“Smart Markets” for Nutrient Trading
Why do nutrient markets work so badly?
A solution.

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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,” . . .
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 $\sum_{\text{traders}} \sum_{\text{bids}} \sum_{\text{nutrient}} \sum_{\text{season}} (BuyPrice_{u,b,n,t} buy_{u,b,n,t} - SellPrice_{u,b,n,t} sell_{u,b,n,t}) - \sum_{\text{traders}} WPrice_u w_u$

2. $q_{u,n,t} = D_{u,n,t} + \sum_{\text{bid steps}} (buy_{u,b,n,t} - sell_{u,b,n,t})$ for non-wetland trader $u$, nutrient $n$, season $t$.

3. $x_{j,n,t} = \sum_{\text{trader} u \in j} q_{u,n,t} + \sum_{k \mid (k,j) \in \text{stream segs}} (1 - A_{(k,j),n,t}) x_{k,n,t} + \sum_{l \mid (l,j) \in \text{wetland segs}} (x_{l,n,t} - WA_{(l,j),n,t} w_u)$ for node $j$, nutrient $n$, and season $t$. Dual price $p_{j,n,t}$

4. $x_{last,n,t} \leq \alpha G_{last,n,t}$ for assessment point node last, nutrient $n$, season $t$. Dual price $p_{last,n,t}$

5. $0 \leq buy_{u,b,n,t} \leq BuyQty_{u,b,n,t}$, $0 \leq sell_{u,b,n,t} \leq SellQty_{u,b,n,t}$ for trader $u$, bid step $b$, nutrient $n$, and season $t$.

6. $q_{u,n,t}$ free for each trader $u$, nutrient $n$, season $t$; $x_{j,n,t} \geq 0$ 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.
Figure 1: Total payments for farmers and wetlands.

1.1 Nodal prices

The prices can differ at each node in the stream network. Interestingly, the downstream nodes of some accepted wetlands may have prices of $0 for a nutrient or season. For example, Table 1:

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<th>Percentage of current load allowed</th>
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<tbody>
<tr>
<td>20%</td>
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<tr>
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<td>60%</td>
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<td>80%</td>
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<table>
<thead>
<tr>
<th>Payment for farmers</th>
<th>Payment for wetlands</th>
<th>Total payment</th>
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</thead>
<tbody>
<tr>
<td>$0</td>
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<td>$500,000</td>
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<tr>
<td>$2,000,000</td>
<td>$2,000,000</td>
<td>$4,000,000</td>
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Forthcoming book: Raffensperger & Milke, Smart Markets for Water Resources, Springer

End. Any questions.