USING CITIZEN SCIENCE & AGENT-BASED MODELING TO FOSTER COALITION BUILDING IN AN URBAN-RURAL WATERSHED

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AGENDA FOR REDESIGNING THE URBAN-RURAL INTERFACE (RURI)
ALONG THE MISSISSIPPI RIVER WATERSHED

Introduction

Watersheds are one of the most challenging human-environmental systems for community coalition building. Because watershed divisions cut across jurisdictional and ownership boundaries, they involve stakeholders with often-competing values and needs that complicate collaborative action, planning, and policy-making.

Our Objective: To empower citizens to work together with researchers and community partners to:

- Assess water quality using citizen-science engagement coupled with certified lab testing
- Foster community connections across a watershed through stakeholder coalition building and use of an Agent-Based Model

Using field test equipment and collecting lab samples during stream monitoring at site of a stormwater retention pond outlet

Methodology & Engagement

This project is part of Iowa State University's Translational Research Network (Fig. 1):

Our U-TuRN team devises its methods and questions in partnership with community stakeholders within urban-rural watersheds with these two key foci:

- Water quality & flow:** data collection and data sharing, connecting environmental health to public health & well-being
- Collaborative community building:** integration of social-hydrological modeling, storytelling, and participatory action

Initial community partners:

Expanding network of collaborating community partnerships:

- Squaw Creek Watershed Management Authority Board (Story, Boone, and Hamilton County Soil and Water Conservation District committee members, county supervisor staff, city staff)
- Certified labs: Iowa State University Water Quality Research Lab; State Hygienic Lab ; City of Ames Water/Wastewater Lab
- City of Ames - Public Works Dept., Pollution Control & Water Dept., Smart Watersheds program
- Other NGOs: Iowa Stormwater Education Partnership; E-Resources Group
- College and preK-12 student groups - ISU Environmental Science Club, ISU Chemistry undergraduate labs, Ames High School science teachers and students; The Community Academy
- Ringgenberg Park Homeowner Association and residents of other neighborhoods in watershed
- Izaak Walton League of America - IWLA Save Our Streams & Clean Water programs

Location & Rationale

Initial U-TuRN project work focused on the south branch of Worrell Creek, tributary to the HUC-10 Squaw Creek watershed within the HUC-8 South Skunk River watershed in Iowa.

There, the Tedesco Environmental Learning Corridor (TELC) is a new and highly unusual public county park: it's located on university-owned land in a rapidly urbanizing area within the city of Ames. Set aside for stream restoration, wetland construction, and park land in south Ames, this 37-acre parcel and the land up- and downstream in its watershed represents the mix of features, needs, and potentials in many Midwestern watersheds with its:

- Degraded waterway, increasing flashiness
- Water quality and flood concerns
- Mixed land use area in watershed: upstream still predominantly in tile-drained row-crop and livestock agriculture but downstream increasingly urbanized
- Multiple partner interest in collaborative community building
- Potential to become a watershed project to mentor others

Assessing Water Quality via Citizen-Science & Certified Testing Labs

Fig. 2: Average monthly *E. coli* or coliform bacteria counts in Ames, Iowa waterway sites from 2009 to 2018. Data collected by the urban stream monitoring program at the City of Ames, the citizen-science Squaw Creek Watershed Coalition, and this U-TuRN project. EPA Class A1 surface water quality standard is recommended limit for *E. coli* in recreational waters.

Stirred up sediment near stream gauge seen on water quality monitoring date

"Flashiness" of waterway evident from variation in gauge depth measurements in response to high precipitation events

Algal bloom on edge of residential stormwater pond

Fig. 5: Minimum, mean, and maximum *E. coli* by site across the watershed.

SQUAW CREEK WATERSHED - PUBLIC HEALTH CONCERNS

- E. coli* or fecal coliform bacteria monitored as water quality indicator (Fig. 2), but DNA source tracking needed to distinguish human vs. wildlife vs. livestock
- 10-year urban sample mean & max. bacteria counts (overall ave. 2844; max. 110,000 cfu/100 ml) exceeded federal standard by 12X and 475X, respectively

WORRELL SUB-WATERSHED - E. COLI BY DATE

- Mean *E. coli* bacteria counts were above the federal EPA surface water quality standard for most of year of the U-TuRN study (Fig. 3)
- Peak *E. coli* levels detected often tied to high rainfall events (data not shown)

WORRELL SUB-WATERSHED - PHOSPHORUS BY DATE

- Spikes in Ortho-P levels occurred throughout the watershed following large precipitation events in mid-June 2018 and mid-March 2019 (Fig. 4)

WORRELL SUB-WATERSHED - SPATIAL PATTERNS OF NUTRIENT POLLUTION

- E. coli* was highest in the north fork sites where animal and row crop agriculture is upstream of neighborhood retention ponds (Fig. 5)
- Ortho-P varied by site and on average was greatest at north fork sites (Fig. 6)
- Total P, Non-soluble P, Dissolved Oxygen (data not shown) and Nitrate (Fig. 7) varied by site:
 - N highest downstream of the south fork, which is dominated by row crop / livestock production
 - Total P and Non-soluble P tend to decrease as stream passes through urban stormwater ponds
 - DO levels lowest at outflow of set of urban retention ponds that displayed highest P & E. coli values

Fig. 3: Minimum, mean, and maximum *E. coli* by sample date among all sites surveyed on that day.

Fig. 4: Minimum, mean, and maximum orthophosphate by sample date among all sites surveyed per day.

Fig. 6: Minimum, mean, and maximum orthophosphate by site across the watershed.

Color-comparator used to determine orthophosphate in the field during water quality monitoring

HARNESSING THE POWER OF CITIZEN SCIENCE: The U-TuRN project partners notably rely heavily on citizen-collected data. Adult and youth volunteers were recruited from Squaw Creek Watershed Coalition, ISU Environmental Science Club, Ames High School, other stakeholders, and residents in the watershed. We determined nitrate concentrations using three methods to assess citizen-derived field vs. lab results (Fig. 7):

- Iowa DNR volunteer field test kit
- ISU Water Quality Research Lab
- Deltares Nitrate cell phone app

Fig. 7: Average nitrate concentrations by month using three methods: Iowa DNR volunteer kit, ISU Water Quality Research Lab, and the Deltares Nitrate cell phone app.

Coalition Building & Action

We have built an agent-based computer simulation model (ABM) to be used in community engagement workshops that bring into coalition citizen stakeholders, researchers, and community partners. Our "Watershed Community" ABM has these key features:

- Fosters creative thinking & stakeholder ownership**
Allows stakeholders to explore and configure—for themselves—multiple lines of socio-environmental response to environmental change. By creating their "what if" scenarios, users engage in creative, adaptive thinking and get to probe areas that match their needs and values
- Uses simple, open source software (making it portable & flexible)**
Built on the computer platform NetLogo, the model can be downloaded onto laptops for use in community settings, and users change parameters themselves to receive instant feedback
- Has storytelling-based design from the humanities**
Stories that invite multiple interpretations and inspire imaginative ownership do so, in part, when they have gaps—spaces left for each reader to fill with local knowledge, values, and needs. Using rigorous simplicity, our model leaves space for stakeholders to tell their stories, set goals, devise collaborations, and take action

The marshalling of multiple agents in the model mitigates soil erosion by strategic planting of vegetation. Planting near left margin symbolic of upstream—a location that dramatically improves erosion

A reduction in community connectedness markedly decreases projects. Water pollution trebles.