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A Multidisciplinary Approach to Sustainable Management of Watershed Resources

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Multidisciplinary team

- Heberling, Thurston: Economics
- Roy: Ecology
- Morrison: Aquatic chemistry
- Shuster, Beaulieu: Hydrology, biogeochemistry
- Parikh, Clagget: Law (vacancy)
- The multidisciplinary approach is usually complicated by competing disciplinary goals and objectives
- Yet, we intentionally learned the objectives and roles of each other's disciplines, and found that the interdisciplinary experience can be very productive
- Collective interest in environmental management drives this productivity

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A new take on environmental management

- A combination of legal (property), socioeconomic (political boundaries vs. watershed boundaries, expectations and perceptions), and ecological-hydrologic constraints must be addressed for effective management
- Water resources management is full of issues that could benefit from a multidisciplinary perspective
- In the USA, we often do not have a regulation that is effective for management of certain stressors, such as stormwater quantity - and therefore a multidisciplinary approach is merited

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What we have done

- Auctions have some attractive features, both in terms of attracting interest to a particular objective and cost-effectiveness
- We used a reverse auction approach in a recent project (Shepherd Creek, Mt. Airy OH) to control storm water runoff quantity
- Overall objectives were to decrease the frequency of combined sewer overflows and improve aquatic habitat in headwater, low-order streams in the Mill Creek drainage
- Consent decree actions and recent Phase II SW regulations have spurred interest from regulated community for alternative management
- We bring together the concepts of source control, which involves keeping rainfall in its place through rain gardens and rain barrels….
- ….that are installed with the motivating forces of a market-based incentive to study attributes of sustainability gained realized through voluntary approaches to watershed management

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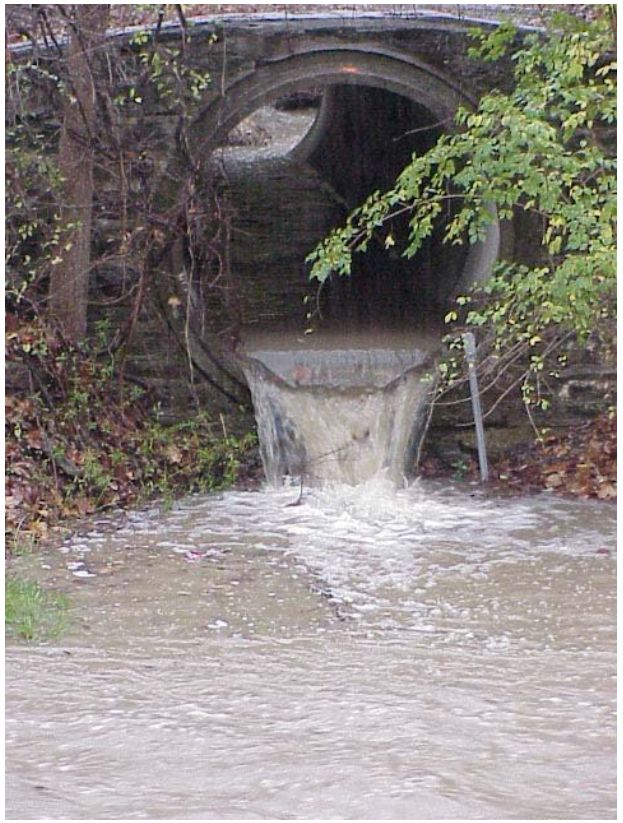
Shepherd Creek Pilot Project

Problem:

- Dominant land use is suburban residential
- *Source* is primarily storm water runoff from impervious areas
- Multiple stressors: storm water quantity, nutrients, bacteria, and sediment

Will incentives induce the placement of an adequate number of BMPs, and will implementation result in quantifiable hydrologic, ecological and water quality improvements in the watershed?



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The majority of Shepherd Creek impervious area is in rooftops and driveways (and on private property), so this suggests a modular retrofit approach

Rain garden
(one, 16 m^2)

Rain Barrel
(up to four)

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Reverse auction approach

Process:

- Eligible participants given brochure and bid form
- Submit sealed bids (free SWMP + payoff)
- Bids ranked in ascending order based on cost (bid amount and installation cost) and environmental benefits so that: Rank = Cost ÷ EBI
- Bids awarded until $$ exhausted or reserve met

Environmental Benefits Index (EBI) is estimated based on:

Rain Barrels

- number of barrels
- % rooftop area connected to storm sewers

Rain Gardens

- % total impervious area
- soils on property
- proximity to stream channel

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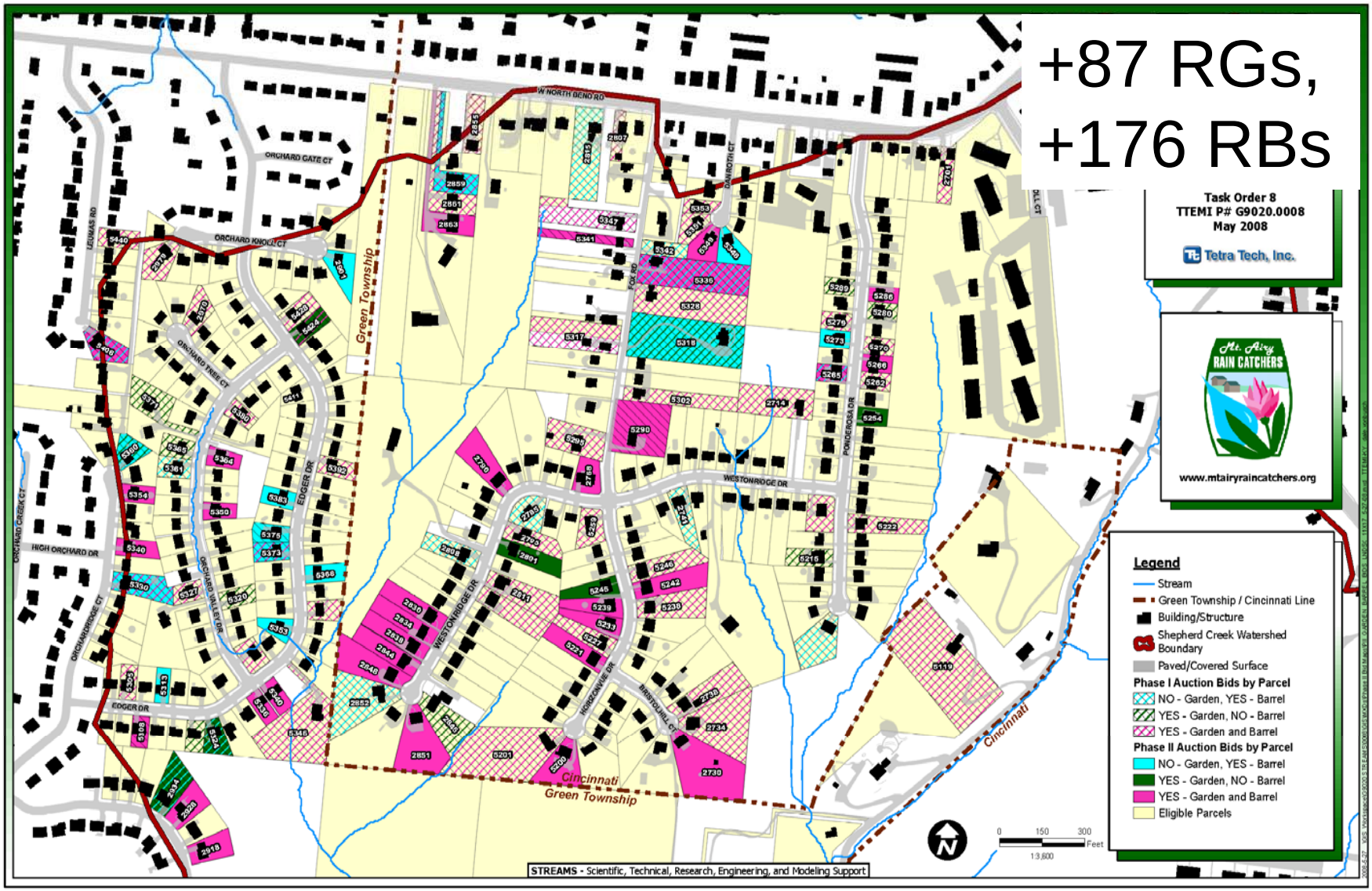
What we have done

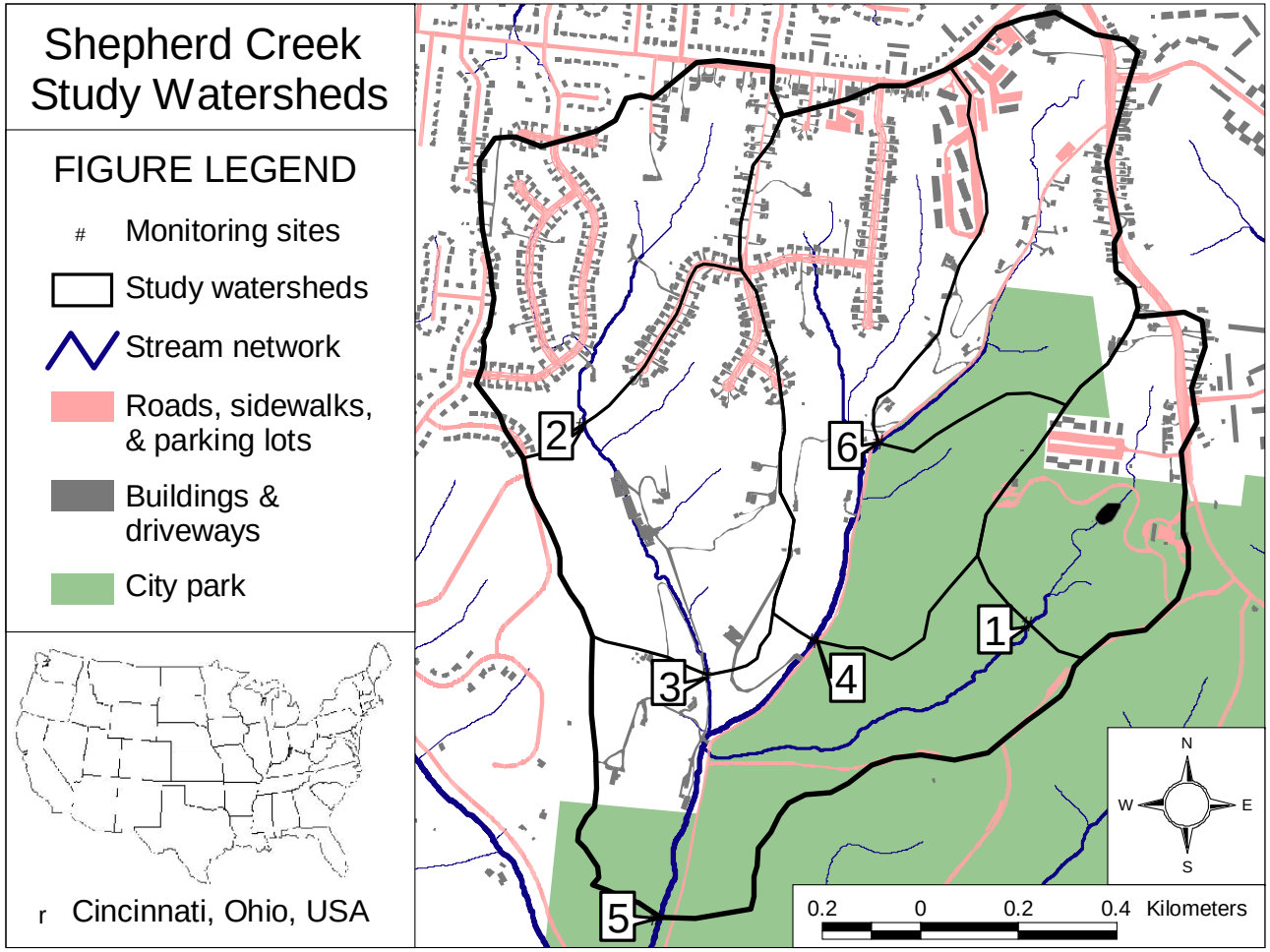
- We pay land owners their “willingness-to-accept” bid, install rain barrel(s) or rain garden, maintain these for 3-year study period
- Two auctions, one each in 2007, 2008
- Place retrofit storm water management practices (SWMPs) on the parcels of the most willing participants (low bids = least cost to us)
- Disconnect impervious area from sewer system and re-connect storm flow from rooftops and other residential impervious surfaces to subsurface flow systems (interflow, shallow water tables, etc.)
- We note that some landowners are routing rain barrel overflow to rain gardens, if it is not already routed there

2008 Auction results



Site details and experimental design

- 1.8 km^2 watershed
- 13% TIA
- Mixed land uses: residential, forest, farm
- BACI design (before-after-control-impact)
- Two controls (1, 6), four treatments (2, 3, 4 & 5)
- Additional gaging at neighborhood-scale outfalls, SWMPs



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The notion of sustainability

- We posit that attributes of sustainable environmental management may include **citizen participation**; and going to the root of the problem with **source controls** that impart a systemic, positive impact
- We substitute **social and cultural capital** for the presently dominant **technological and natural resource-intensive capital** by engaging the interest of citizens and making SW management a part of everyday business that could help maintain the effectiveness of parcel-level management
- Temporary detention in rain barrels may relieve some of current burden on domestic water supplies, which may be seen as a move towards conservation
- Sustainability is a viable scientific endeavor that we must experiment with to identify its practical attributes

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Markets for environmental improvement

- Market mechanisms utilize incentives or competitive market forces to encourage behavior towards a certain and legal endpoint (e.g., reduction of SW quantity)
- Incentives like auctions recruit participants and can tell us about how people value certain resources
- Water quality trading capitalizes on differences in abatement costs among motivated players (set a legal cap, reduce emissions under the cap by trades amongst players)

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Multiple Markets

- Some environmental management practices can offer multiple benefits or ecosystem services
- A multiple market context can be used to recognize and add value to these benefits
- In one conception, the producer is allowed to sell credits or abatement capacity in different markets
- Known also as double-dipping, a single practice may effectively service the intents of several marketable environmental objectives

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Example 1: Multiple Markets

- A wetland can process nutrient-rich agricultural runoff, provide retention capacity for runoff quantity, provide habitat for diverse plant or animal communities, maintain local water tables, among other ecosystem-level services
- A single-incentive may not offset costs of a wetland install or restoration (compared to reducing the amount of fertilizer used)
- However, if the farmer can sell credits on several markets, then these funds can be applied against the costs of wetland installation
- It is therefore more likely that an individual will adopt the intended practices if there is a perceived benefit and risk is low

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Example 2: building on current work

- Since rain gardens operate on the principal of infiltration, these SWMPs:
  - Primarily provide detention of SW runoff quantity
  - Can provide recharge or maintenance of water tables perched in local soil formations (see Shuster et al. 2007, JSWC)
  - May make available some percolate to deep storage-recharge
  - And, once in the groundwater system, baseflow in nearby headwater stream networks may be restored or enhanced
- Each of these benefits might be used in one or more markets to earn credits in: a stormwater control water market, groundwater or water table recharge program

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Can we manage with multiple markets?

- Although the economic theory is not well-developed at this stage, our vision is to recognize and value the potential contribution from implementation of SWMPs, conservation measures, etc.
- These practices can be utilized to yield a cascade of ancillary benefits that can interlock among the various components of the hydrologic cycle…
- ….and provide for complementary management amongst different, yet connected water resources

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Can we manage with multiple markets? Challenges

- Benefits must be valued in a homogeneous manner (what you see is what you get, a unit of groundwater recharge is the same in the market as a unit of storm water captured)
- Not easily done in practice because the transference of one unit of storm water to groundwater is entirely situational (unless groundwater injection is involved)
- Temporal scales of contributions (infiltration) versus registering responses (higher groundwater surface) may frustrate participants, lessen efficiency of markets
- A challenge to the monitoring community is developing capacity to measure and differentiate credits from one practice

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Can we manage with multiple markets? Challenges

- Can basic requirements be met for all markets? A “laundry list” of requirements includes:
- Clear, transferable property rights, bankable permits, adequate information about risks, legal cap or limit, defensible initial allocation of permits or rights
- Most importantly, the function of any market is improved by large numbers of buyers and sellers that each have a high degree of variety in their ability to buy or capacity to sell credits
- However, incentives like auctions may be best for regions where we know that effectiveness would be high
- So we need to know something about the extant hydrologic cycle

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Where does the water go?

- Subsurface attributes are critical to the determination of fluxes between various water resources and planning for management actions, monitoring effectiveness
- Our plan is to identify a water resource system with representative surface water, groundwater, wetland resources, etc.
- Integrate remote sensing data, including:
  - Light Detection and Ranging (LiDAR),
  - some combination of airborne or surface-based sensing of the location of saturated zones with time-domain electromagnetic (TEM), induction, or ground penetrating radar (GPR)) taken during both wet and dry seasons,
  - and detailed soil surveys
- These may improve our view of connectivity of surface and sub-surface flows

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Data applications

- Integrate these data sets into a hydrologic model(s)
- Examine the projected impacts and potential benefits of an optimized SWMP implementation, wetland management, conservation measures, etc. on flow of multiple benefits amongst the various water resource components
- Apply management actions within the context of a reasonable experimental design, and long-term monitoring program

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Conclusions

- We have gained some experience with market-based incentives
- Sustainable attributes include: engaging the public and making water resources management a part of everyday business, front-load system with well-designed, self-sustaining technologies (e.g., rain gardens)
- When we started to upscale our ideas for management to encompass a wider variety of water resource management objectives, this implicated multiple water resource markets
- We see potential for applications of multiple markets in cooperatively and simultaneously managing linked water resources

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Collaborators

- Cincinnati Metropolitan Sewer District
- Cincinnati Parks
- Hamilton County/Cincinnati Health Departments
- Hamilton Co. Engineers, SW district
- Hamilton Co. SWCD
- USDA-NRCS
- US Geological Survey
- USEPA Region 5