# "Smart Markets" for Nutrient Trading

## *Why do nutrient markets work so badly?*
## *A solution.*

**John F. Raffensperger, RAND Corp., jraffens@rand.org**

R. A. Ranga Prabodanie, Wayamba Univ., Sri Lanka,

Jill A. Kostel, The Wetlands Initiative, Chicago

Reference: "Feasibility Assessment of a Nutrient Trading Market in the Big Bureau Creek Watershed Final Report," for U.S. EPA Targeted Watershed Grant WS-00E71101, The Wetlands Initiative, 2014.

*This is not a RAND output.*

# Why do nutrient markets work so badly?

- People want to trade, because they can make money.
- Policymakers try to help. Scientists try to help.

So what's wrong?

- Unclear rights?
- Lack of TMDLs?
- Unclear science?

But trading is rare even with
clear rights, firm TMDLs and good science.

http://www.bls.gov/ooh/images/15736.jpg

# Because the transaction cost (TC) is big.

To make a trade, say, a WWTP must:

- find a trading partner (TC),
- negotiate a price (bigger TC),
- write a contract (even bigger TC),
- take the deal to the state agency for approval (huge TC),
- enforce the contract with the trading partner (vast TC).


If the state has the data, they

- check the trade against the effects,
- negotiate with both traders,
- verify they did what they promised.

Time 6 months? A year? 2 years?

**Result**: "Thin trading," "inactive market,"
"lack of demand," "lack of supply," "people don't want to trade,"
"business risk," "uncertain business environment," . . .

www.cmtengr.com/images_2014/wr_smsd.jpg
www.semissourian.com/photos/16/99/03/1699033-L.jpg

# What if?

A hydrologist/hydrogeologist wrote a detailed **optimization**,

- detailed hydrological data, nitrate + phosphorus,
- all relevant users PS & NPS, detailed effects by season,
- users' values for discharge, runoff, land use changes,
- all TMDLs, by season.
- Choose point and non-point source discharges to minimize the cost of satisfying the TMDLs.
- Maybe even give landowners the option to build wetlands, with bids to build the wetlands at various locations.

Push button solution: lowest cost discharges that meet TMDLs.

A fantasy!

- The scientist does not know users' values for discharge.
- The scientist has no real authority to implement the solution.

# Solution: put up a web page & ask for bids.

“Smart market”:

a centralized market, operated by the regulator, cleared with an optimization model.

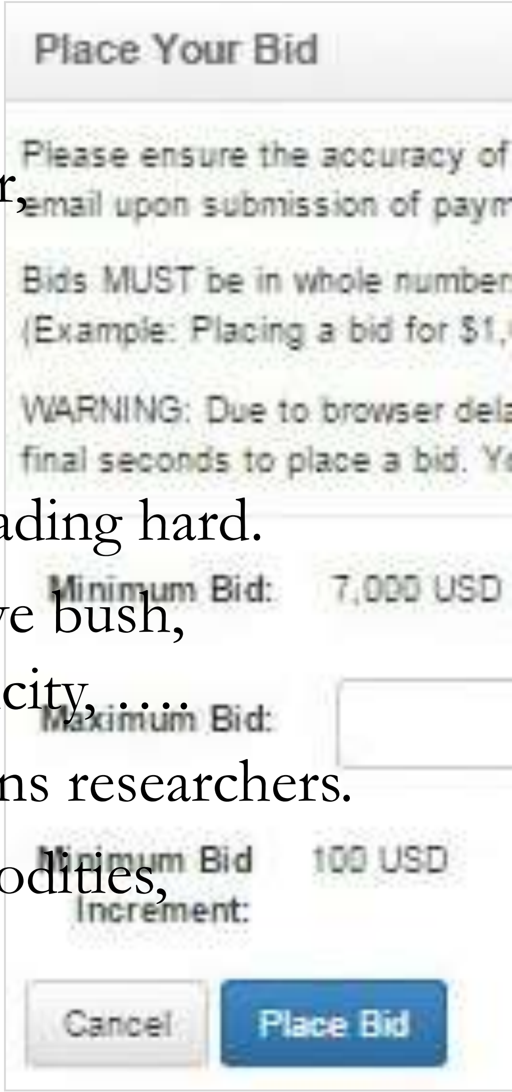
People buy from and sell to a market manager.

Best for a market that **needs help**, when **complexities** would otherwise make trading hard.

Radio spectrum, transportation, natural gas, Aus native bush, kidney transplants, medical internships, electricity, ….

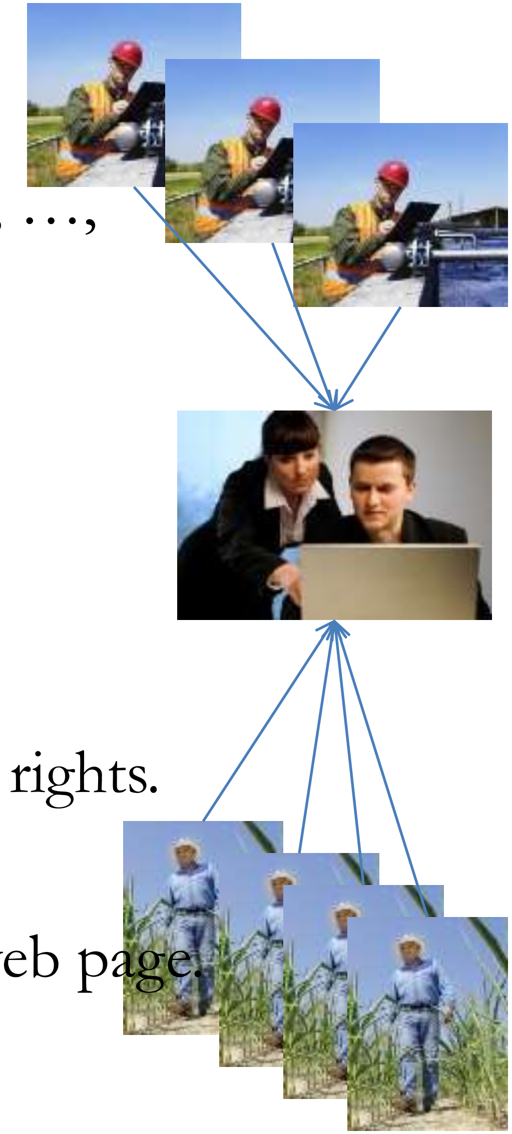
Lots of work by experimental economists & operations researchers.

Active implementation world-wide, for lots of commodities, **except water resources**.*




** Mammoth Trading claims to have a smart market for water qty.*

# How it works



All users, PS, NPS, wetland builders, non-profits, govt, …, trade only with the central market manager.

The market manager uses an optimization model to

- choose bids to accept,
- set prices,
- ensure the discharges satisfy the physics, and
- ensure the discharges satisfy TMDL constraints.

Trades are *leases* for a season of underlying permanent rights.

Simultaneous many-to-many trading.

Much lower transaction costs – users just bid onto a web page.

Same **prerequisites** as other market designs:

- TMDLs, specification of initial rights, recording of rights.
- Decide who runs it (local regulator is probably best).

# *Model* complexity, but *market* simplicity

Bids, kg: $BuyQty_{u,b,n,t}$ & $SellQty_{u,b,n,t}$ and prices, \$: $BuyPrice_{u,b,n,t}$ & $SellPrice_{u,b.n,t}$ each user $u$, bid step $b$, nutrient $n$, season $t$.

Initial permit holdings of traders, kg: $D_{u.n,t}$

Stream attenuation factors, kg: $A_{(k,j),n,t}$

Nutrient absorption of proposed wetlands, kg: $WA_{(l,j),n,t}$, price $WPrice_u$

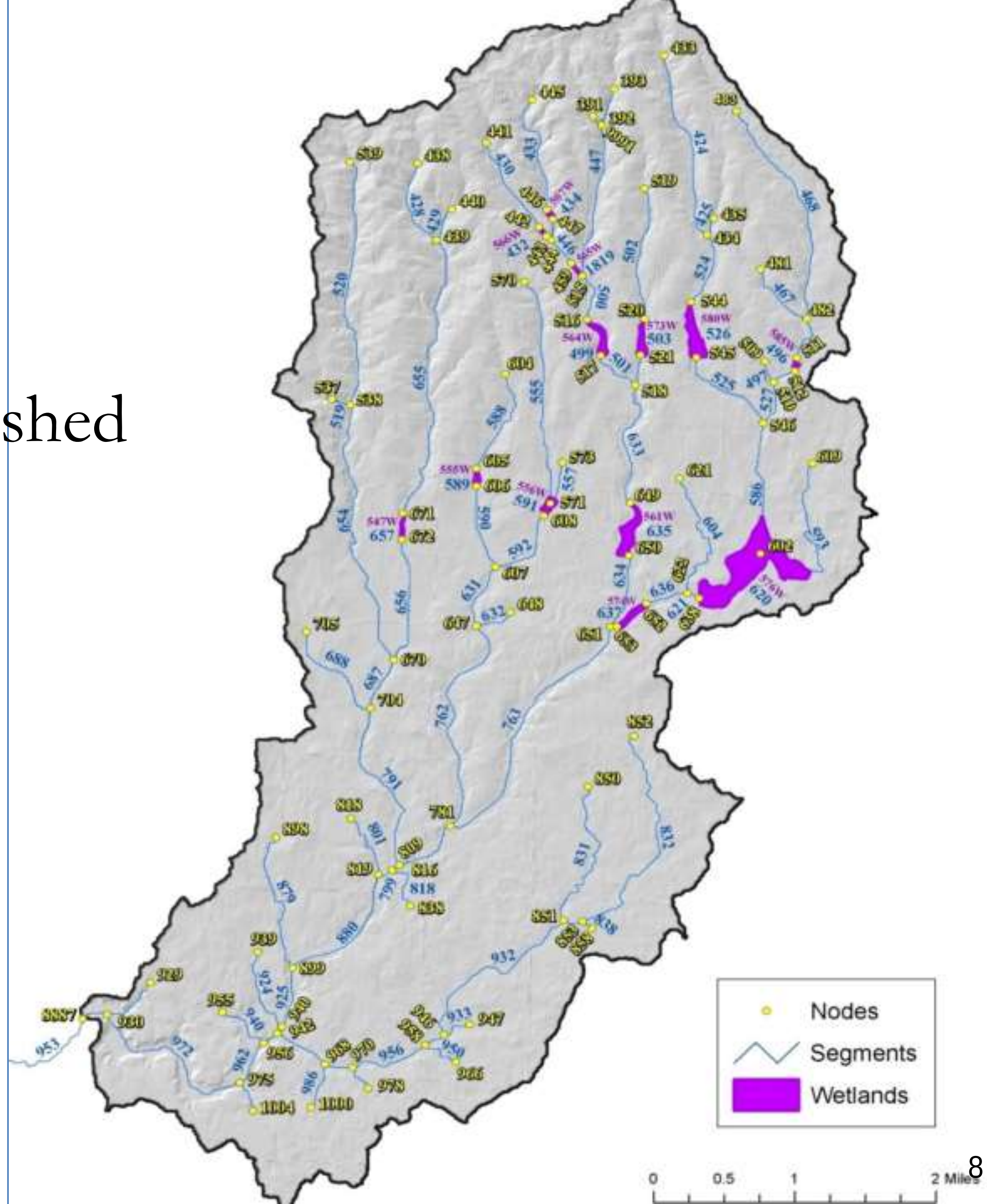
Load limits at the outlet: $\alpha G_{last,n,t}$ where $\alpha$ is % of current load $G_{last,n,t}$

Quantity to accept from each bid, kg: $buy_{u,b.n,t}$ and $sell_{u,b.n,t}$. Acceptance of wetland offers: $w_u$, 0 or 1.

Final right-to-discharge of each trader, kg: $q_{u,n,t}$. Nutrient load at each node of the stream, kg: $x_{j,n,t}$

1. Max $\sum_{\text{traders } u}\sum_{\text{bids } b}\sum_{\text{nutrient } n}\sum_{\text{season } t} (BuyPrice_{u,b,n,t}buy_{u,b.n,t} - SellPrice_{u,b.n,t}sell_{u,b.n,t}) - \sum_{\text{traders } u} WPrice_u w_u$
2. $q_{u,n,t} = D_{u.n,t} + \sum_{\text{bid steps } b}(buy_{u,b.n,t} - sell_{u,b.n,t})$ for non-wetland trader $u$, nutrient $n$, season $t$.
3. $x_{j,n,t} = \sum_{\text{trader } u \in j} q_{u,n,t} + \sum_{k\,|\,(k,j)\in \text{stream segs}} (1- A_{(k,j),n,t})x_{k.n,t} + \sum_{l\,|\,(l,j)\,\in\, \text{wetland segs}} (x_{l.n,t} - WA_{(l,j),n,t}w_u)$
   for node $j$, nutrient $n$, and season $t$. Dual price $p_{j.n,t}$.
4. $x_{last.n,t} \le \alpha G_{last,n,t}$ for assessment point node *last*, nutrient $n$, season $t$. Dual price $p_{last.n,t}$
5. $0 \le buy_{u,b,n,t} \le BuyQty_{u,b,n,t}$, $0 \le sell_{u,b,n,t} \le SellQty_{u,b,n,t}$ for trader $u$, bid step $b$, nutrient $n$, and season $t$.
6. $q_{u,n,t}$ free for each trader $u$, nutrient $n$, season $t$; $x_{j,n,t} \ge 0$ for each node $j$, nutrient $n$, season $t$.

# Lime Creek Watershed TWI (2014)



# Lime Creek Simulation

1 STP, 462 farms, 13 potential wetlands, 10 year auction period.

Cost data for offers: TWI 2014 economic analysis.

Results:

- Attainable reductions of 20%, 30%, 40%, 50%, 60%.
- Infeasible for reductions of 80% and 100%.
- Depending on % reduction, accepted up to 7 of 13 wetland offers.
- Some proposed wetlands were uneconomical under all scenarios.
- Wetlands are more attractive downstream.
- *Please see our paper to understand how we price the non-convex wetlands!*

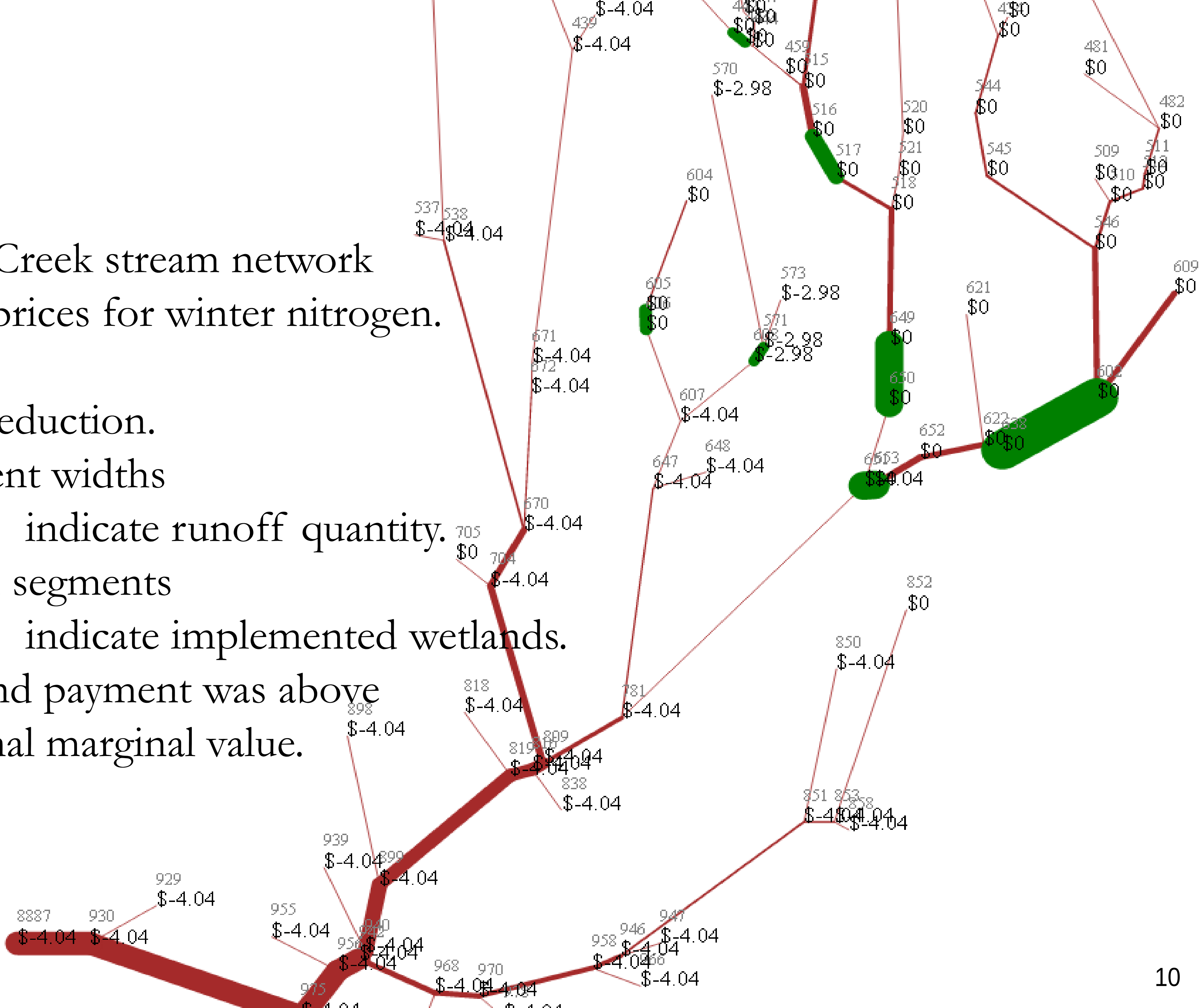
Lime Creek stream network node prices for winter nitrogen.

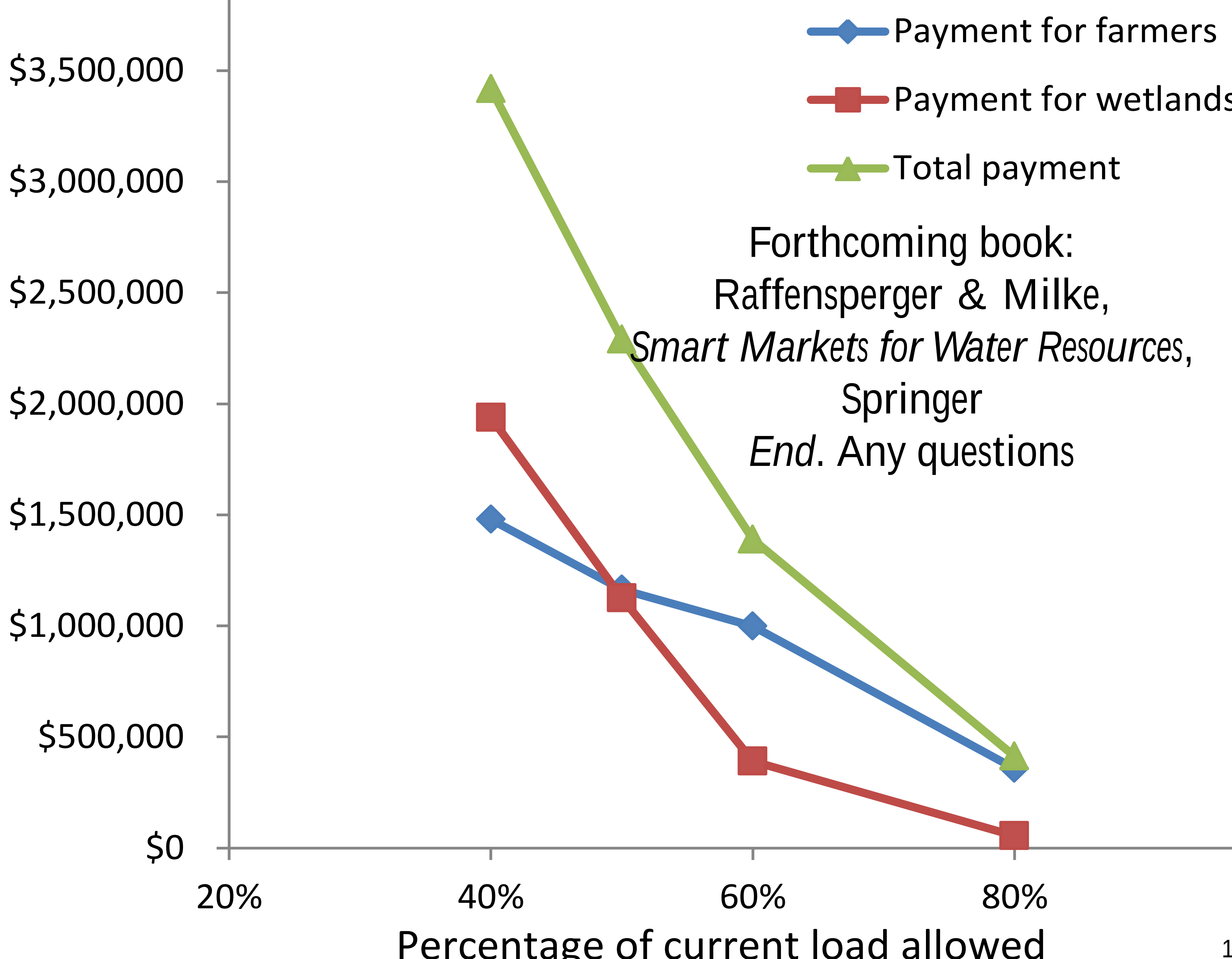
60% reduction.

Segment widths indicate runoff quantity.

Green segments indicate implemented wetlands.

Wetland payment was above seasonal marginal value.






Forthcoming book:
Raffensperger & Milke,
*Smart Markets for Water Resources*,
Springer

*End*. Any questions