Maximizing the Value of Existing Monitoring Technologies:

Stream Temperature and Dissolved Oxygen as Best Case Examples

2014 National Monitoring Conference

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The Challenge

- Restoration monitoring programs are "predestined to fail" (Ralph et al, 2003)
- Only 10% of 37,000 projects totaling $14B included monitoring (Bernhardt et al, 2005)

- Bernhardt, E.S., Palmer, M.A., Allan, J.D., Alexander, G., Barnas, K., Brooks, S., et al., 2005. *Synthesizing US River Restoration Efforts*. Science 308: 636–637.
- Ralph, S.C., Poole, G.C. 2003. *Putting Monitoring First: Designing Accountable Ecosystem Restoration and Management Plans*. Restoration of Puget Sound Rivers, Chapter 9. David R. Montgomery, Susan Bolton, Derek B. Booth, Leslie Wall, editors. Center for Water and Watershed Studies, University of Washington Press.
- Meyer, S.M., Konisky, D.M., 2005. Community-based Environmental Protection: A status Report and Some New Evidence. Paper presented at the annual meeting of the The Midwest Political Science Association, Palmer House Hilton, Chicago, Illinois, Apr 07, 2005.
- Palmer, M., Allan, J.D., Meyer, J., Bernhardt, E.S., 2007. *River Restoration in the Twenty-First Century: Data and Experiential Knowledge to Inform Future Efforts*. Restoration Ecology 15(3): 472-481.

Proposal: Redefine Water Quality Protection

Technical Aspects

1. Finite list of “ideal” parameters (e.g., temperature, DO)
2. Rental service of sensor technology (private sector)
3. Central data analysis/storage (public sector or NGO)
    - Statistical stability is key

People Aspects

4. ‘Headwaters first’ approach,

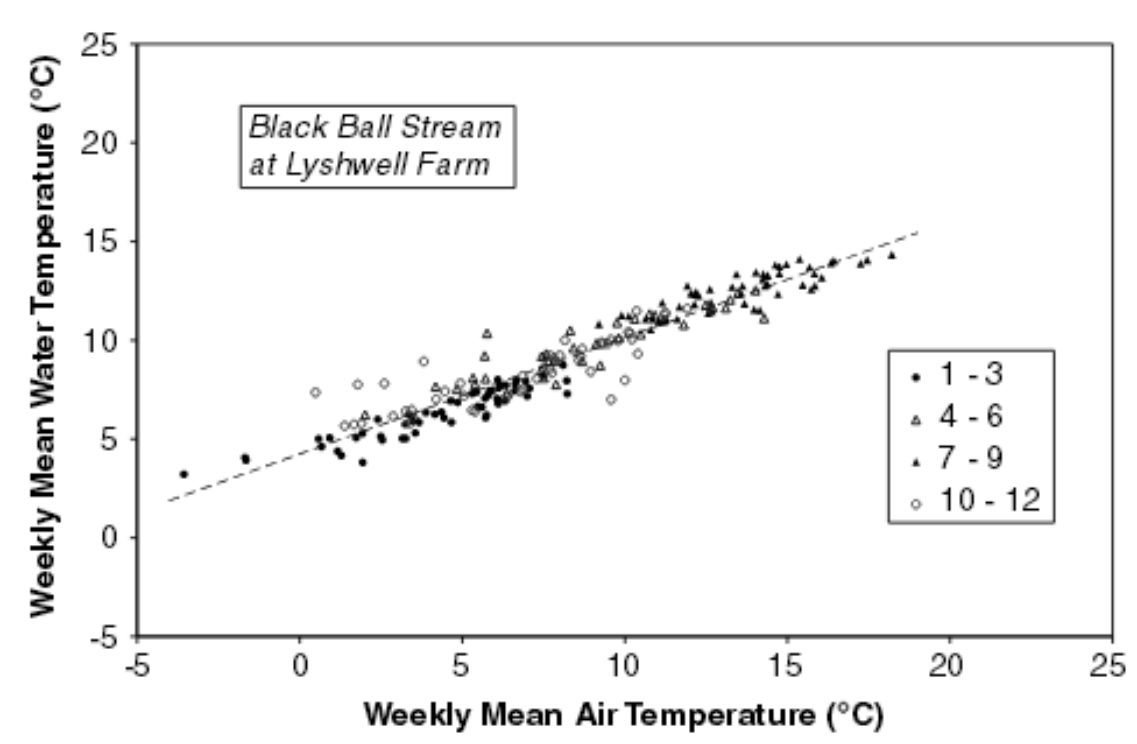
5. ‘Restore what we can measure first’ approach

Bonus

Division of labor to assess our Nation’s waters

Water-Air Temperature Relationship

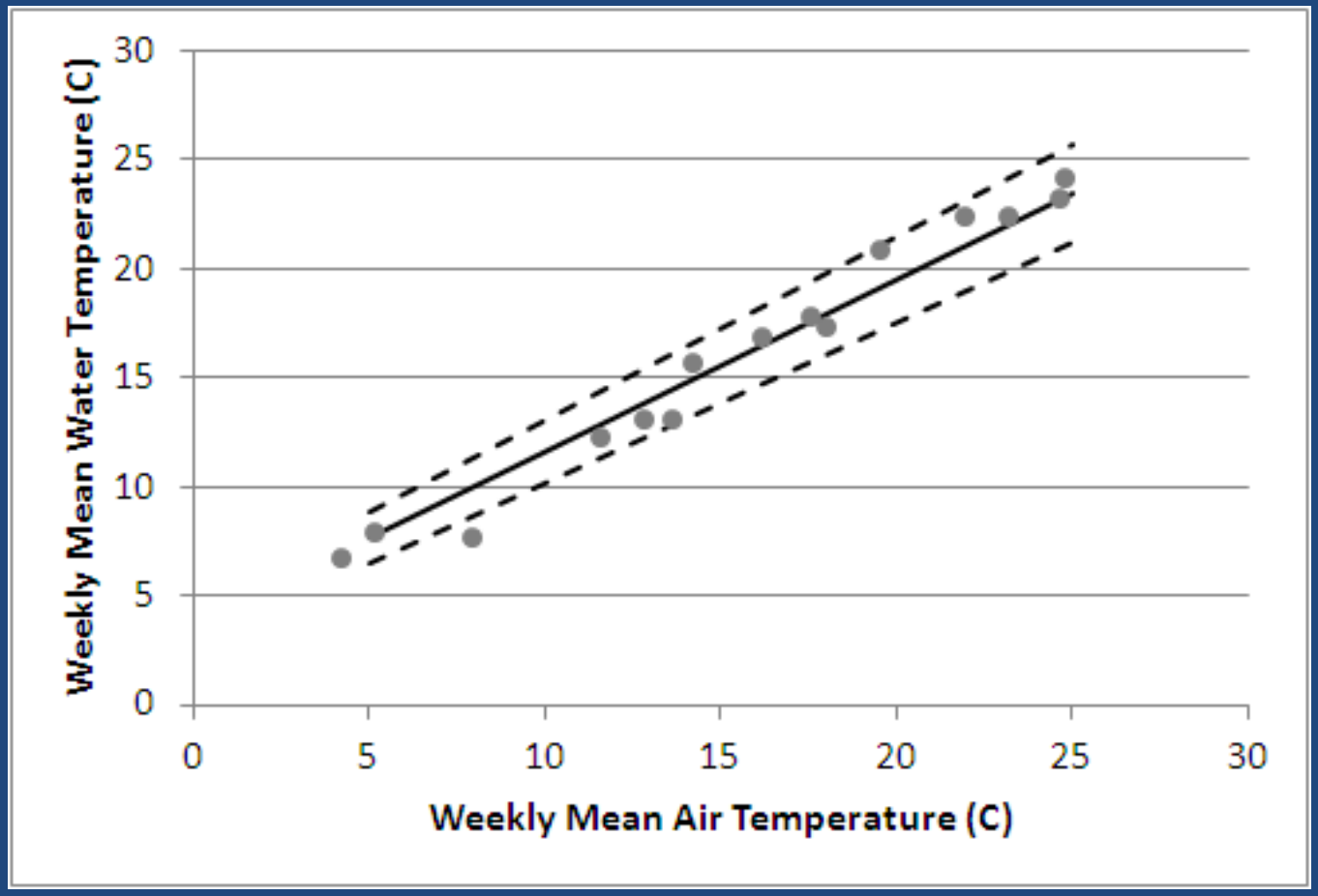
- Air temperature can be nearby weather station



- Webb, B.W., Clack, P.D., Walling, D.E., 2003. *Water–air temperature relationships in a Devon river system and the role of flow*. Hydrological Processes, 17: 3069-3084.
- Pilgrim, J.M., Fang, X., Stefan, H.G., 1998. *Stream Temperature Correlations with Air Temperatures in Minnesota: Implications for Climate Warming*. Jour. of the American Water Resources Association 34(5): 1109-1121.
- Bogan, T., Mohseni, O., Stefan, H.G., 2003. *Stream temperature-equilibrium temperature relationship*. Water Resources Research 39(9): 1245.

95% certainty with just 3 months of data

- Data gathered in Fall 2012 near Washington, DC
- 95% confidence of the slope is extremely good



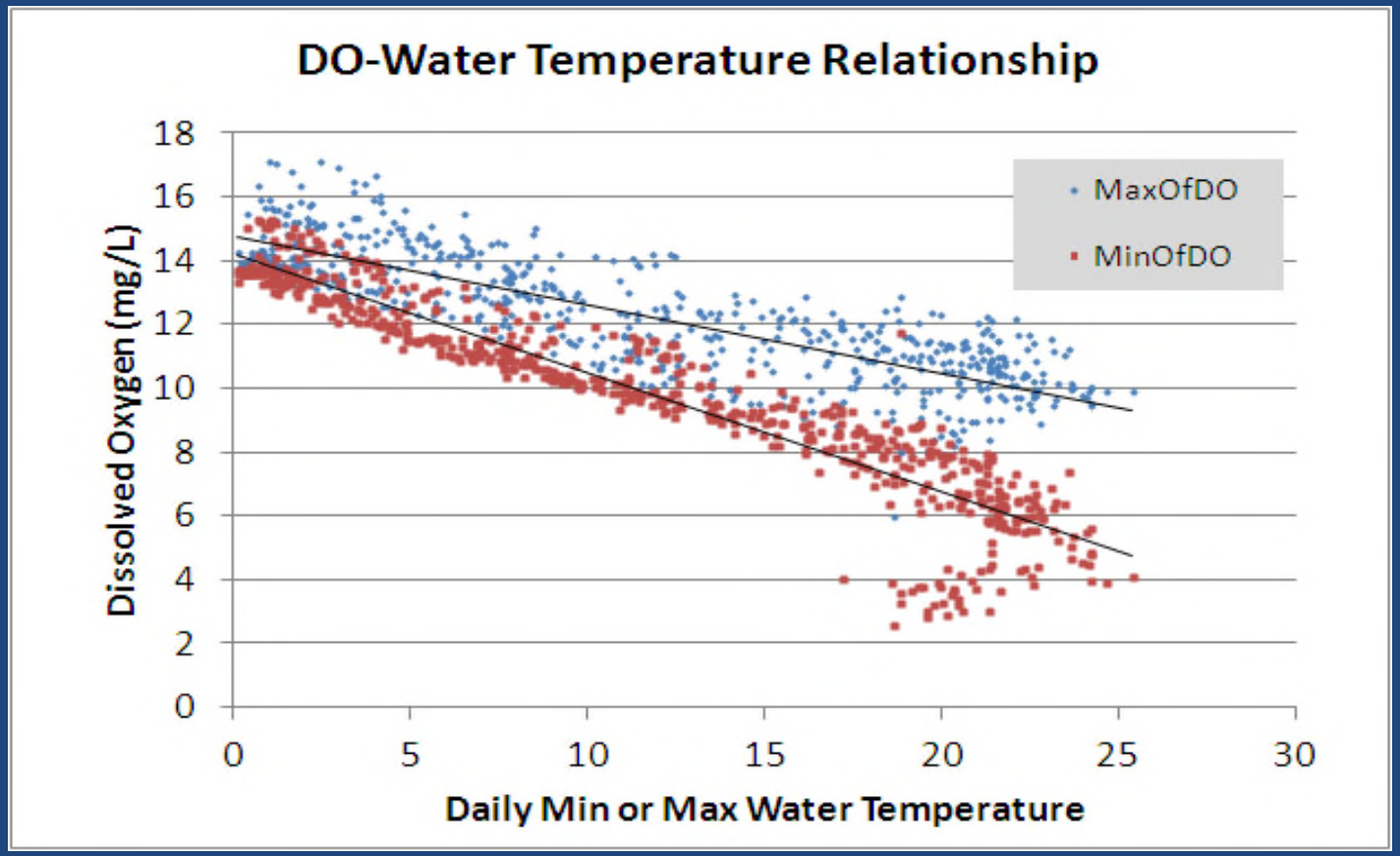
Advantages compared to maximum daily/weekly temperature

- Less sensitivity to year-to-year variability of precipitation
- Insensitive to year-to-year variability of air temperatures
- Insensitive to precision of a given sensor,
- Insensitive to sensor random error,
- Slope is insensitive to sensor one-way bias error,
- 95% confidence of the slope is extremely good.

Conclusion – Slope of Water-Air Temperature Relationship is an ideal parameter for assessing year-to-year changes.

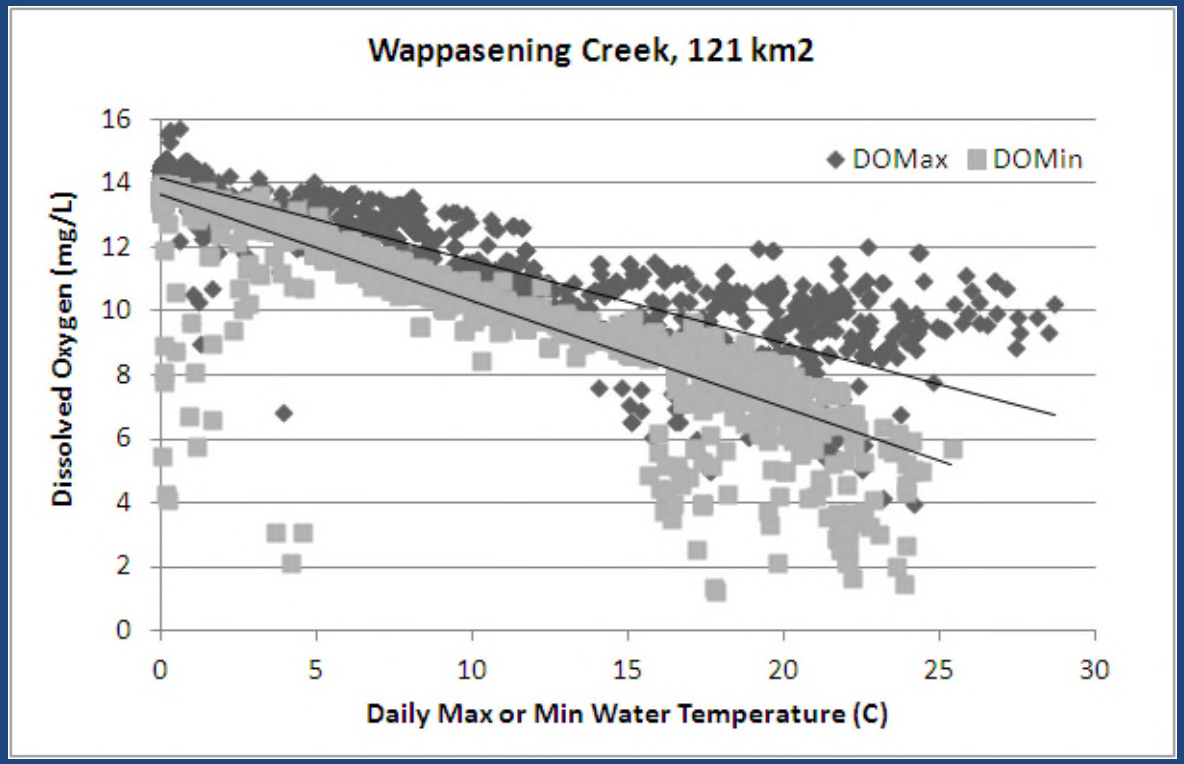
DO-Water Temperature Relationship

- Crooked Creek, PA
  - Data source: Susquehanna River Basin Commission
- Methodology proposed by Rose, unpublished



DO-Water Temperature Relationship

- Single point min DO would greatly miss the big picture
- This methodology was the most statistically robust of every option tried
- As seen, DO data is very challenging



DO-Water Temperature Relationship

Proposed Methodology

- Plot daily max DO vs daily max water temp.
- Plot daily min DO vs daily min water temp.
- Min and Max DO are surrogate measures of in-stream photosynthesis and respiration (Wang, Mullholland)
- Visual inspection of plot is also recommended

Conclusion – Slope of DO-Water Temperature Relationship is an ideal parameter for assessing year-to-year changes.

- Wang, H., Hondzo, M., Xu, C., Poole, V., Spacie, A., 2003. *Dissolved oxygen dynamics of streams draining an urbanized and an agricultural catchment*. Ecological Modeling 160 (2003): 145-161.
- Mulholland, P.J., Houser, J.N., Maloney, K.O., 2005. *Stream diurnal dissolved oxygen profiles as indicators of in-stream metabolism and disturbance effects: Fort Benning as a case study*. Ecological Indicators 5: 243-252.

Redefining Water Quality Protection

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Bonus (assessment, not restoration per se)

Division of labor to assess all our Nation’s waters

Rental Service (private sector)

- Amazon.com-like experience
- User never connects the device to computer
- User never opens the battery compartment
- User never has to store data on a spreadsheet
- Data is centrally uploaded when the device is mailed back

If we value the user's time at $50/hr, renting is less expensive for the user and society.

Data Service (public sector or NGO)

- Free online service[1]
- Central data analysis and storage
- "Ideal" parameters only[2]
- All data in the public domain
- Bring your own technology (or rent)
- User enters who, what, where, when, how…
- Unique ID and URL for each data set

Less expensive for the user <u>and society</u>.

1. If you charge just $1, people will not use it.
2. EPA already offers an "all data" storage option, without the standardized analysis feature

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'*Headwaters First*' Approach

- Upstream restoration benefits entire stream/river and downstream lake/estuary
- But….temperature is typically an upstream issue
- Yet…DO is typically a downstream issue

Pragmatic, Two Step Approach

1. Measure as far upstream as impacts can be detected
2. Prioritize restoration where it best impacts the in-stream measurement

Alexander, R.B., Boyer, E.W., Smith, R.A., Schwarz, G.E., Moore, R.B., 2007. *The Role of Headwater Streams in Downstream Water Quality*. Journal of the American Water Resources Association 43(1): 41-59.

'Restore What You Can Measure First' Approach

Surrogates

- e.g., DO instead of Phosphorus and Nitrogen

Substitution

- e.g., Temperature instead of TSS
  - Both involve planting forest buffers and mitigation stormwater

Leadership

- Take you money somewhere else
- There's a lifetime of work, don't obsess

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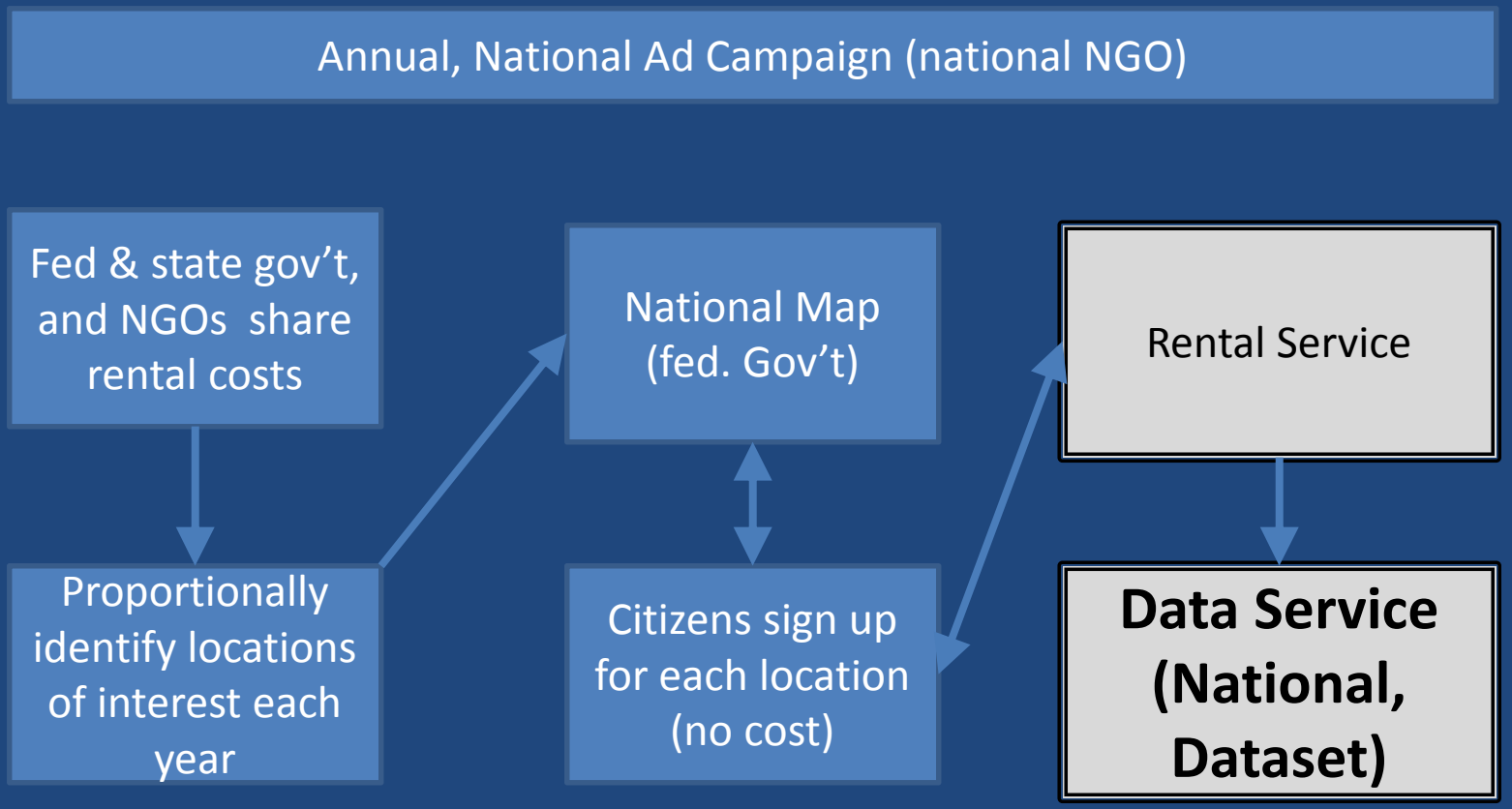
Fictitious Goal – In next 10 years, assess 1M locations for temperature and DO.

- **Permanent monitoring stations?** Too $$$
- **Professional staff?** Too $$$
- **Citizen monitoring?** No, not as currently conceived

- We need 100,000 per year
- National Audubon Society bird count = 50,000 persons/yr
- Audubon dropped their $5 fee; it was a barrier

Solution is division of labor

National Audubon Society. http://birds.audubon.org/christmas-bird-count.



- Past, reliable citizens move to front of the line
- All participants receive newsletter (ala Audubon)
- Annually fine tune the process

Suggestions?

Volunteers?