Challenges and Opportunities for Emerging Groundwater Markets

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Groundwater plays a critical role in

- Mitigating drought and climate change risk
- Maintaining agricultural productivity, food security, and rural economies
- Sustaining freshwater ecosystem services

Today's seminar

Water stories

1. Groundwater is a common property resource
2. Declining groundwater levels are the primary driver of change in groundwater management
3. It's not feasible to monitor and enforce groundwater pumping restrictions
4. We have measured the surface of Mars at higher resolution and accuracy than we have measured agricultural groundwater use on Earth

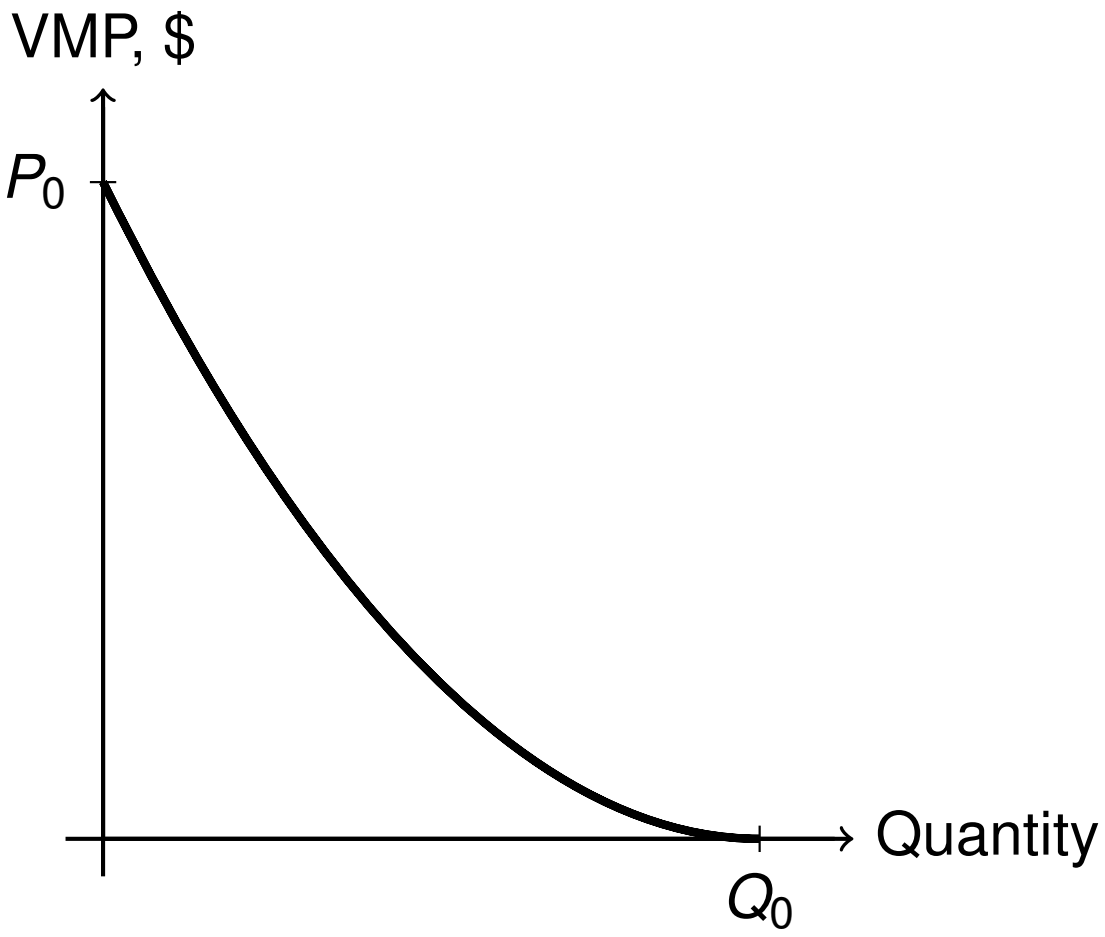
Water story #1

Groundwater as common property

Common property resources

Economic value of groundwater

Value of the Marginal Product



Water story #2

Declining groundwater levels are the primary driver of change in groundwater management

March 18, 2013

In Drought Ravaged Plains, Efforts to Save a Vital Aquifer

The New York Times

WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALT

POLITICS | EDUCATION | TEXAS

Published: May 19, 2013

An Underground Pool Drying Up

Portions of the High Plains Aquifer are rapidly being depleted by farmers

JournalStar.com

Drought's toll on groundwater is steepest on record

MAY 09, 2013 3:45 AM • BY ALGIS J. LAUKAITIS / LINCOLN JOURNAL STAR

Drought conditions across Nebraska forced irrigators, municipalities, industry and other users to pump heavily from groundwater wells last year.

Just how much water they used is beginning to show up in spring readings from observation wells maintained by many natural resources districts, especially those with a lot of irrigation.

The Upper Big Blue NRD on Wednesday reported an average decline of 4.38 feet in groundwater levels from a year ago.

Groundwater depletion in research

Vol 460/20 August 2009 | doi:10.1038/nature08238

LETTERS

nature

Satellite-based estimates of groundwater depletion in India

Matthew Rodell[1], Isabella Velicogna[2,3,4] & James S. Famiglietti[2]

Groundwater is a primary source of fresh water in many parts of the world. Some regions are becoming overly dependent on it, consuming groundwater faster than it is naturally replenished and causing water tables to decline unremittingly[1]. Indirect

India, water crisis means foul sludge' New York Times, 29 September 2006). The World Bank has warned that India is on the brink of a severe water crisis[9]. Nationally, groundwater accounts for about 50–80% of domestic water use and 45–50% of irrigation[4,10]. Total

PNAS

Groundwater depletion and sustainability of irrigation in the US High Plains and Central Valley

Bridget R. Scanlon[a,1], Claudia C. Faunt[b], Laurent Longuevergne[c], Robert C. Reedy[a], William M. Alley[b], Virginia L. McGuire[d], and Peter B. McMahon[e]

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Aquifer overexploitation could significantly impact crop production in the United States because 60% of irrigation relies on groundwater. Groundwater depletion in the irrigated High Plains

Tapping unsustainable groundwater stores for agricultural production in the High Plains Aquifer of Kansas, projections to 2110

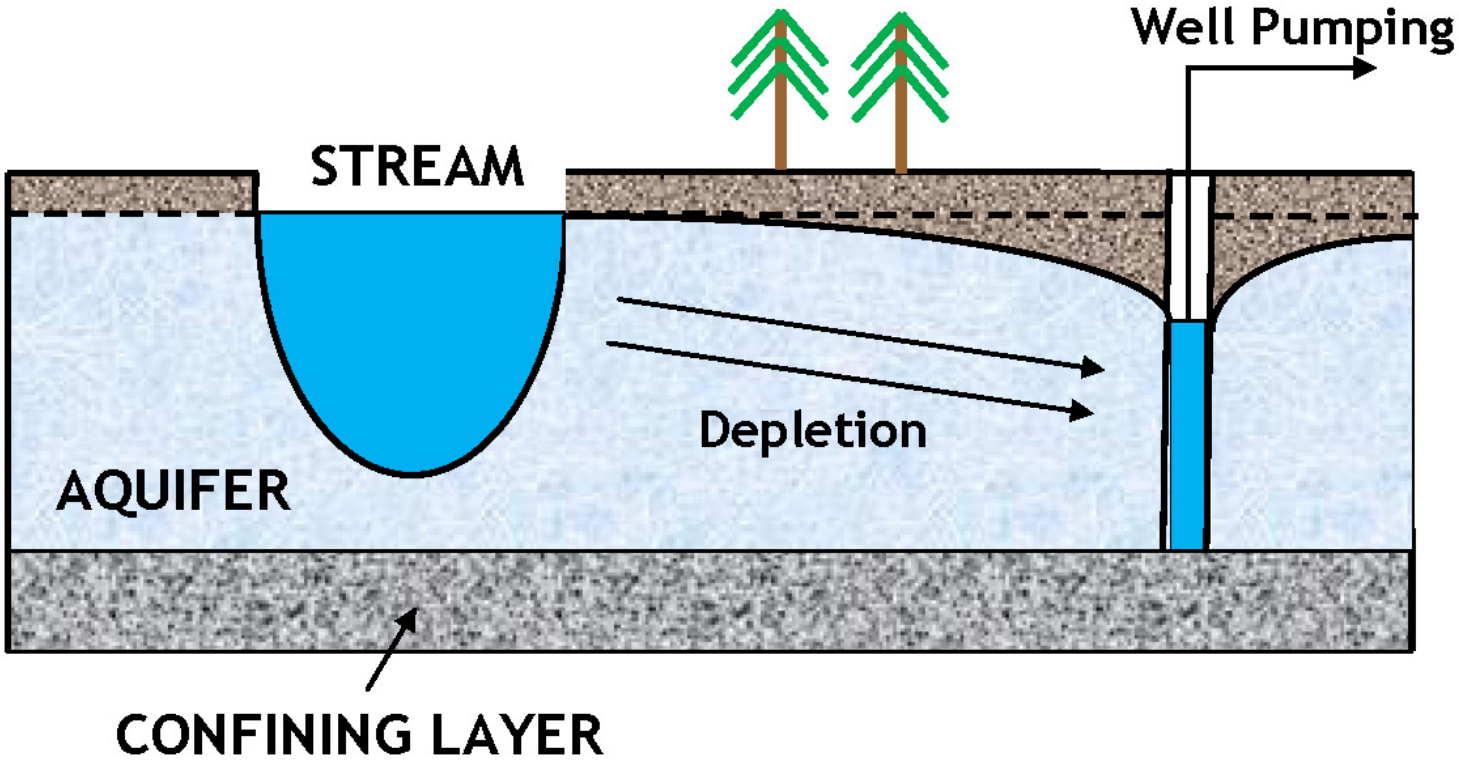
(rivers and aquifers) have only been depleted by ~10% globally, suggesting that we are not running out of water; however, we may be running out of water locally and during droughts because

PNAS PLUS

What drives binding change to groundwater policy?

What drives binding change to groundwater policy?

Surface water – groundwater interaction



Water story #3

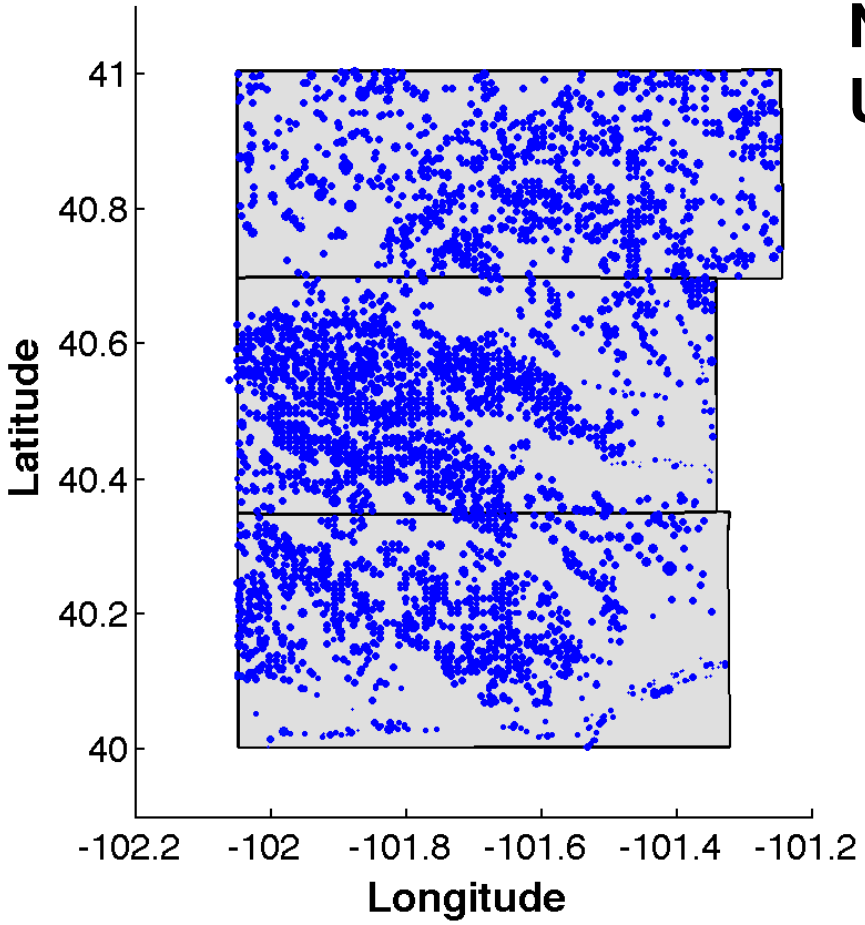
It's not feasible to monitor and enforce groundwater pumping restrictions

State of agricultural groundwater monitoring

- The Upper Republican NRD in Nebraska started metering in 1978 and was fully metered by 1982
- Metered agricultural groundwater use is also found elsewhere (Nebraska, Kansas, Australia, New Zealand, China)
- Meters can be controversial
- Monitoring of pumping restrictions is possible without meters through certification of irrigated acreage

Water story #4

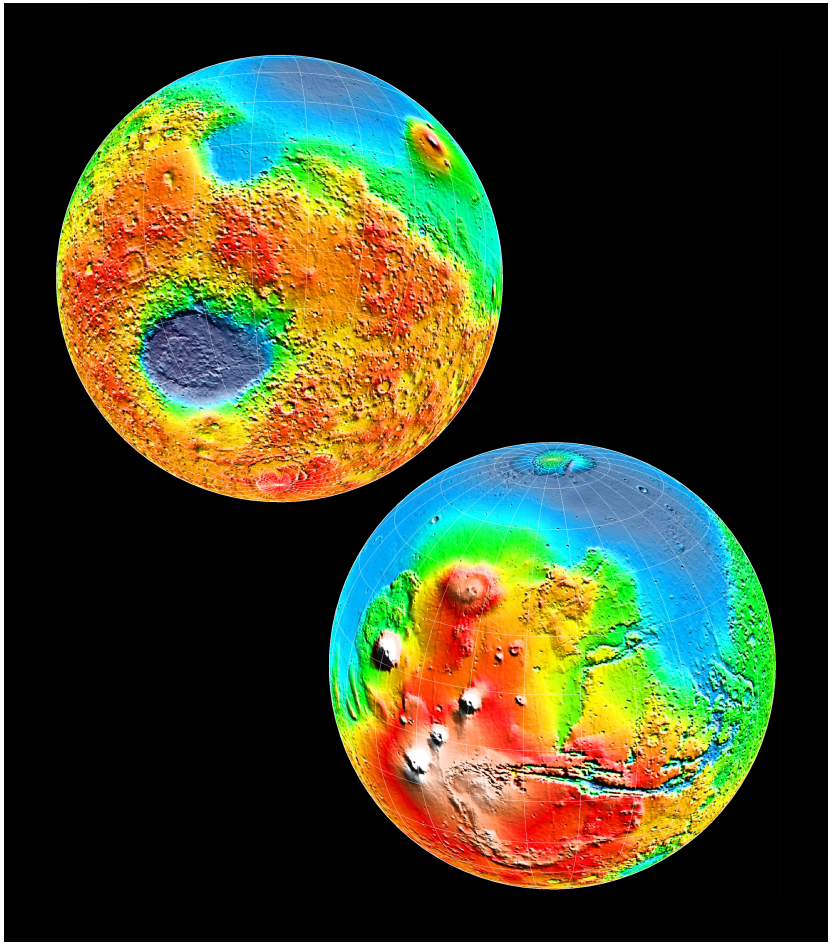
We have measured the surface of Mars at higher resolution and accuracy than we have measured agricultural groundwater use on Earth



NE DNR Wells database, URNRD

- Density: 3,200 data points in 7000 km^2, 1.48 km data spacing
- Accuracy: $\pm$ 2% for propeller flow meter

Martian topography



Mars Global Surveyor MOLA

- Resolution: 512-128 pixels per degree, 119-476 m data spacing
- Accuracy: $\pm$ 0.05%

Accuracy of water use data

		Year				
		2005	*2000*	*1995*	*1990*	*1985*
	Chase	-0.12	5.38	7.65	-4.50	-0.82
County	*Dundy*	5.11	-21.69	-15.59	-5.96	5.82
	Perkins	13.54	31.34	39.17	21.29	0.02

Notes: Numbers are percentage differences between USGS Water Use data and URNRD pumping records. A positive number means that the USGS data exceed the URNRD data for that county and year.

Acknowledgments

Groundwater management research

- Students
- Collaborators
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  - NSF IIP-1313526 (*I-Corps*)

State of groundwater management

Groundwater is generally managed locally, or not at all. There are two policy drivers:

1. **Long-term aquifer depletion**
   - In general, has not produced binding policy change
   - A few voluntary policies are in place
2. **Surface-water groundwater interaction**
   - Impacts on freshwater ecosystems
   - Transboundary surface water allocation
   - Ongoing litigation, with precompliance and regulated systems in place

Design of groundwater trading systems

- Need for a meaningful limit on aggregate pumping
- Monitoring and enforcement
- Transaction costs
- Consideration of spatial externalities
- Conveyance issues
- Consumptive water use
- Other considerations

Design of groundwater trading systems

- **Need for a meaningful limit on aggregate pumping**
  Heterogeneity under pumping constraints drives gains from trading
- **Monitoring and enforcement**
  - Must be present, even if imperfect
  - In 2010, the Upper Republican NRD revoked groundwater pumping rights with value >$3 million
  - Verifiability of decertification is also critical
- **Transaction costs**
  Existence of ‘coffee shop’ markets suggests gains exceed transaction costs

Design of groundwater trading systems

- **Consideration of spatial externalities**
  - Often a primary driver of regulation
  - Lead to complex rules and regulations e.g. zoning, offsets
- **Conveyance issues**
  Unlike surface water markets, conveyance is not an issue
- **Consumptive water use**
  - Existing markets transfer either applied water or irrigated acreage
  - Reasons are likely pragmatic
- **Other considerations**
  Paper water, carryover provisions. . .

State of agricultural groundwater trading

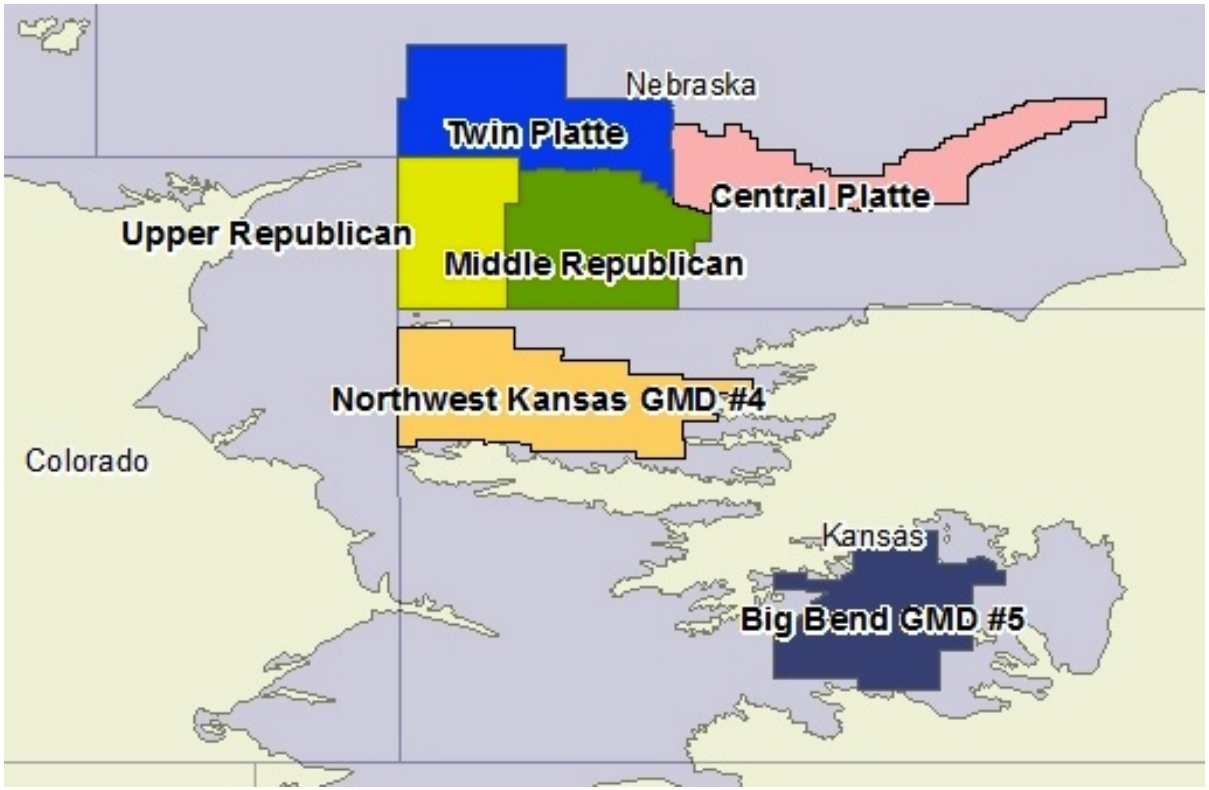
There are growing number of regions with frameworks for trading, and a few emergent informal and formal groundwater markets:

- US High Plains region
- Australia
- Other regions

State of agricultural groundwater trading

US High Plains region

- Nebraska (e.g. Republican and Platte River Basins)
- Kansas (e.g. Sheridan-6 LEMA)



State of agricultural groundwater trading

- **Australia**
  (National Water Initiative e.g. Murray-Darling Basin)
- **Other regions**
  (Texas, Arizona, California, New Zealand, China, South Asia)

Example: Groundwater markets in the High Plains Aquifer

- Basic issue: Pumping needs to be reduced from historic levels
- Goals of management:
  1. Compact compliance for stream depletion (Republican)
  2. Endangered species protection (Platte)
  3. Desire for long-term aquifer preservation

Example: Groundwater markets in the High Plains Aquifer

Approaches:

- Certification of irrigated acreage
- Moratoria on new wells
- Metering of wells (mandatory in RRB)
- Quantified and allocated irrigation rights (**quotas**)
- Strong local enforcement
- Active **land retirement**/stream augmentation projects (>$100 million in 2011 and 2012)
- Limited **transferable permit** systems

Policy questions

Motivation

- Have a spatial, dynamic hydrologic system with many heterogeneous decision makers
- Each management choice
  - Provides different incentives to each farmer
  - Leads to different hydrologic impacts
  - Produces a different tradeoff between lost agricultural production and instream benefit
- Multiple types of policies are currently in use
- It is important to understand which policies are effective, and why

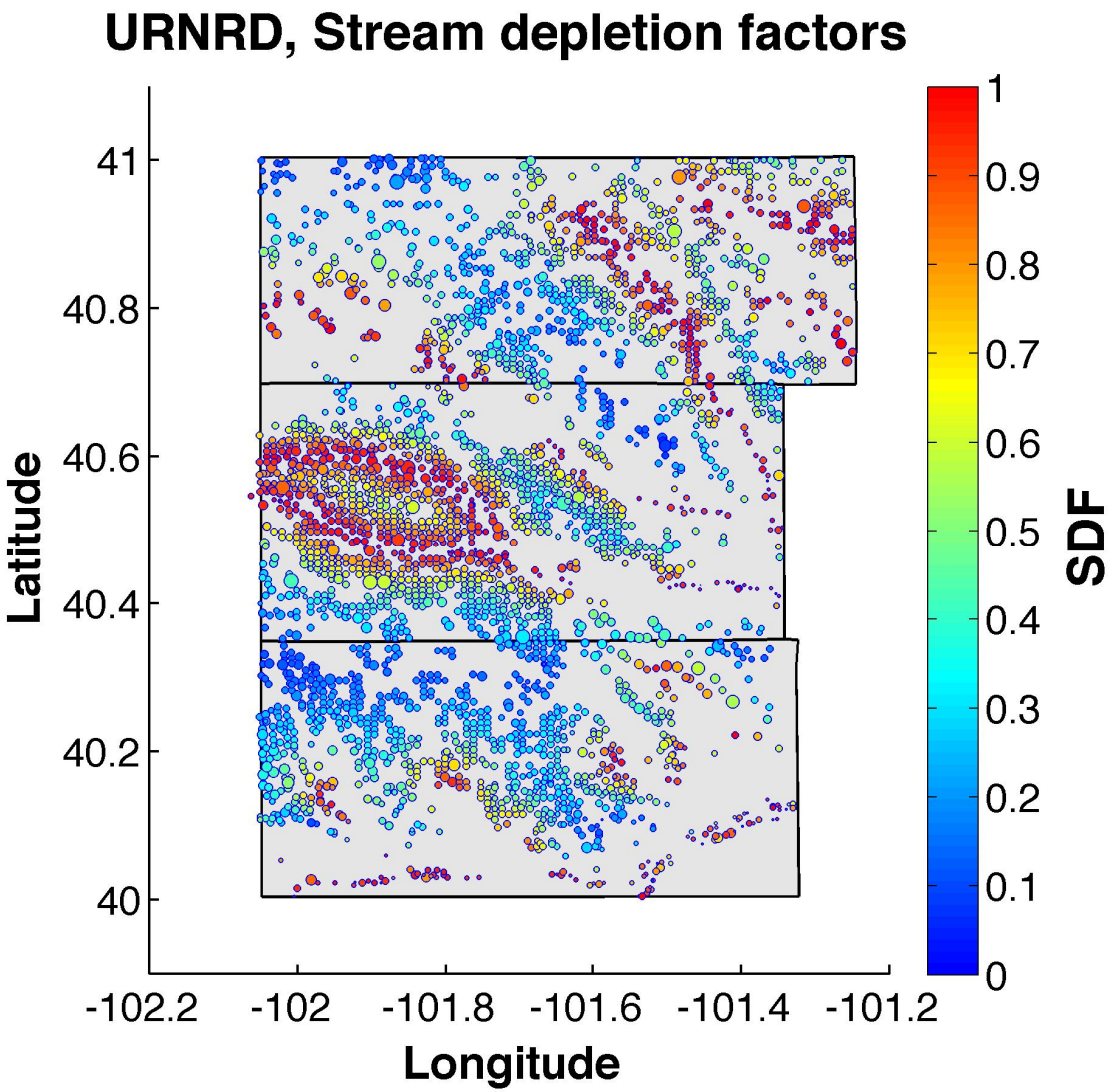
Policy Analysis

Policies may be *targeted* in many different ways:

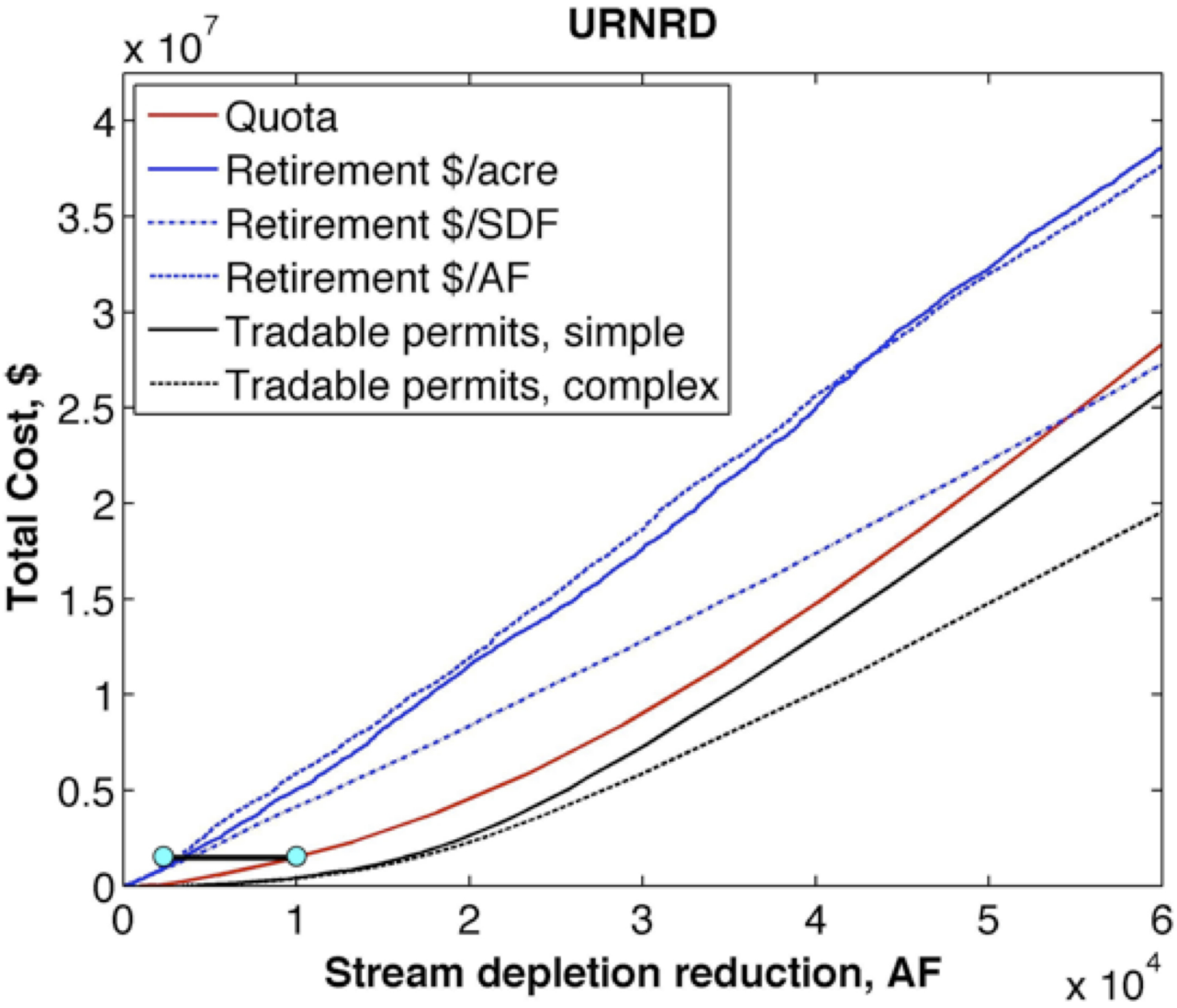
1. Land retirement ($/acre, $/AF, $/SDF)
2. Quotas (with or without zoning)
3. Tradable permits (simple, complex)

Analysis at Natural Resources District level, as this is the management unit

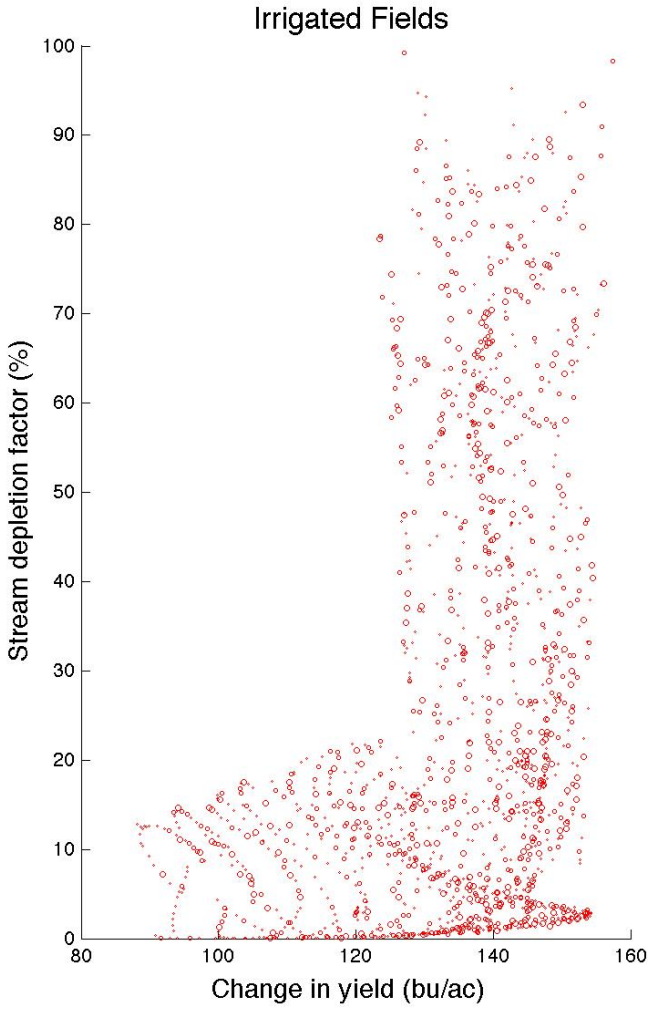
URNRD, Republican River Basin, NE

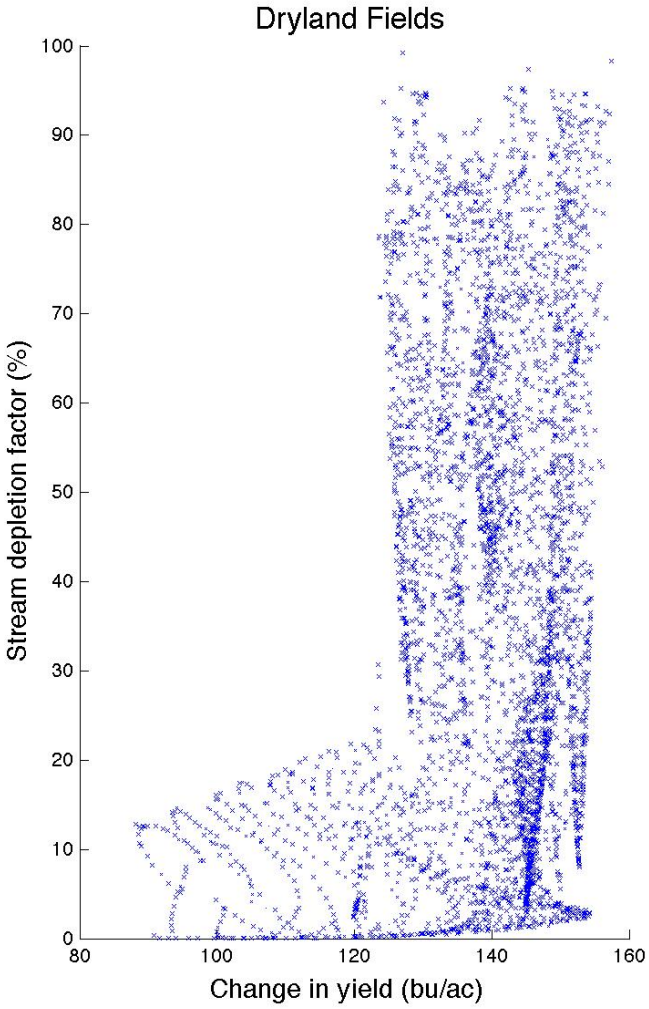


Comparison of Water Management Policies



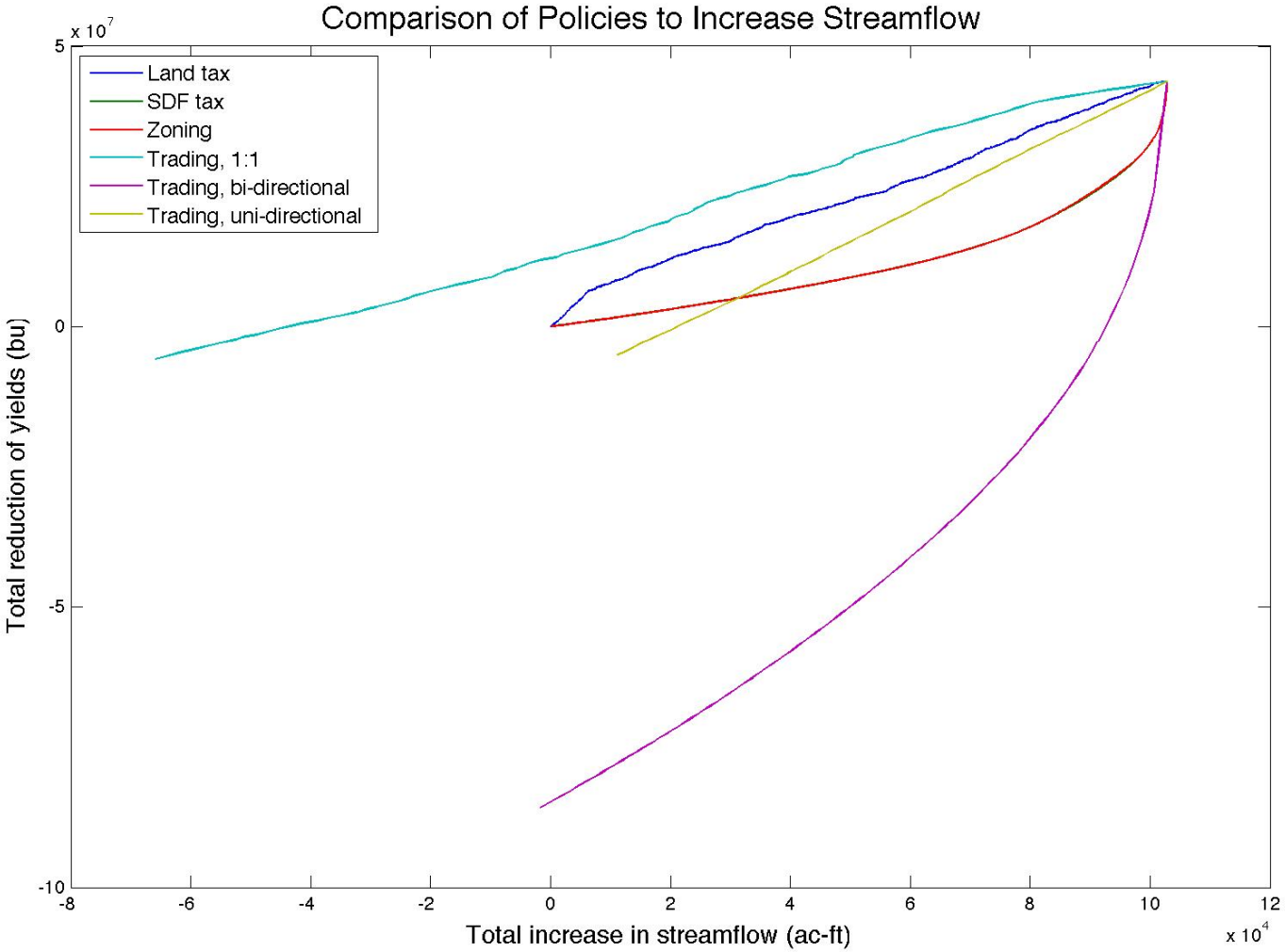
TPNRD, Platte River Basin, NE





Comparison of Water Management Policies

TPNRD, Platte River Basin, NE



Experiences with setting up online groundwater markets

- Many environmental markets are ‘coffee shop’ markets or bulletin boards
- We’re working with producers and water districts in Nebraska to build custom online trading systems
- Permanent transfers and leases of groundwater (URNRD); permanent transfers (TPNRD)
- Online systems offer:
  - Anonymous, confidential bidding
  - Automated clearing for regulatory compliance and checks on verifiability
  - Expedited permitting

Trading groundwater rights – lessons learned

- In the US, local water districts manage transfers
- Regulations are complex and dynamic
- How transfers are permitted is often quite different to how regulations are written
- Verifiability is the most important issue for water managers
- Value proposition is the most important issue for producers

Summary

- Stream depletion is the primary driver of changes in groundwater management
- Binding pumping constraints with monitoring and enforcement are feasible
- Nascent groundwater trading systems exist worldwide
- Trading systems offer increased profits to producers and resource conservation benefits
- There is mismatch between current economic research on groundwater management and applied needs

Thank you!

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