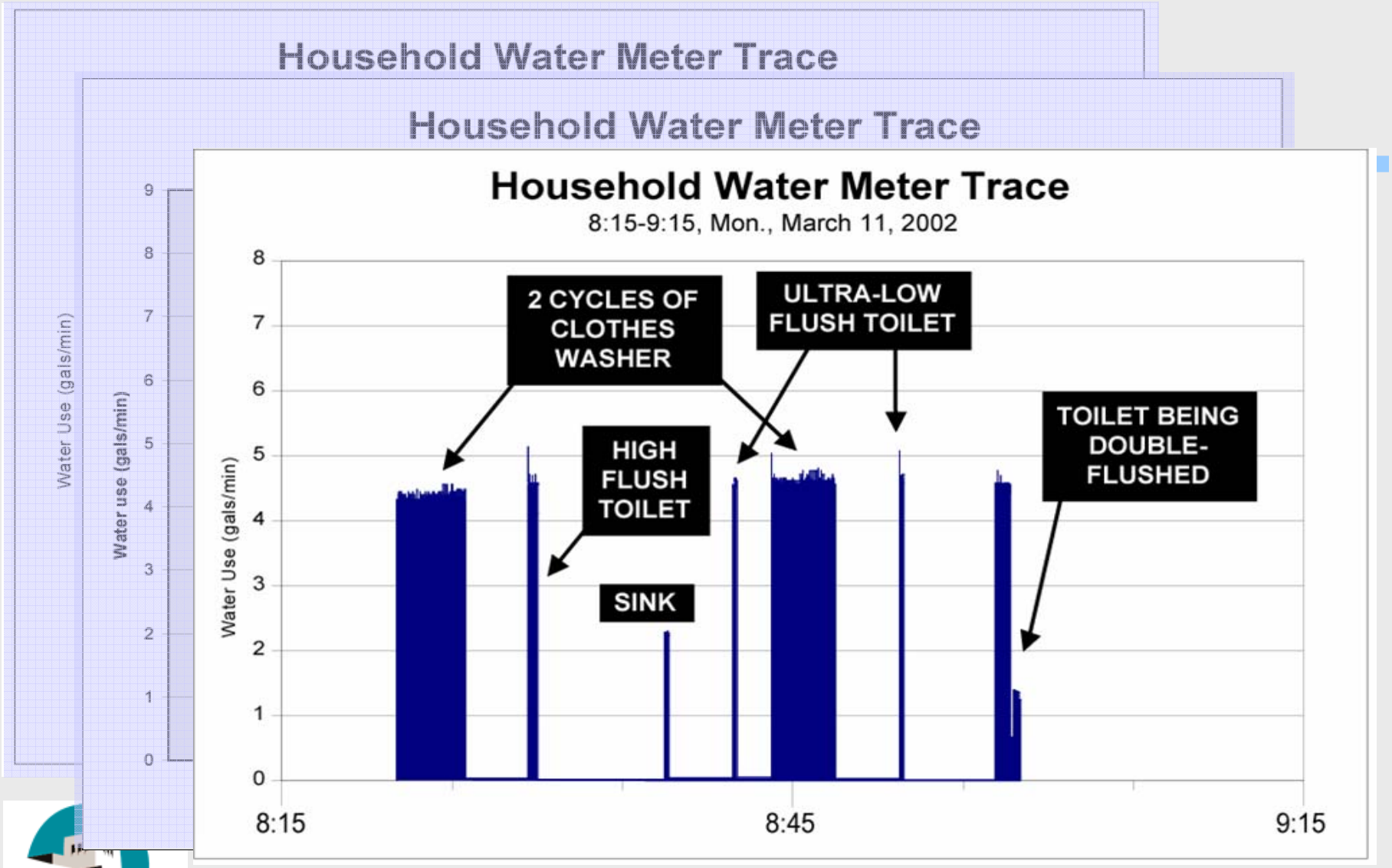
From: Woodard (2002)

Water Meter Traces Reveal Water Use



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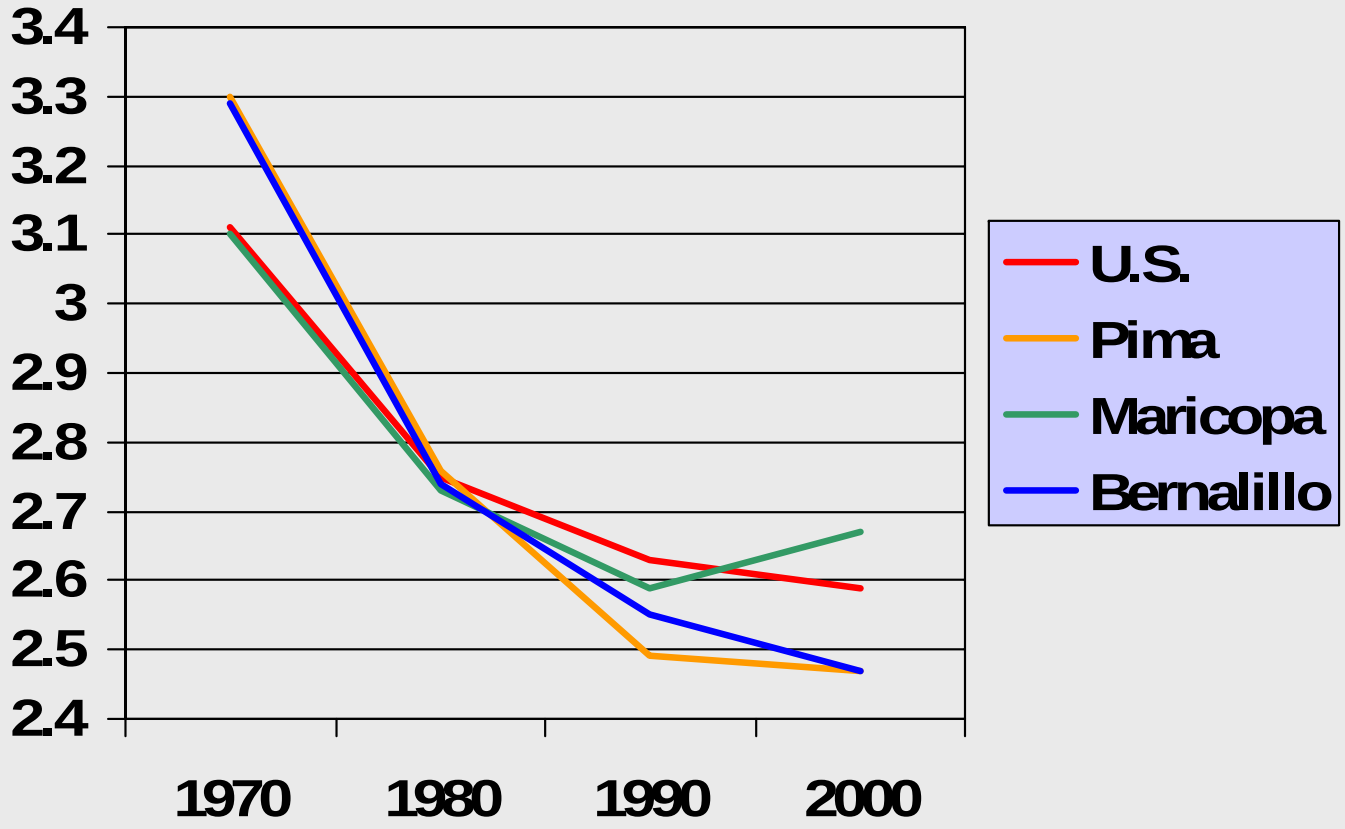
From: Woodard (2002)

Trends: Persons per Household (PPH)

PPH



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*From: Woodard (2002)

Impact on Housing Demand

Housing Demand Impact from:

Area	% from Pop Growth	% from PPH Drop
USA	50	50
Albuquerque, NM	57	43
Tucson, AZ	69	31
Phoenix, AZ	81	19

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From: Woodard (2002)

Does Homeownership and Type Matter?*

Outdoor demand is a function of housing type. Residents of Single Family Residences use more water outdoors than residents of townhouses and condos, which in turn use more water than residents of apartments and mobile homes.

Owner-occupied homes are associated with greater outdoor water demand.

Changes in the housing stock mix are increasing outdoor water demand.

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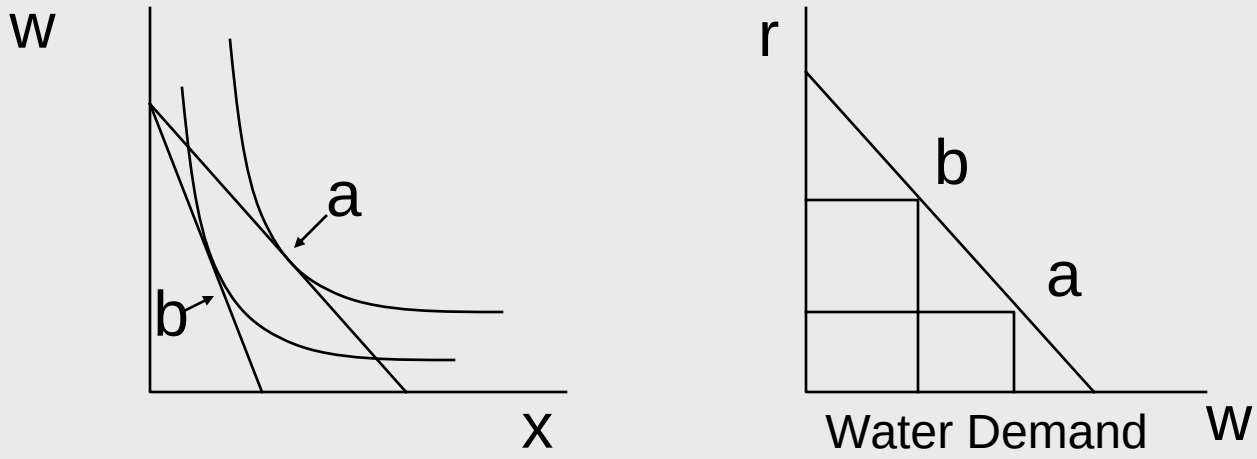
From: Woodard (2002)

Demand?

$$\max_{\mathbf{x},w} U = u(\mathbf{x}, w; \beta)$$

$$s.t. \quad \mathbf{px} + rw \leq E$$



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Factors that Impact Demand[1]

- Price (-)
- Income (+)
- Education (-)
- Gender: Male (+)
- Native (+)
- Home Ownership (-)
- Protestant (+)
- Non-denominational (+)
- DNR religion (+)
- Republican (-)
- Other Political Affiliation (-)
- Geographic Location (-)
- Temperature (+)

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Consumers are not heterogeneous: one size pricing does not fit all…

1 Krause et al 2002.

How Do Water Prices Fit In?

- Historic Realities
- Current Trends
- Future Directions

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Conventional Wisdom

Residential consumers do not vary responsive to price, therefore price is not an effective management tool.

Based on?

Data

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Empirical Evidence?

- Majority of empirical studies find residential consumers unresponsive to price changes

- Brookshire, et al (2002), Espey et al (2000)

Why?

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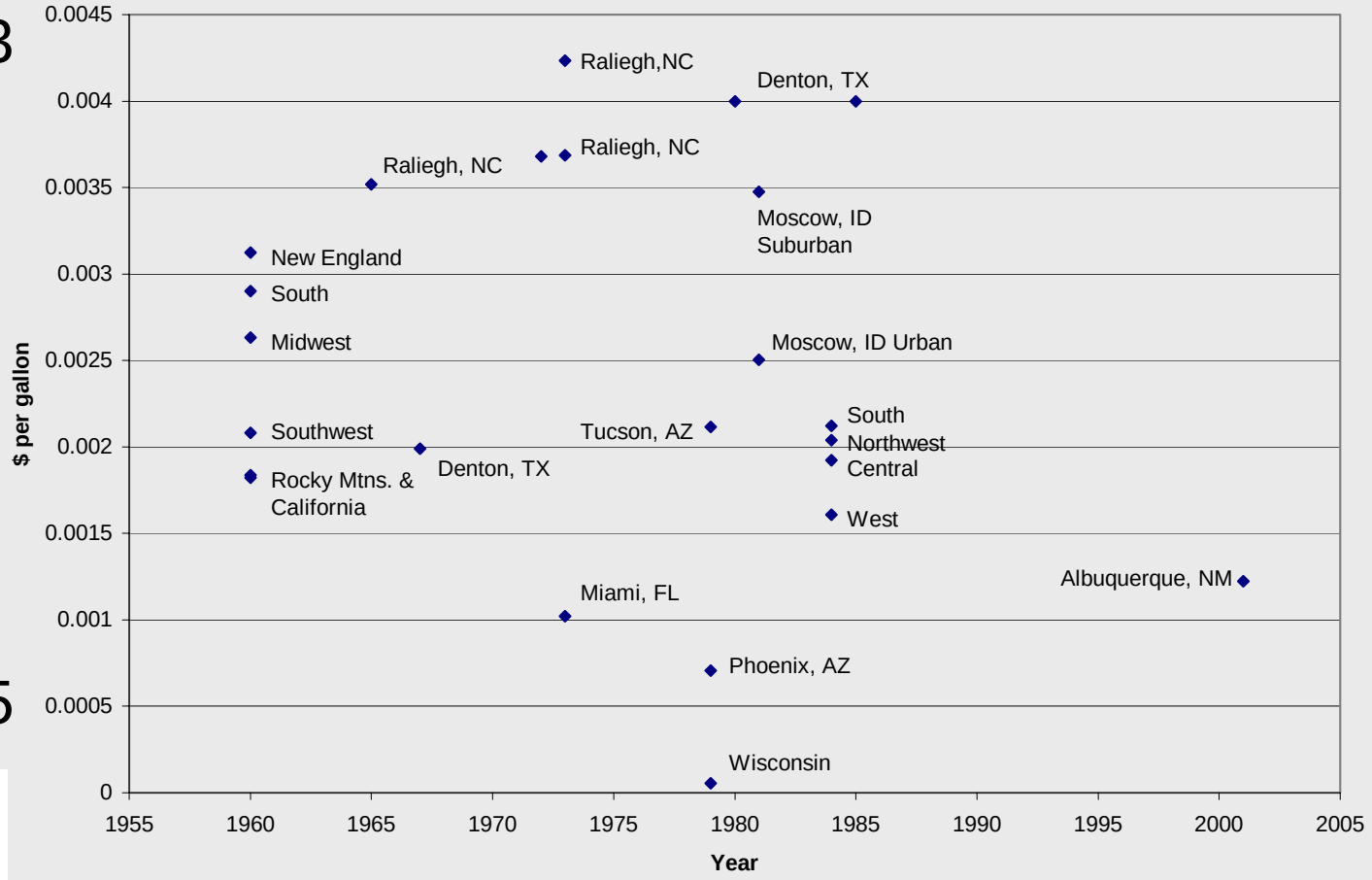
Historical Pricing in US

$0.0043

$0.0005



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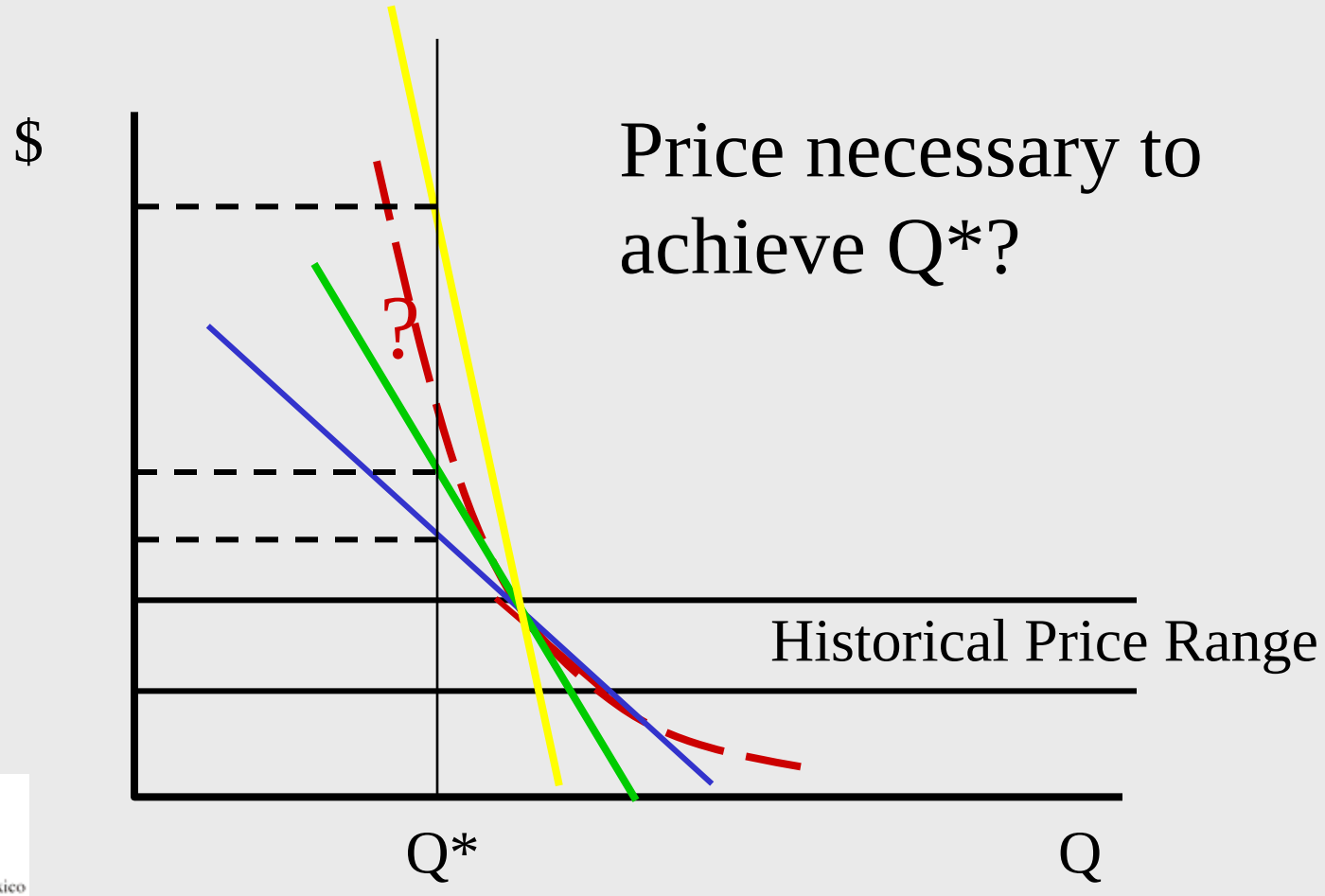
Problem with Historical Prices



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Current Pricing Trends

- Base (Fixed) Charge
- Commodity Charge
- Block Rate Structure
- Summer Surcharge
- Drought Policies

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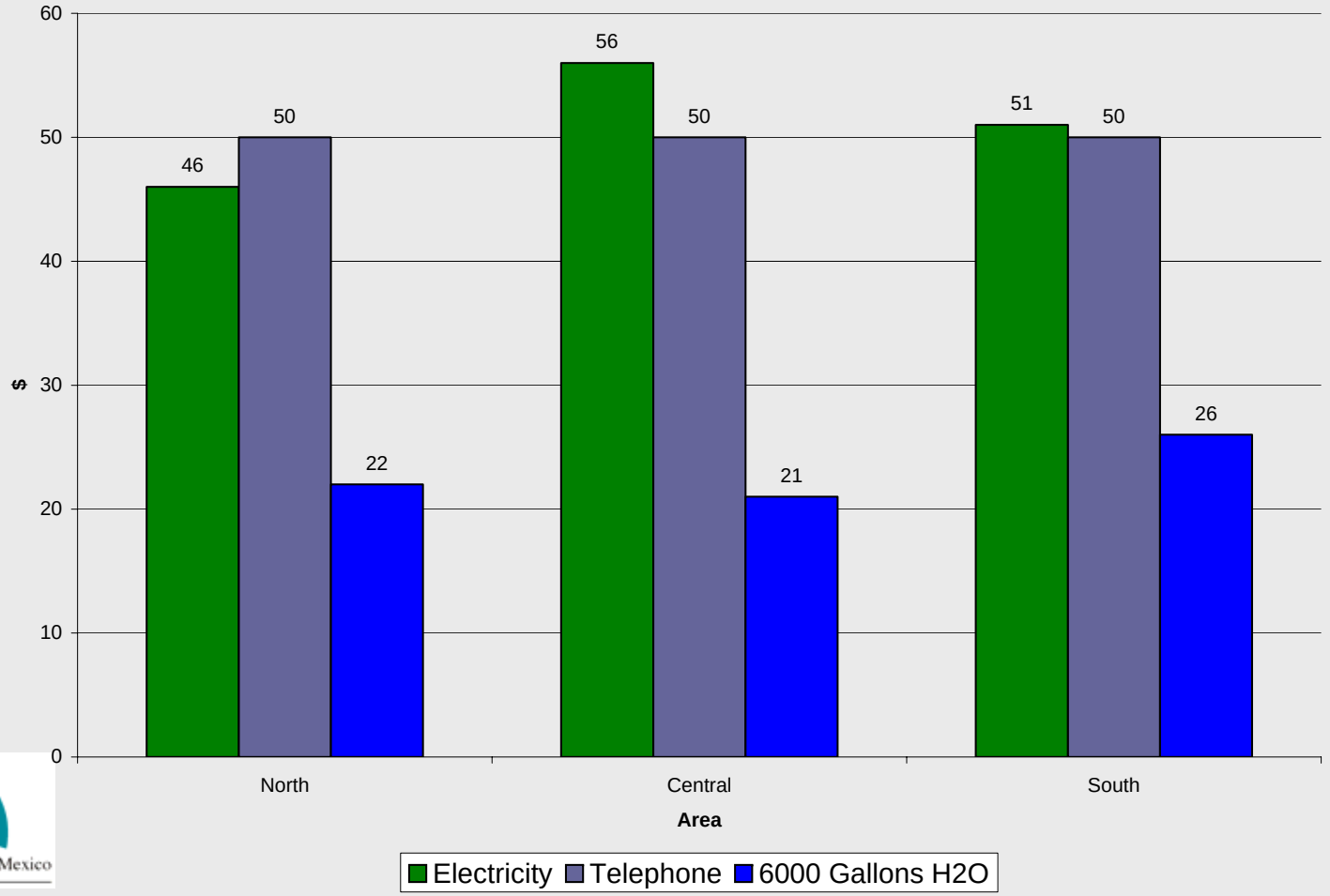
SW Pricing Examples (2005 info)

Location	Base	Commodity (1000 gallons)	Comments
Albuquerque	$4.60	$1.65	Surcharge
Santa Fe	$14.50	$5.32-$15.32	Surcharge+ Block Rate
T or C	$8.15	$1.75	Block Rate
Denver	$3.41	$1.63	Block Rate
Fort Collins	$12.72	$1.78	Block Rate
Tucson	$5.35	$1.03	Block Rate
Tucson	$11.96	$1.98	Block Rate
Phoenix	$5.16	$1.93	Uniform
Las Vegas	$3.72	$1.05	Block Rate
Los Angeles	None	$2.46 (tier 1) $2.56 (tier 2)	Block Rate, by tier by month

Average Monthly Utility Expenditures



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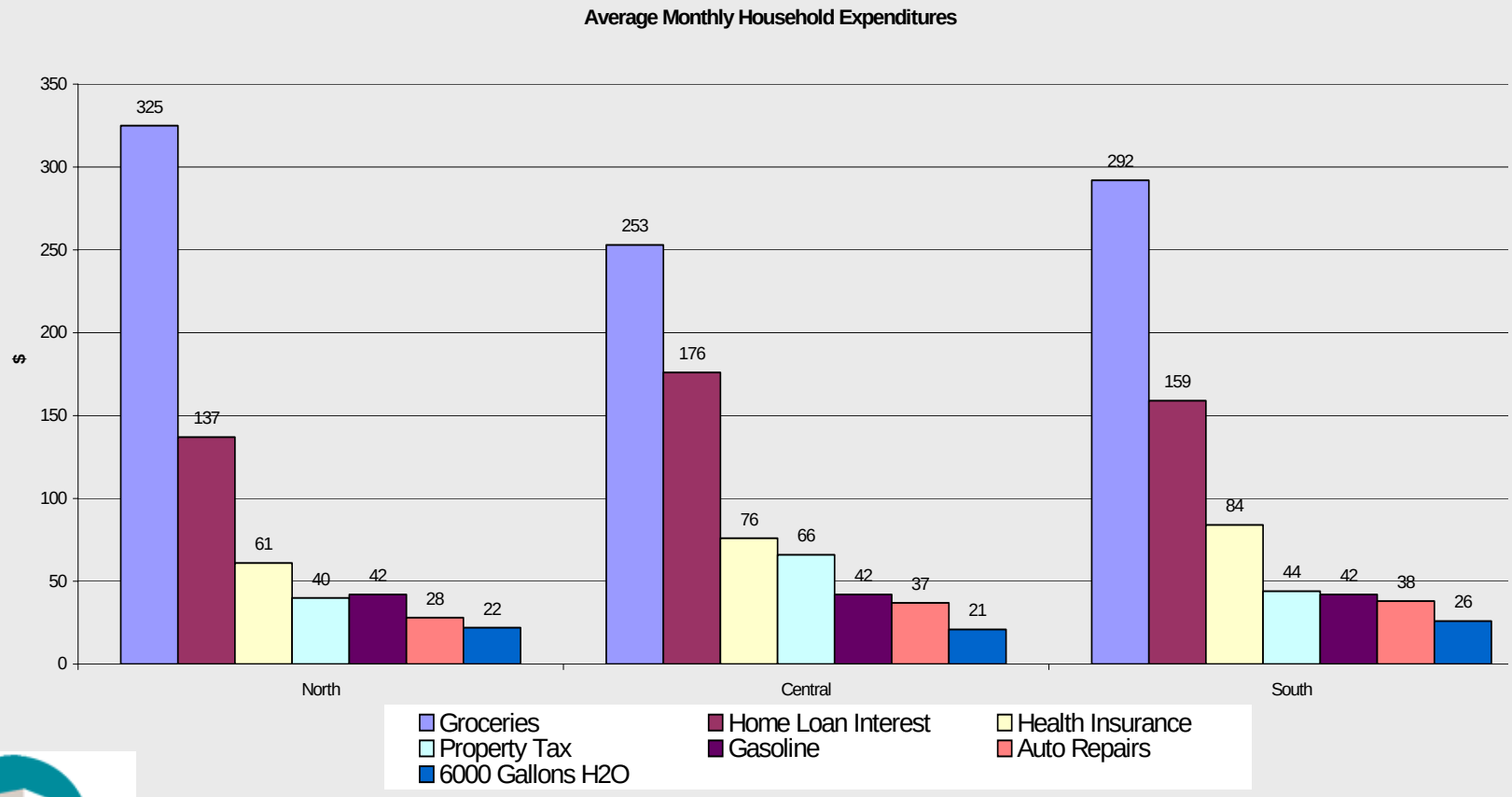
Average Monthly Household Necessities Expenditures for a Family of Four



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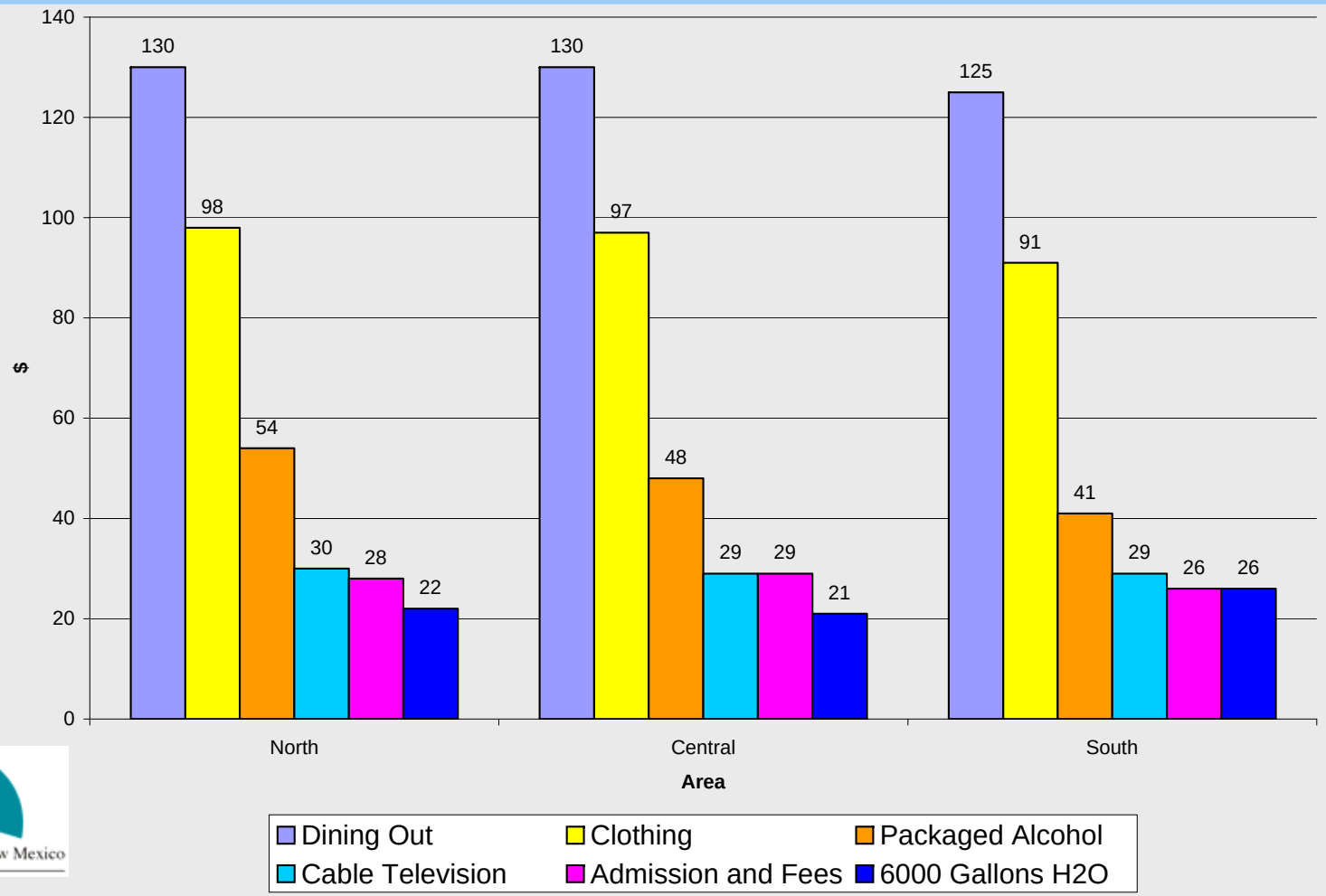
Monthly Discretionary Goods Expenditures



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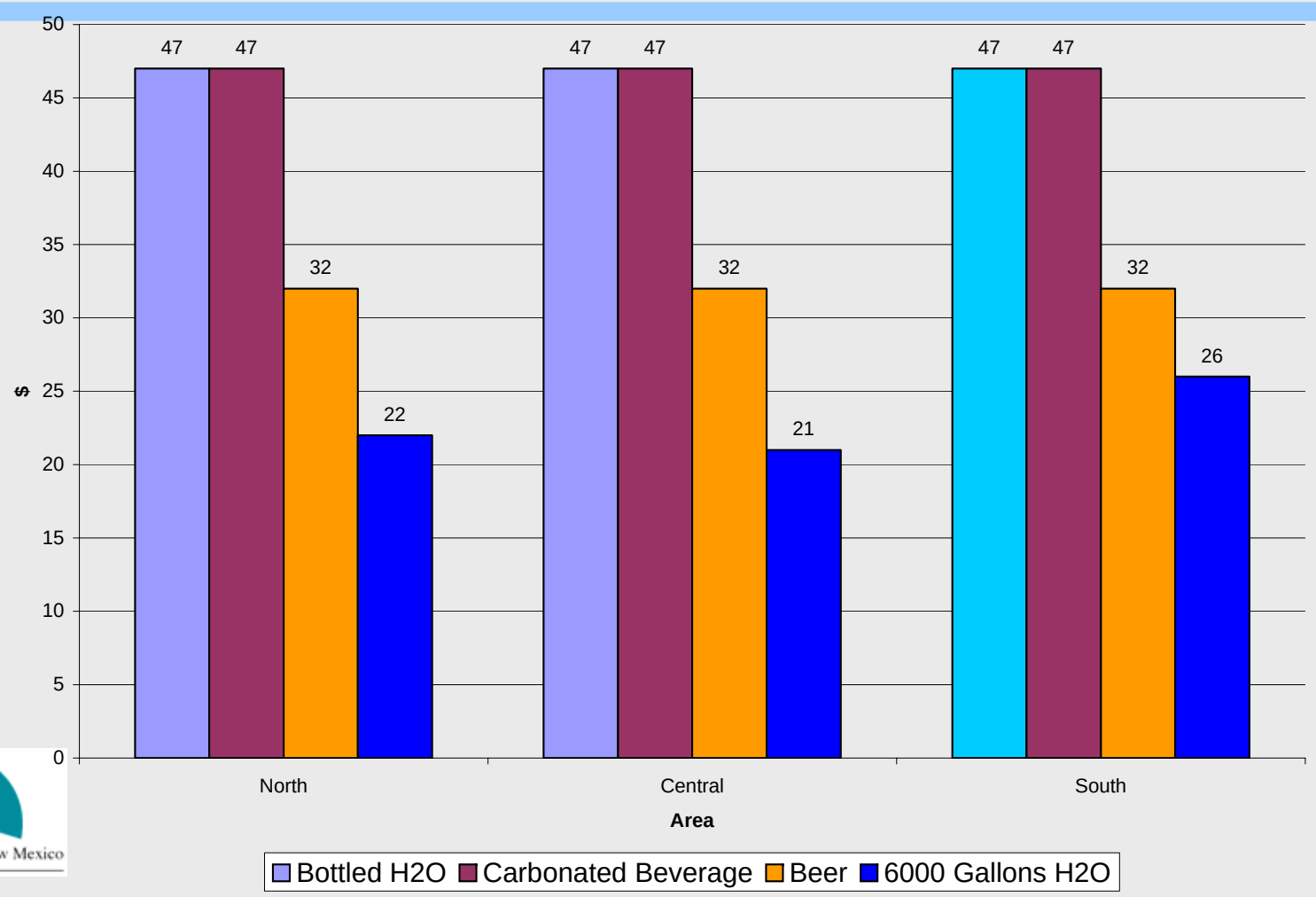
Average Monthly Expenditures of Select Beverages



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Signals and Incentives Given?

- Water is relatively cheap
- Delivery of water is the only thing of value
- Water is abundant

But we still need to trade-off between uses, because there isn't enough water….

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How do We Make Trade-offs?

- Market versus Non-Market
- Agriculture versus Urban Development
- How much and at what price?

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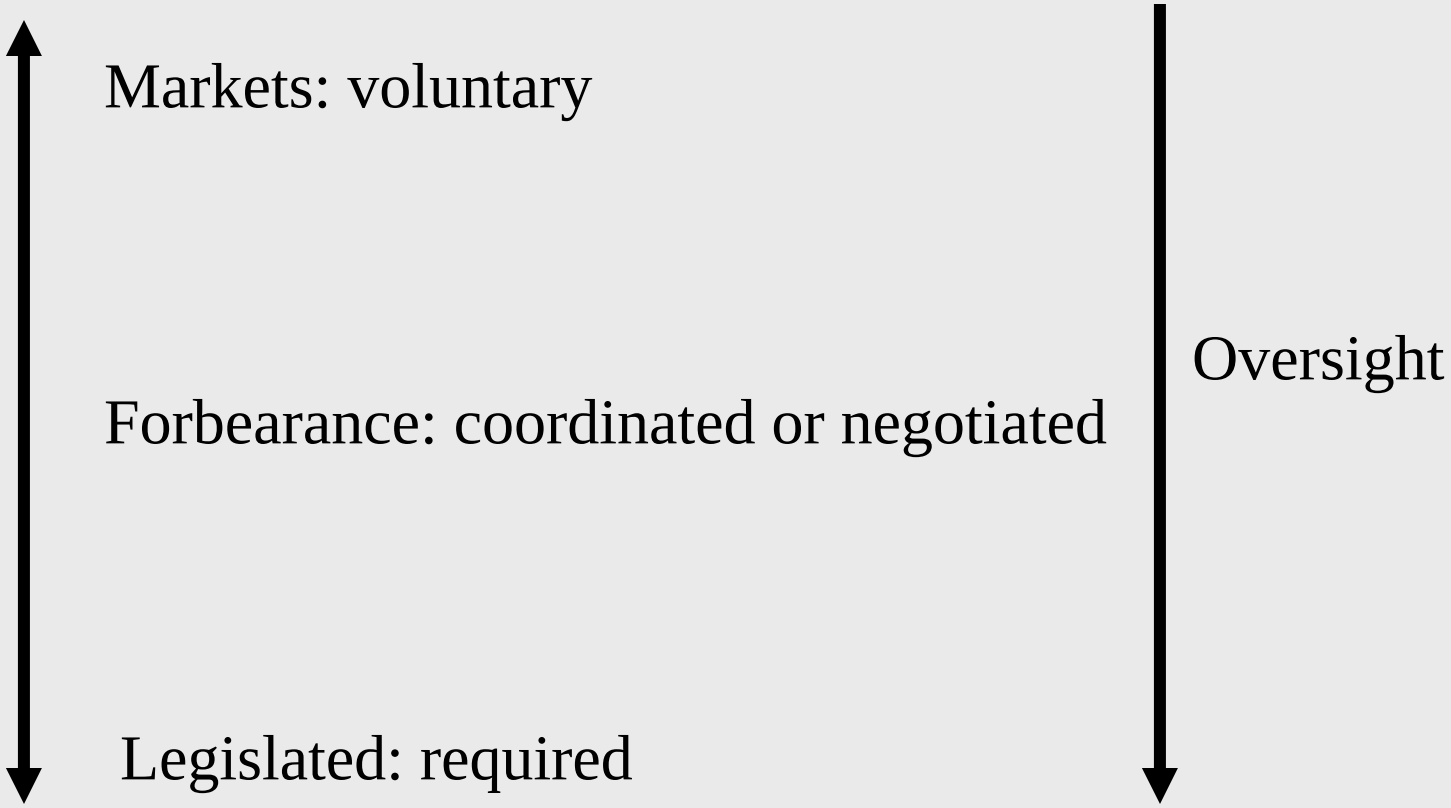
Mechanisms



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COMPETITIVE MARKET EXAMPLE

- Perfect Information
- No Market Power
- Homogeneous Product
- No Market Externalities
- Full Water Allocations

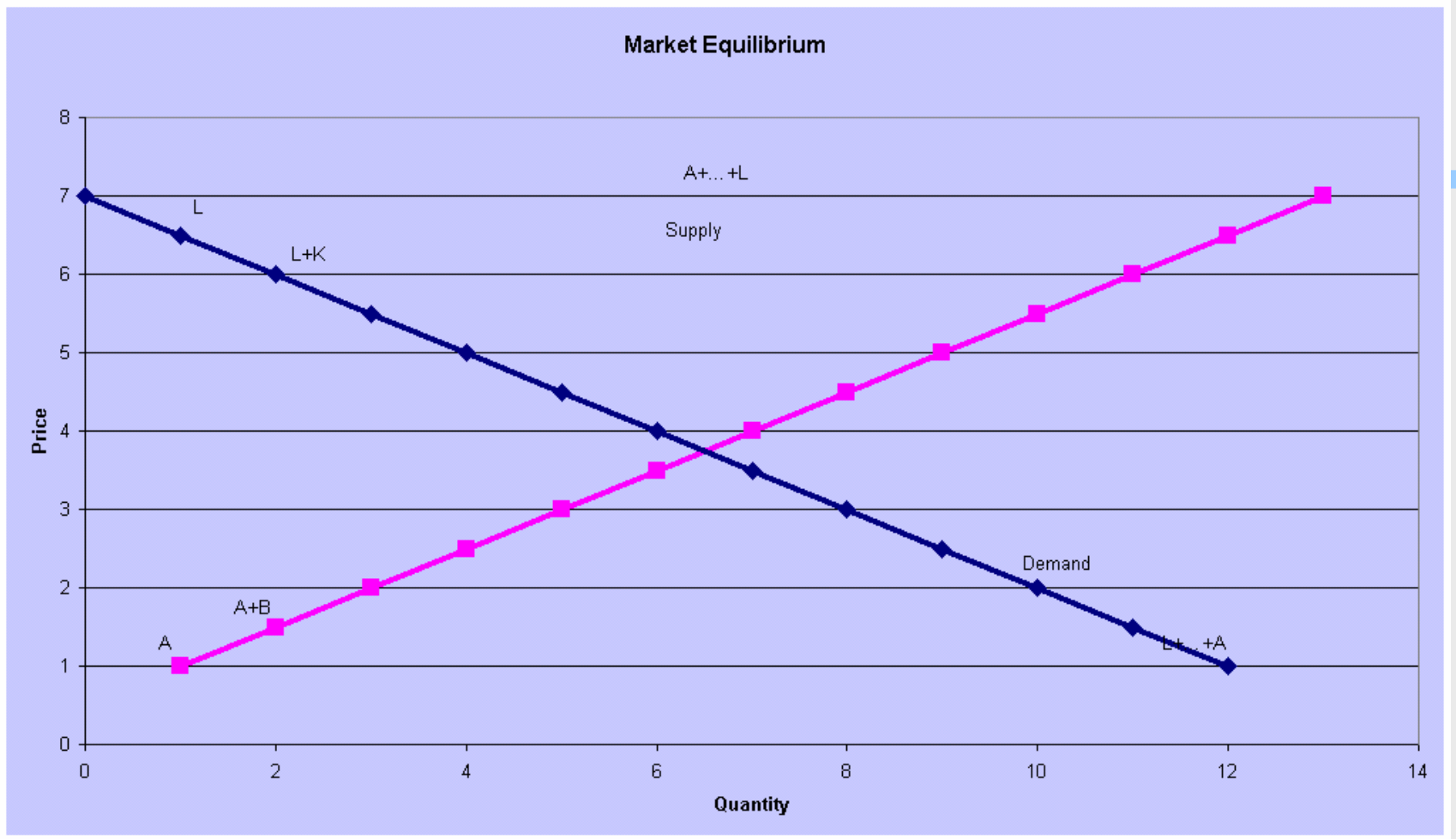
EXAMPLE: PARAMETER VALUES

- Resource: Q=12
- N=12
- MNB Vary Across the Agents
- Optimal Use Level for Each Agent is 2 Units
- Endowment to Each Agent is 1 Unit

INITIAL CONDITIONS

AGENT	$\overline{q}_{it}$	q^*_{it}	VMP	SUPPLY	DEMAND
A	1	2	1	1	12
B	1	2	1.5	2	11
C	1	2	2	3	10
D	1	2	2.5	4	9
E	1	2	3	5	8
F	1	2	3.5	6	7
G	1	2	4	7	6
H	1	2	4.5	8	5
I	1	2	5	9	4
J	1	2	5.5	10	3
K	1	2	6	11	2
L	1	2	6.5	12	1

INITIAL CONDITIONS EQUILIBRIUM



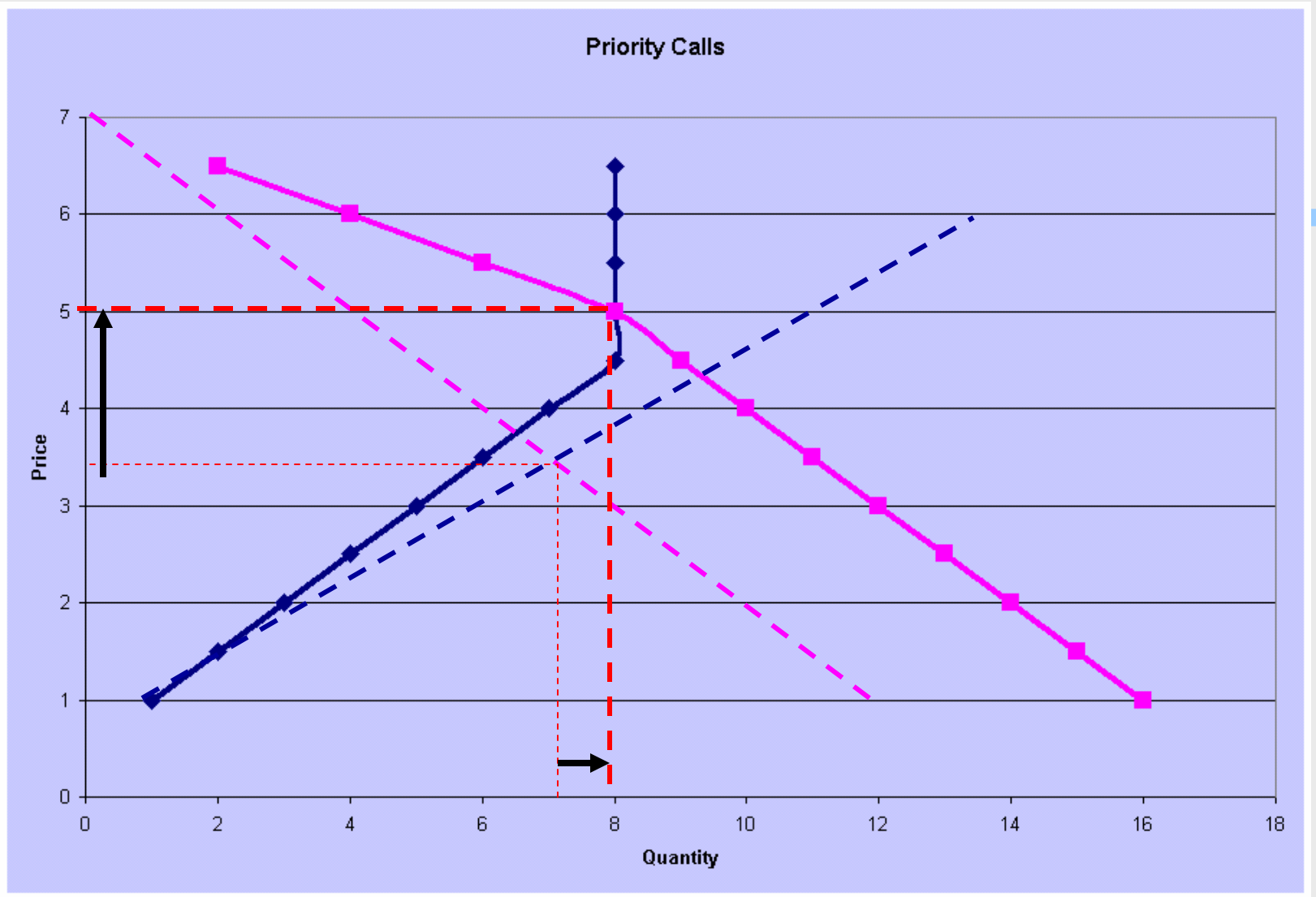
RELAX 100% DELIVERY ASSUMPTION

- Reduce Q_t By 33% (q_{it}=0, for 4 Agents)
- Scenario 1: Junior Priority Rights are high value
- Scenario 2: Junior Priority Rights are low value
- Scenario 3: Junior Property Rights are mid value

SCENARIO 1: SUPPLY REDUCTION
Jr. Rights, Highest Value

AGENT	Priority	$\overline{q}_{it}$	VMP	SUPPLY	DEMAND
A	1	1	1	1	16
B	2	1	1.5	2	15
C	3	1	2	3	14
D	4	1	2.5	4	13
E	5	1	3	5	12
F	6	1	3.5	6	11
G	7	1	4	7	10
H	8	1	4.5	8	9
I	9	0	5	8	8
J	10	0	5.5	8	6
K	11	0	6	8	4
L	12	0	6.5	8	2

SUPPLY REDUCTION (Jr. Rights Highest Value)



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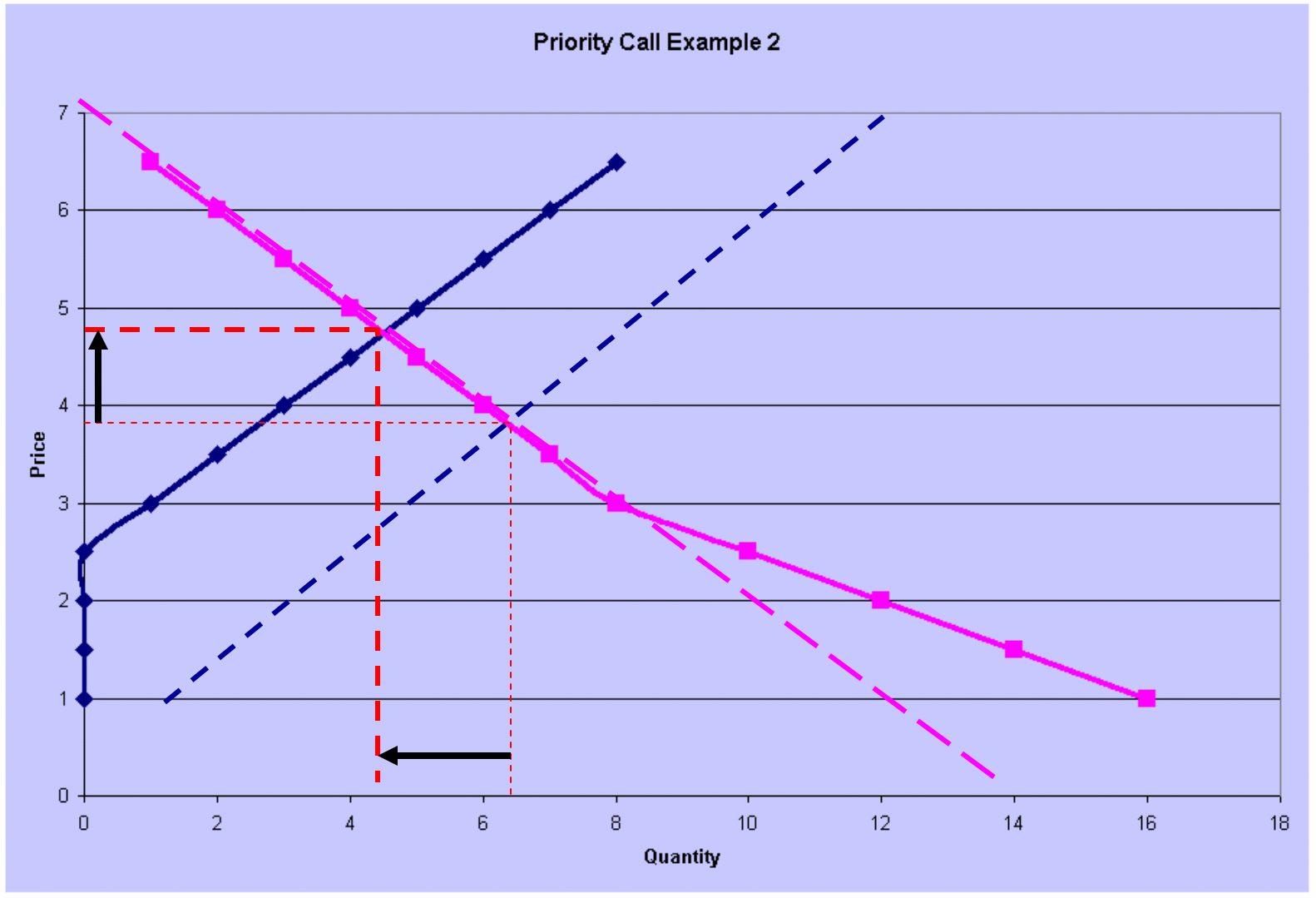
SCENARIO 2: SUPPLY REDUCTION
Jr. Rights Lowest Value

AGENT	Priority	$\overline{q}_{it}$	VMP	SUPPLY	DEMAND
A	12	0	1	0	16
B	11	0	1.5	0	14
C	10	0	2	0	12
D	9	0	2.5	0	10
E	8	1	3	1	8
F	7	1	3.5	2	7
G	6	1	4	3	6
H	5	1	4.5	4	5
I	4	1	5	5	4
J	3	1	5.5	6	3
K	2	1	6	7	2
L	1	1	6.5	8	1

SUPPLY REDUCTION (Jr. Rights Lowest Value)



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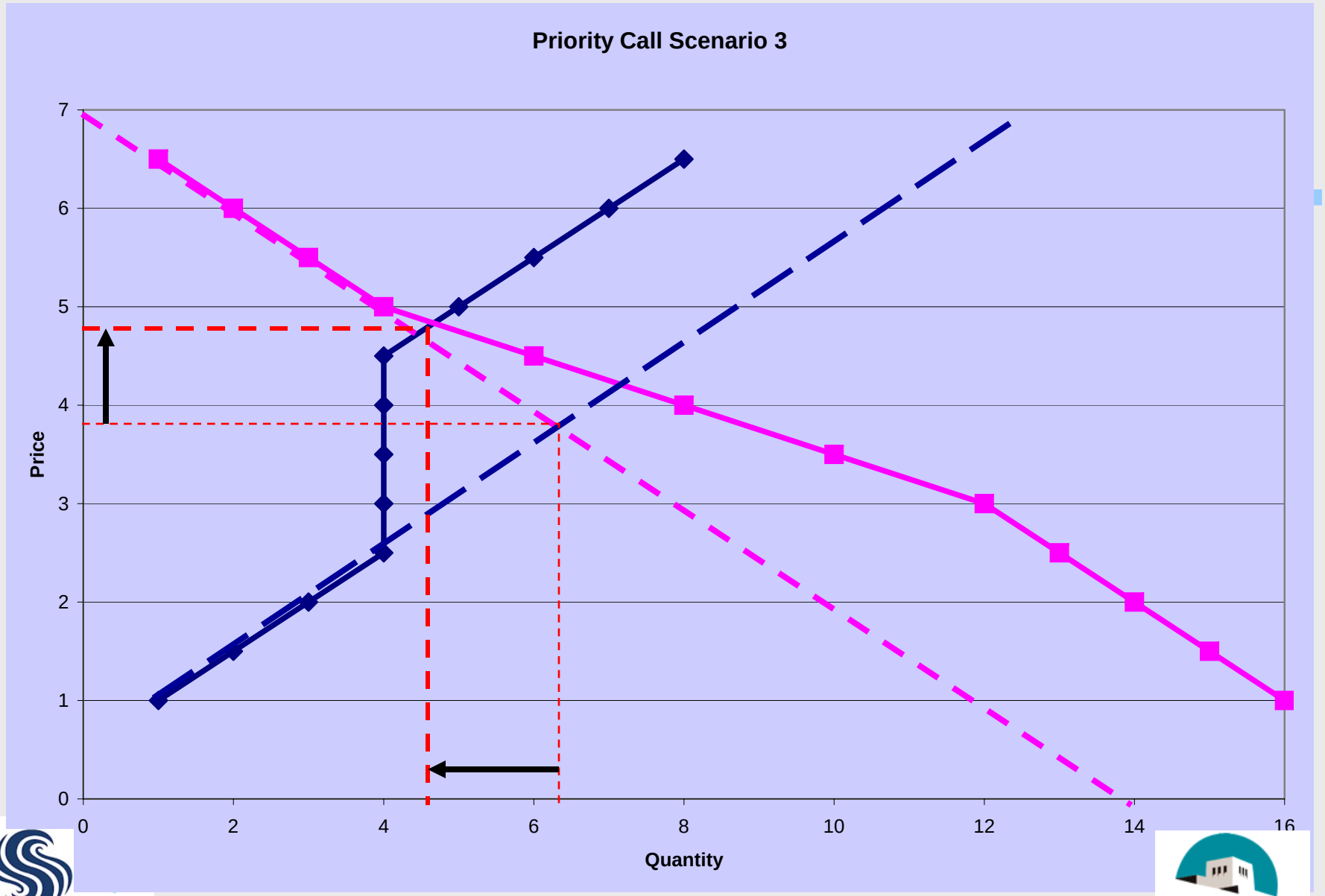
SCENARIO 3: SUPPLY REDUCTION
Jr. Rights Mid-Values

AGENT	Priority	$\overline{q}_{it}$	VMP	SUPPLY	DEMAND
A	8	1	1	1	16
B	7	1	1.5	2	15
C	6	1	2	3	14
D	5	1	2.5	4	13
E	12	0	3	4	12
F	11	0	3.5	4	10
G	10	0	4	4	8
H	9	0	4.5	4	6
I	4	1	5	5	4
J	3	1	5.5	6	3
K	2	1	6	7	2
L	1	1	6.5	8	1

SUPPLY REDUCTION (Jr. Rights Mid-Values)



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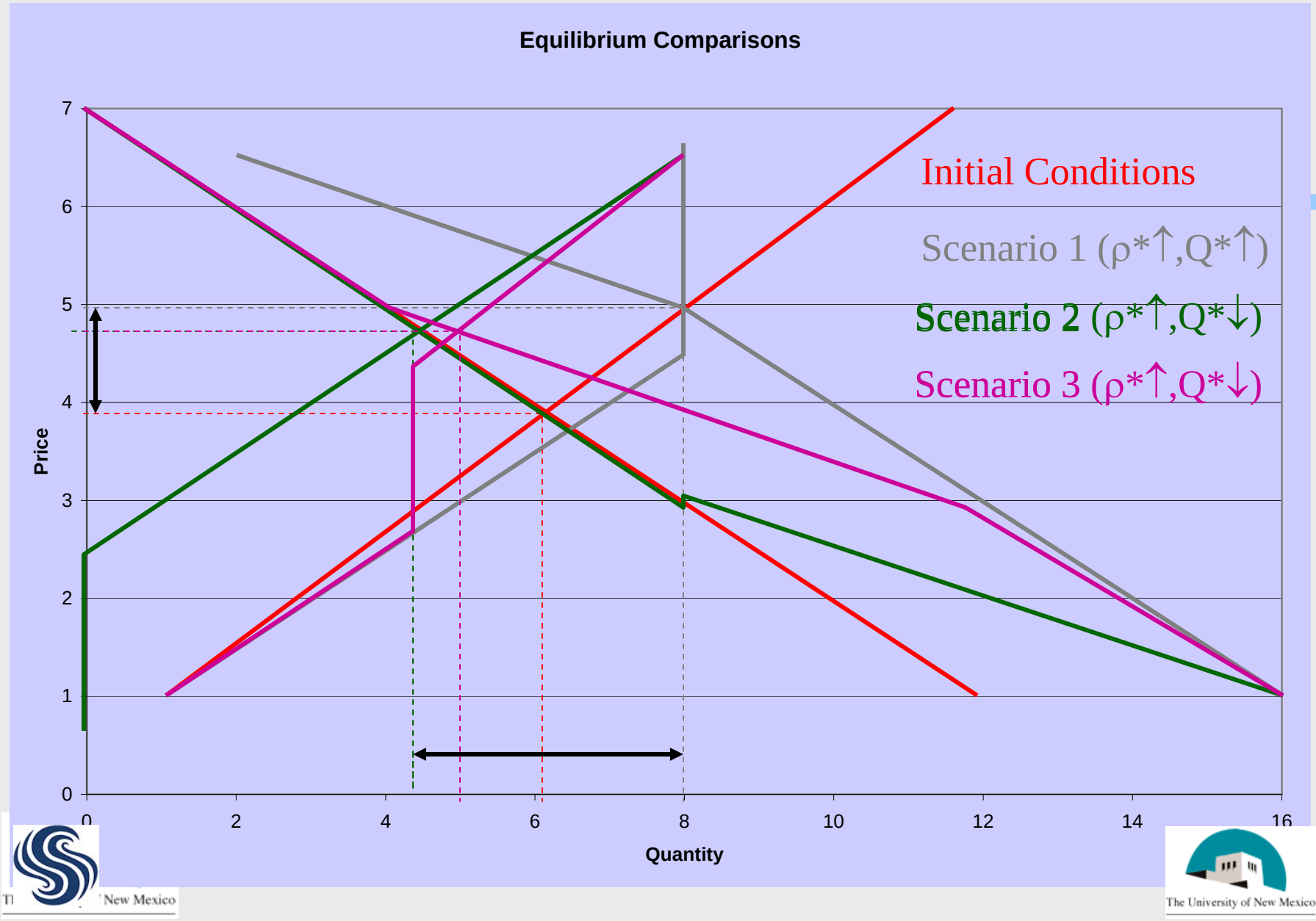
SUPPLY REDUCTION EQUILIBRIUM COMPARISONS



Forbearance

What is the objective?

- Storage
- In-stream flow
- Additional alternative uses

What are the rules?

- Individual choice
- Lateral choice
- Some other group level?

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Legislative or Regulatory

Cost?

Implementation Strategy?

Oversight?

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The Important Starting Questions May Be:

What is the objective?

What is the time frame?

What are the appropriate incentives?

What are the tradeoffs?

How do we implement?

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What are the interactions between the physical and behavioral aspects of the problem?

Economics for the sake of economics,
will fair no better than engineering for
the sake of engineering

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Components of Water Resource Management

- Economic Agents; Consumers, Suppliers

  Irrigators, urban centers, species, recreational

- Natural Physical Constraints; Climate

  Precipitation, river and groundwater systems. vegetation

- Manmade Constraints; Physical, Institutional

  Storage, conveyance systems, International, national, state and local institutions: property rights and agreements

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