

# Modeling, Learning and Planning Together

## Addressing Big Questions with Data, Models, and Participatory Exploration

**Moira Zellner**

Associate Professor, UPP

Research Associate Professor, IESP

Director, UDVL

NSF SUS workshop

The University of Texas at Austin

August 22-24, 2019

THE  
UNIVERSITY OF  
ILLINOIS  
AT  
CHICAGO



# Motivations



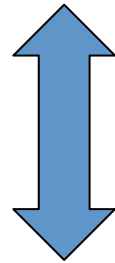
Source: [sanfrancisco.cbslocal.com](http://sanfrancisco.cbslocal.com)



Source: <http://www.greenpeace.org>

# Questions I: Tools for modeling

- Sustainable growth
- Effectiveness of green infrastructure
- Local economic interests v. regional environmental goals
- Managing flooding and drought in agriculture



**Modeling coupled human-natural systems**

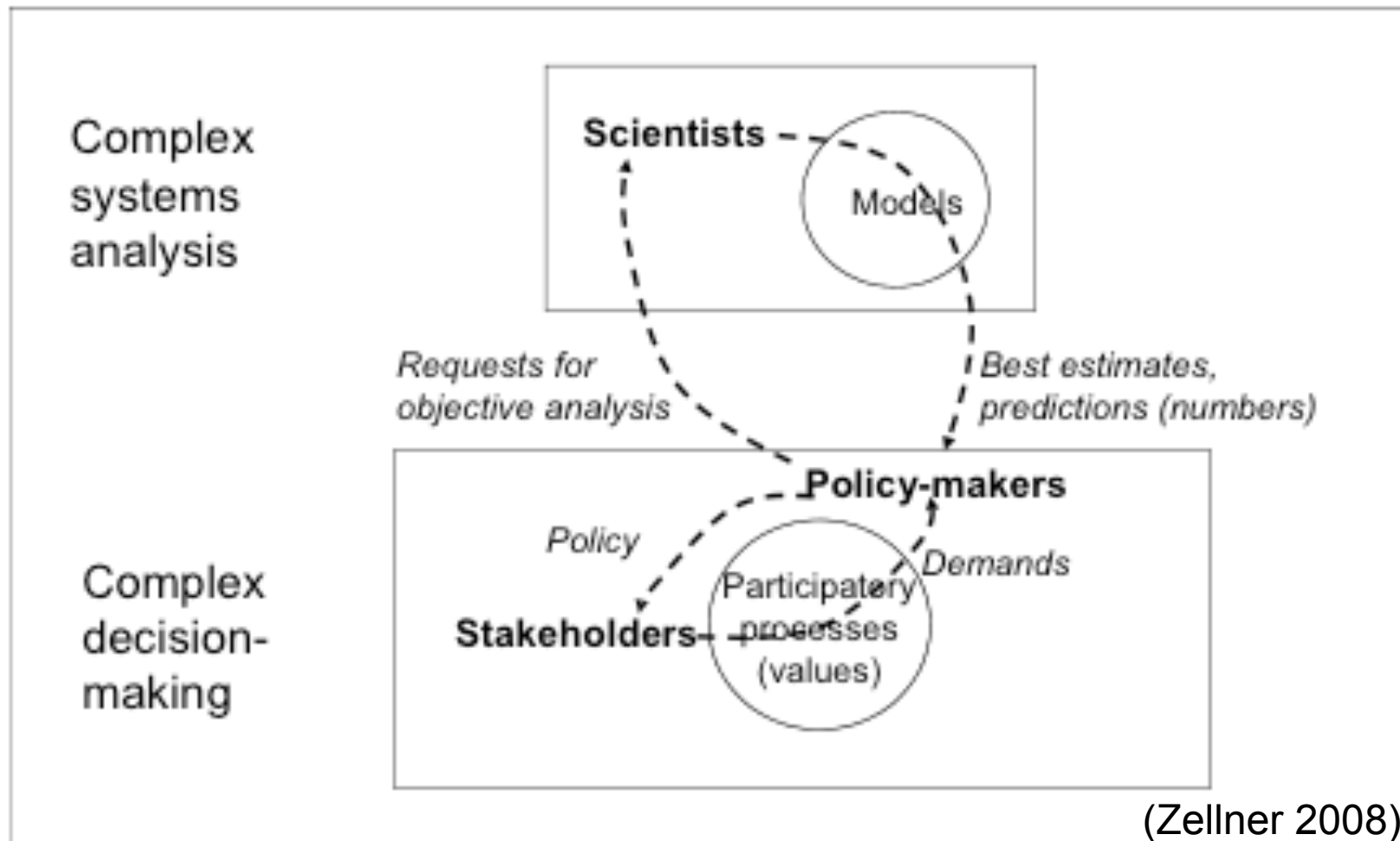
# Demo

- SOME model

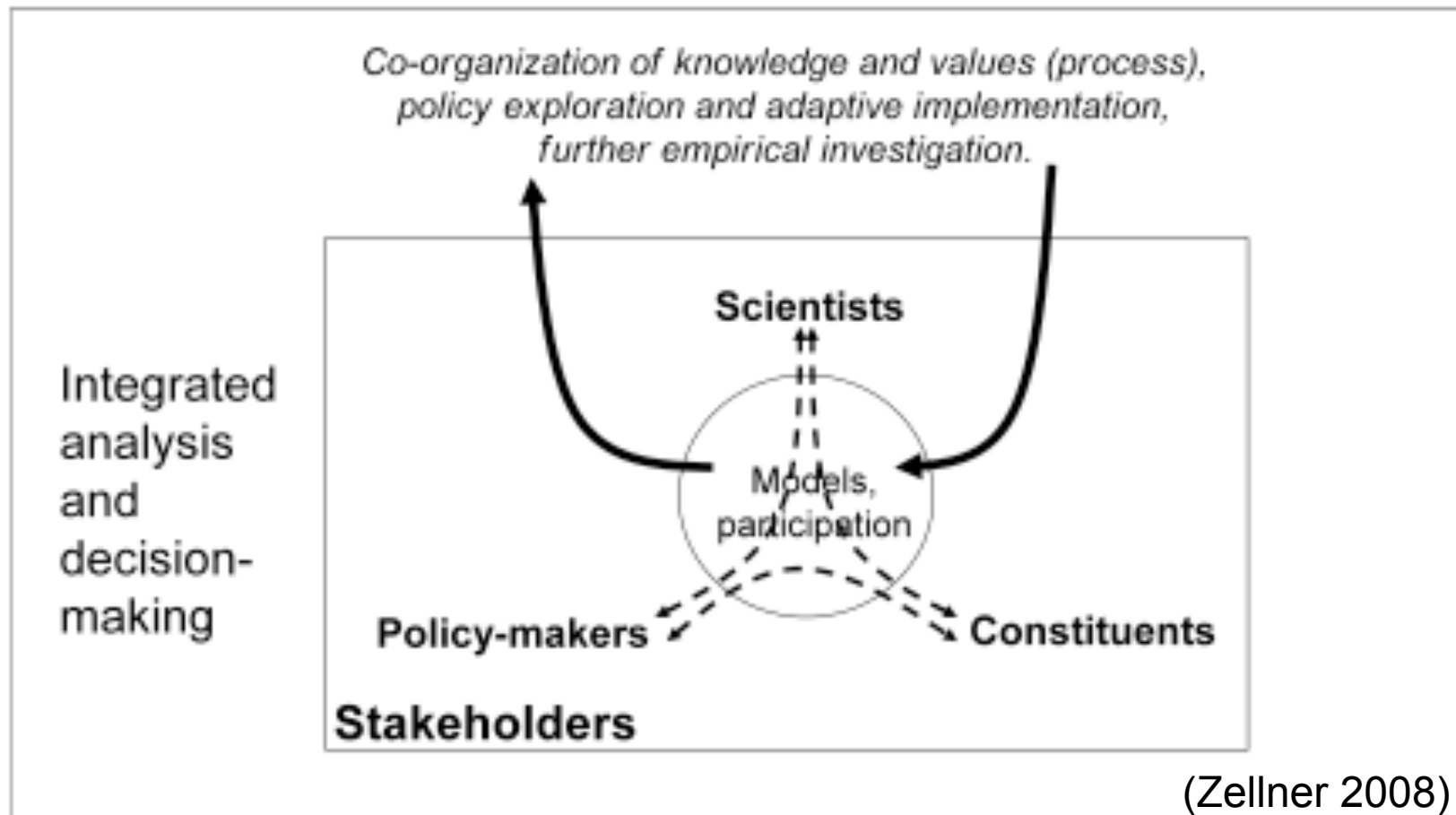
# Answers I: Tools for modeling

- Growth is not sustainable(.)
  - Zellner and Reeves (2012)
- Green infrastructure: Thresholds and layouts
  - Zellner et al. (2016)
- Collaborative conservation can arise under development pressure
  - Zellner et al. (2010)
- Adaptation can reduce crop losses but exacerbate flooding
  - Zellner et al. (2019)

# Conventional planning and modeling



# “Unconventional” planning and modeling



# Challenges

- Communication across expertise
- Spatial thinking and computer modeling
- Confirmatory bias
- Consensus-building and generalization



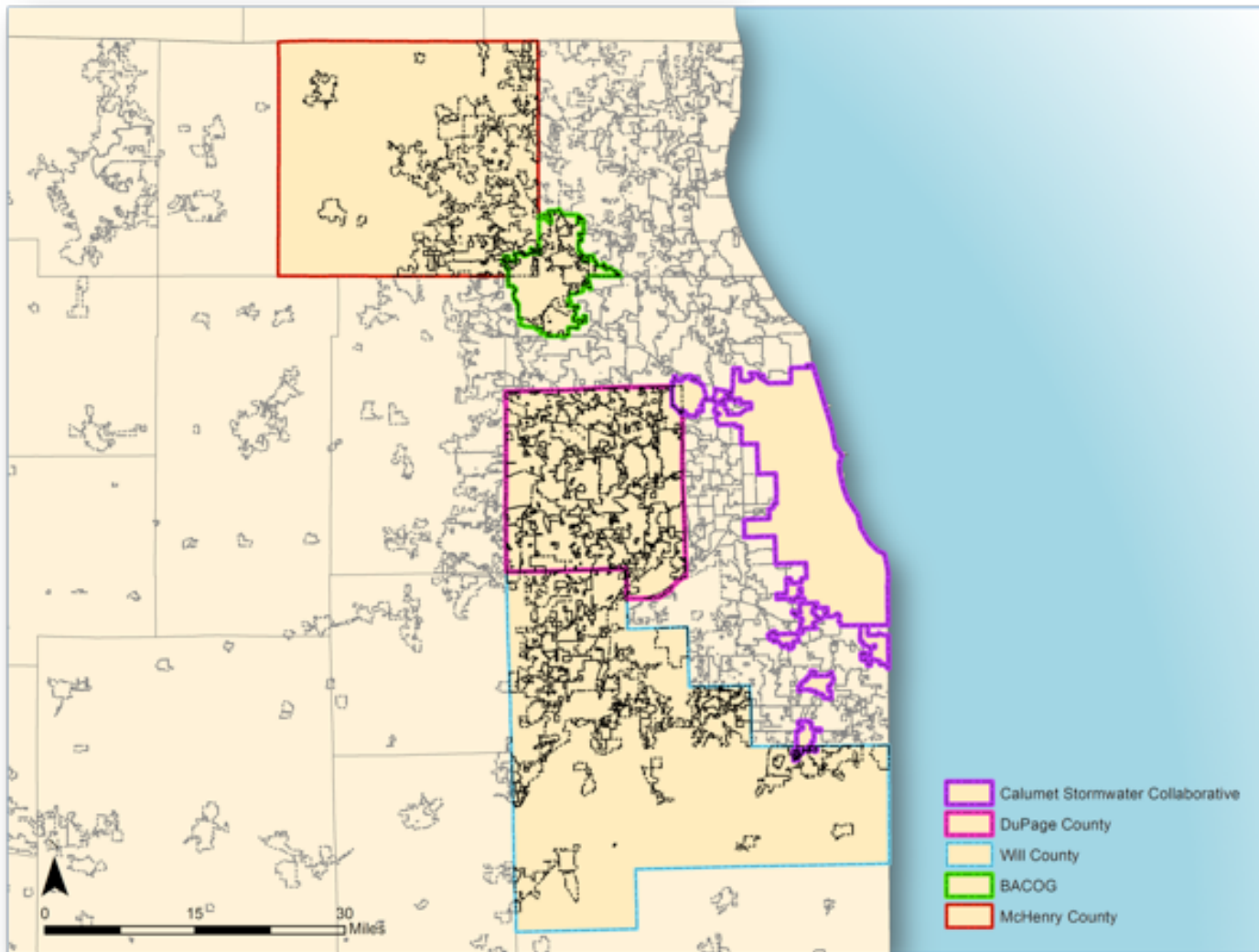
# Questions II: Tools for participation

- How can complex systems modeling help us learn?
- How does learning lead to better planning deliberation and decision-making?

# What we've learned

- It supports learning and innovation
- It's hard!
- It's deeply human
- Two stories:
  - Small is beautiful
  - Making the invisible visible

# Water Sustainability in NE Illinois

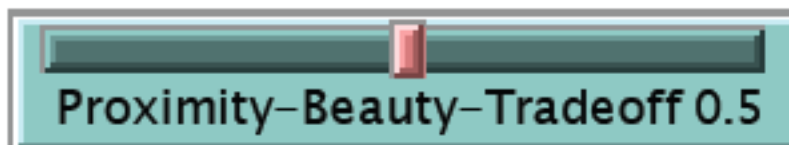
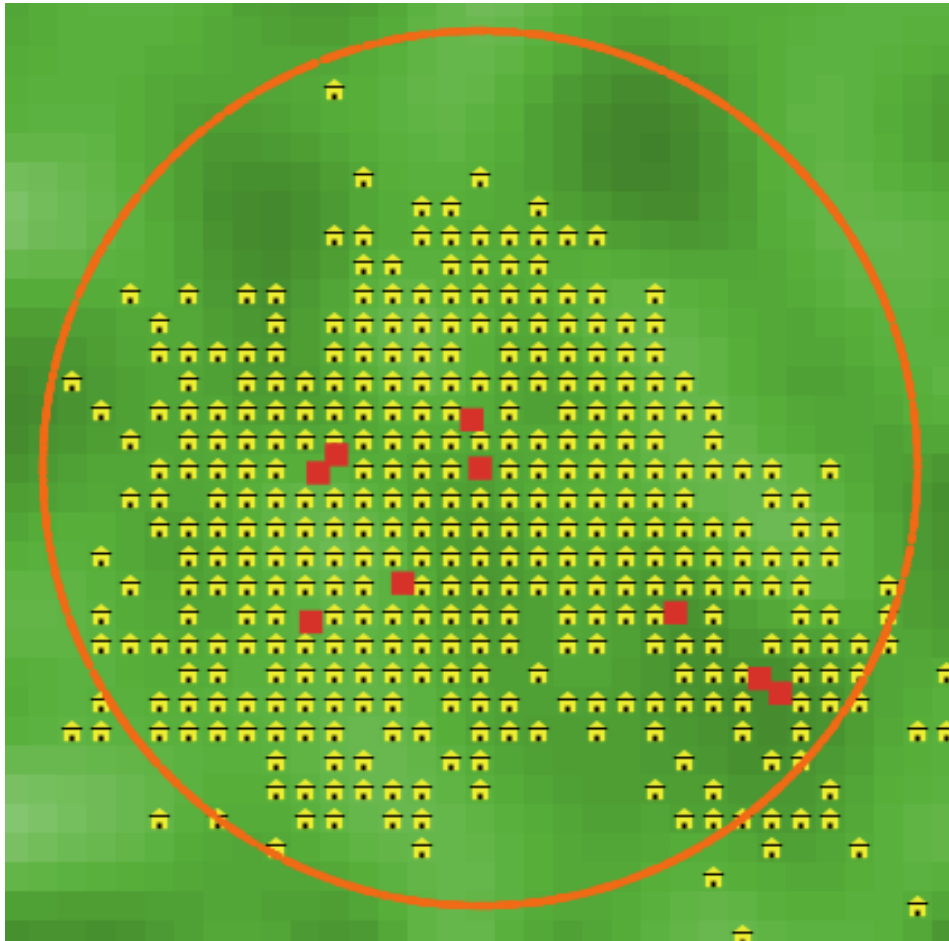


**Small is beautiful**

**Groundwater supply**

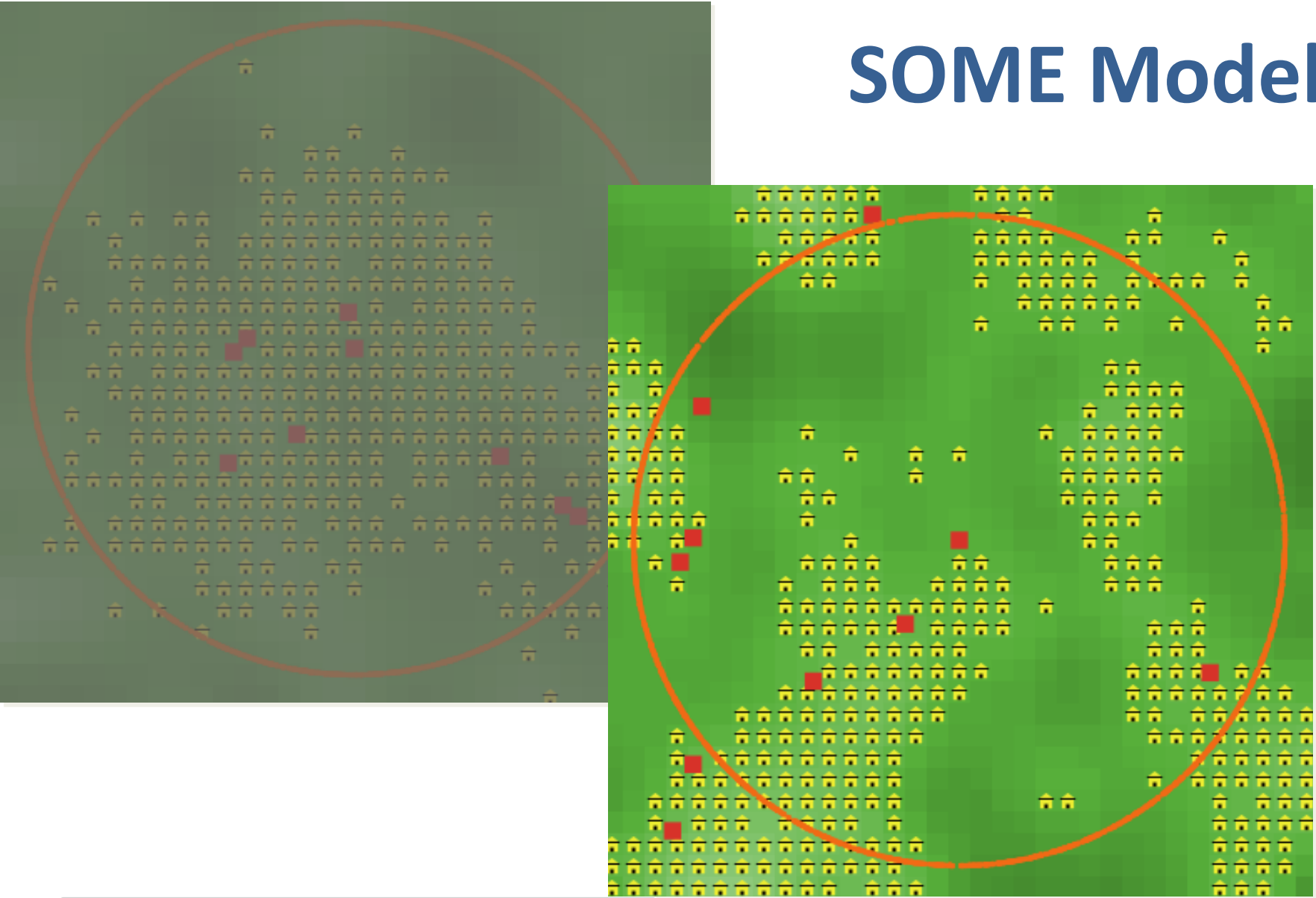
# SOME Model

(SLUCE Project)



(Zellner et al. 2012)

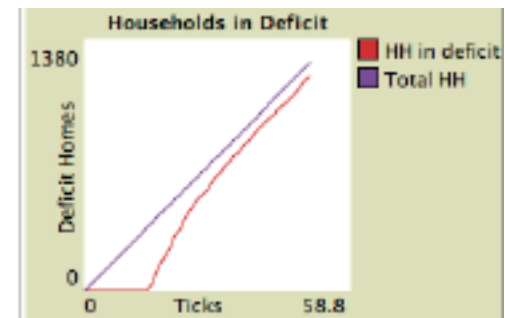
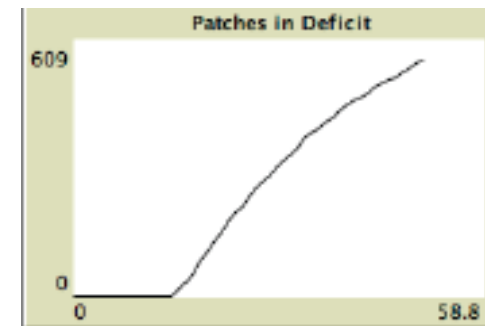
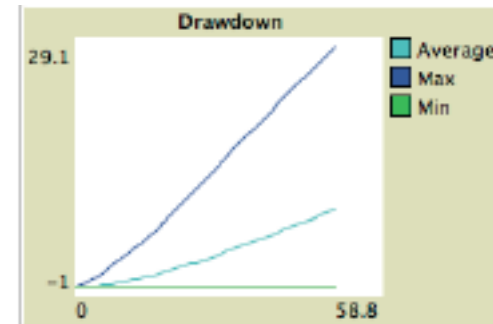
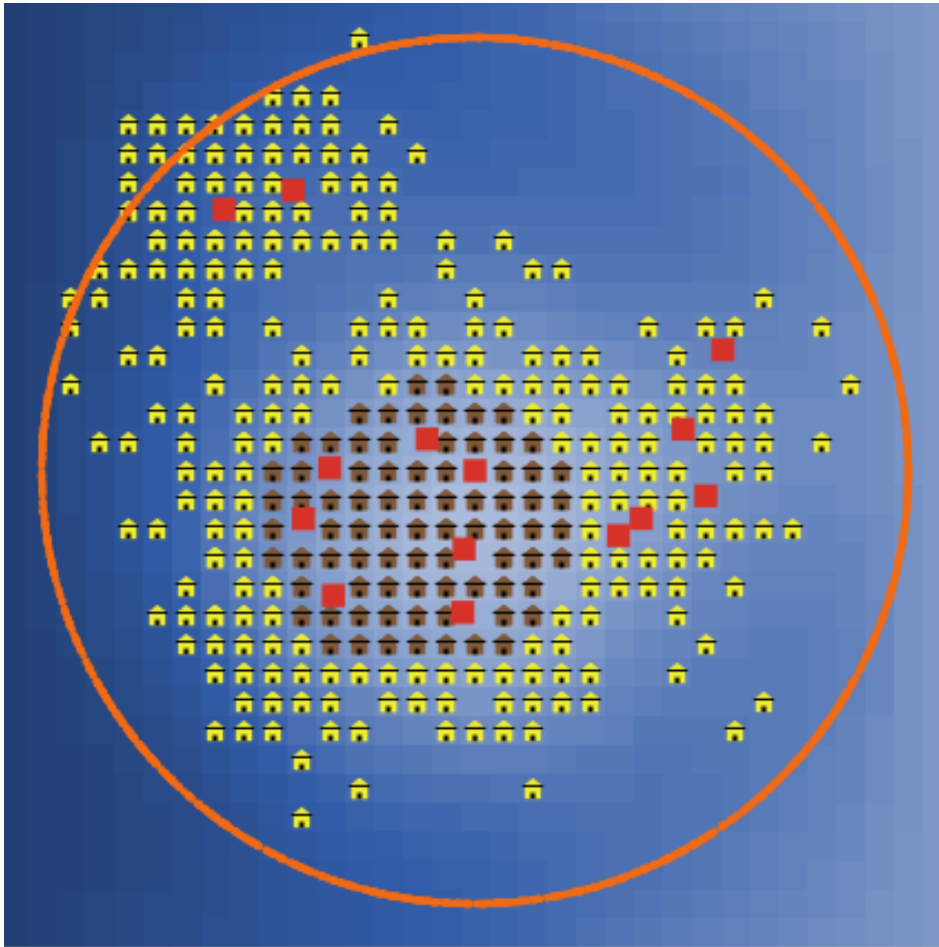
# SOME Model



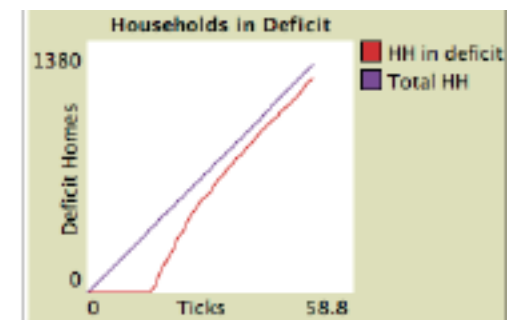
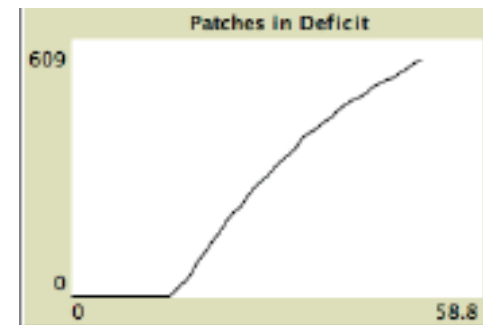
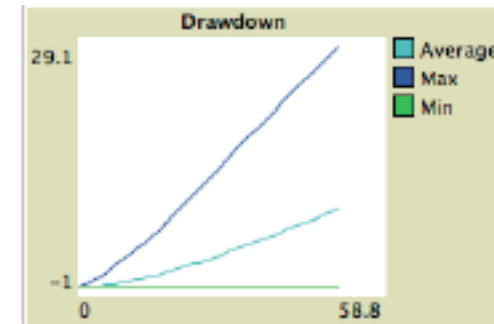
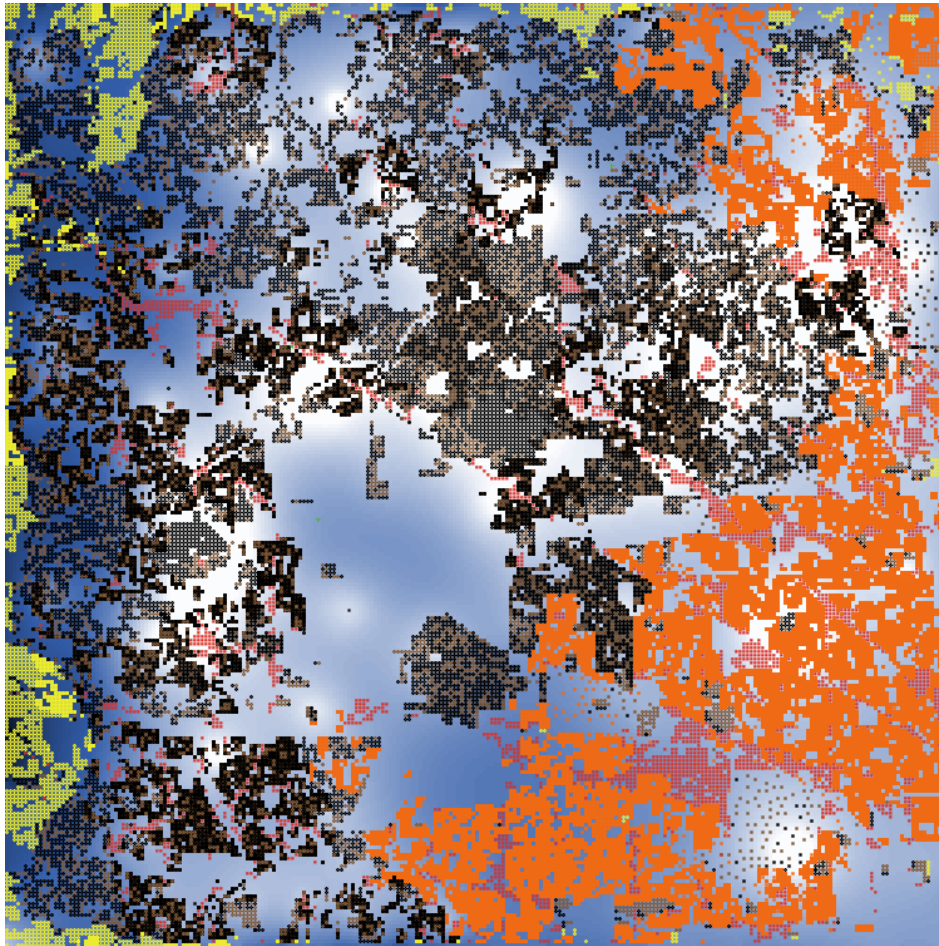
Proximity-Beauty-Tradeoff 0.0

(Zellner et al. 2012)

# SOME-GW Model



# Detailed Model





# Learning, innovation and resistance

- Transparency of assumptions

*There is no residential growth here... except in...*

*“If water is not a problem, then why are communities doing conservation?”*

- Mental modeling

*Lake Michigan water and groundwater effects*

- Favored approaches won't work

*“There's the idea that... we're gonna have such a big impact and it really doesn't”*

*Couldn't isolate themselves from the impact of growth*

- Specificity of alternative solutions

*“Do we create giant recharge areas that will assist the whole region?... “*

*“I think we're learning that {regional water management} is essential for all of us”*

*“I'd never bring this up in a public meeting...” but what about injection?*

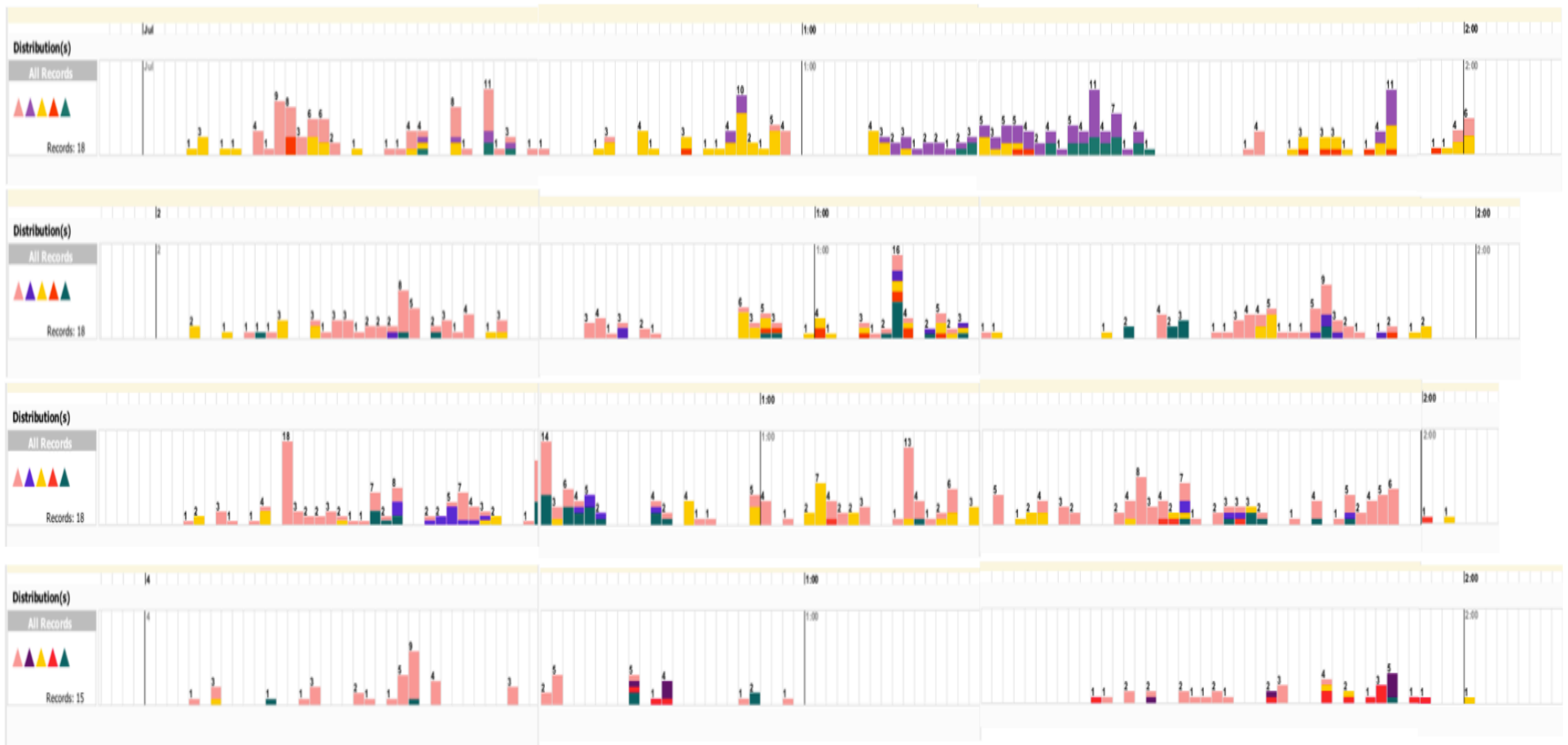
- And yet... rejection (Hoch et al. 2015)

- Inaccuracy

# Discourse analysis I

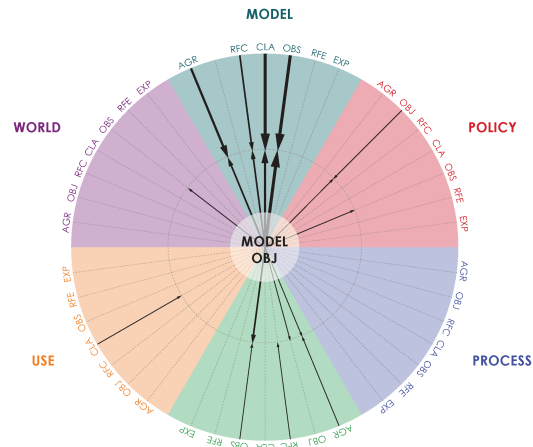
Model – Policy – Process – Use – World

(Radinsky et al. 2016)

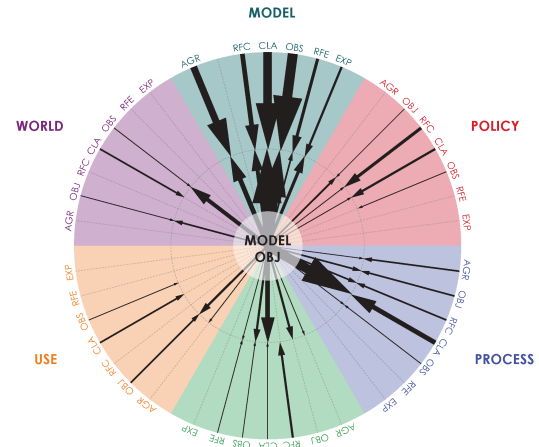


# Discourse analysis II

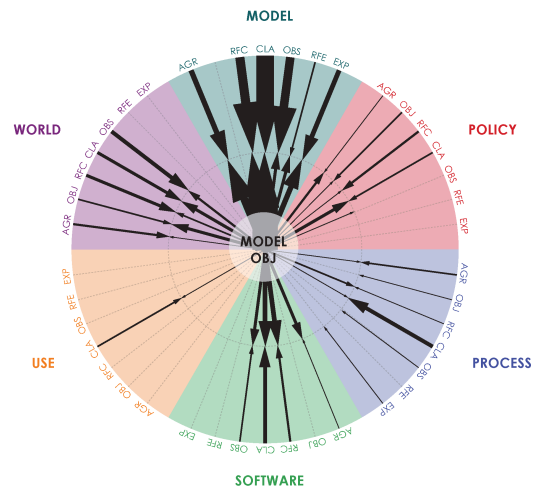
MEETING 1



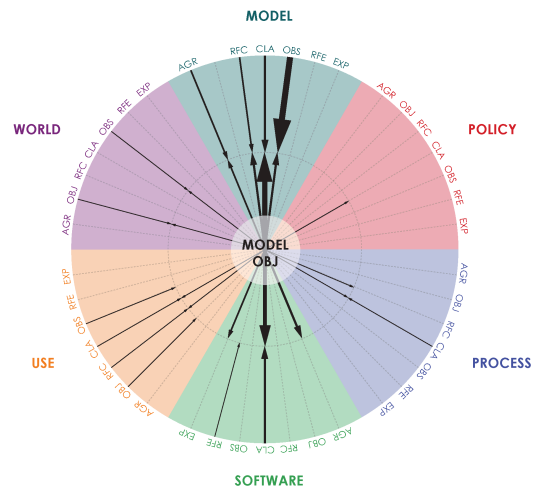
MEETING 2




MEETING 3



MEETING 4



# Simple interfaces...

setup   go once   go 

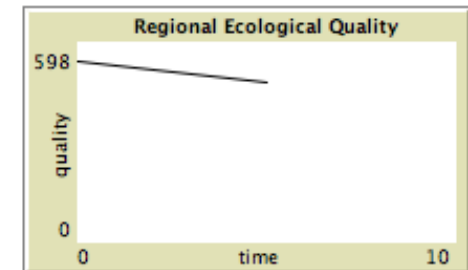
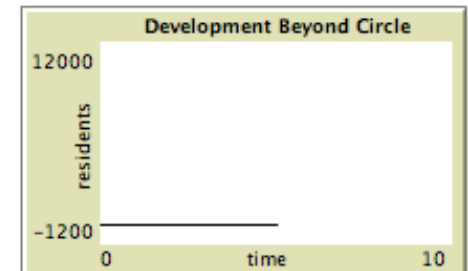
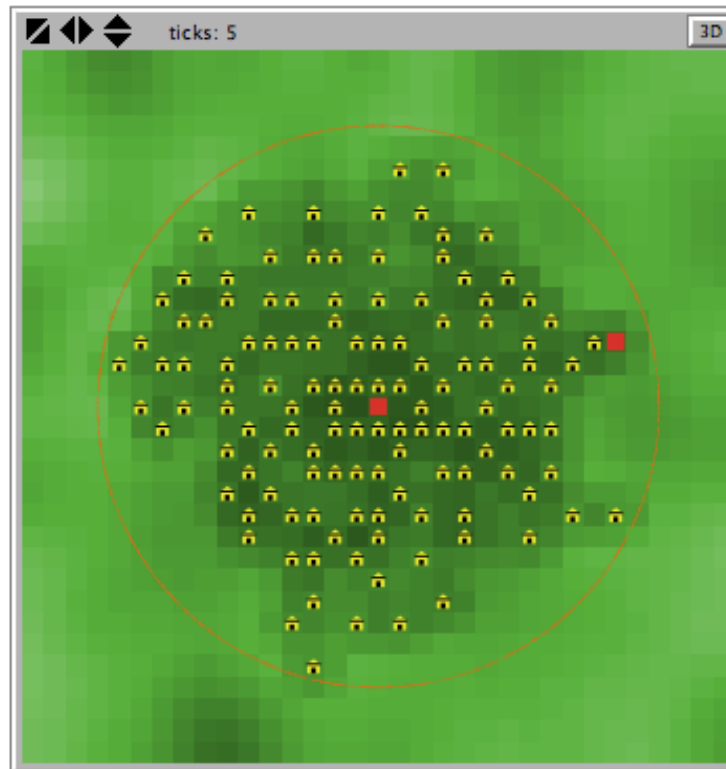
**Simulation settings**

number-of-ticks: 25   length of the simulation

**Land use settings**

dev-impact-beauty: 0.20   impact of development on natural beauty

residentsPerStep: 25   population growth rate



(Zellner et al. In progress)

# To detailed interfaces

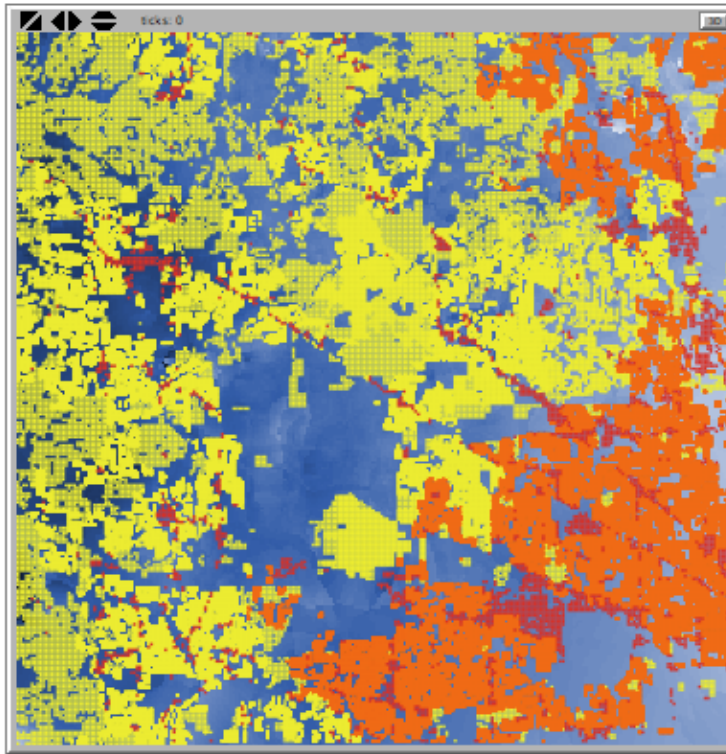
**Simulation settings**

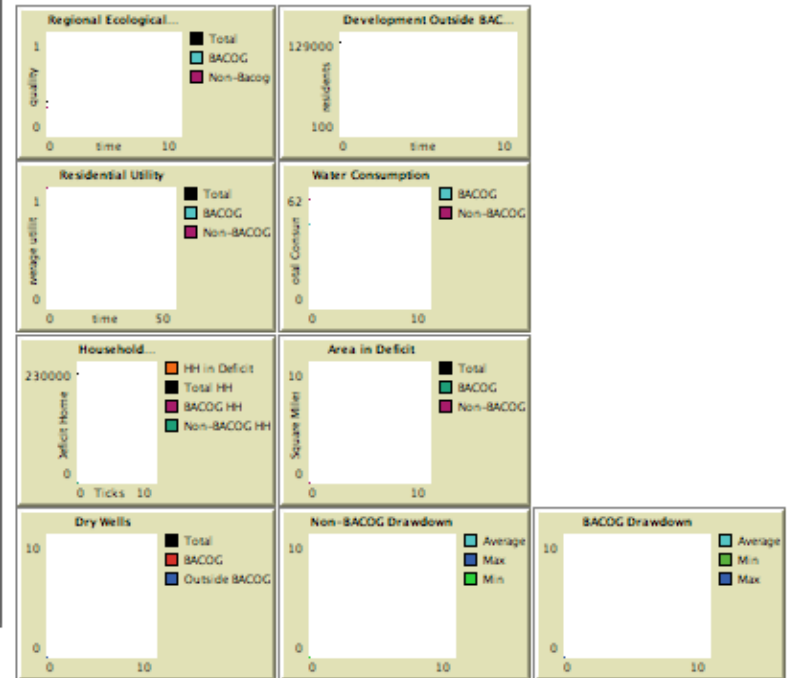
**Display Buttons**

**Land use settings**  
 Impact of development on natural beauty  
 population growth  
 residents' location preferences  
 number of locations a resident will inspect

**Groundwater settings**  
 On  Off  groundwater? activates groundwater component  
 Impact of development on recharge rates  
 groundwater consumption

**Policy settings**  
 On  Off  preserve-SAR...   Municipal...   On  Off  NW-growth  On  Off  NE-growth  On  Off  SW-growth  On  Off  SE-growth

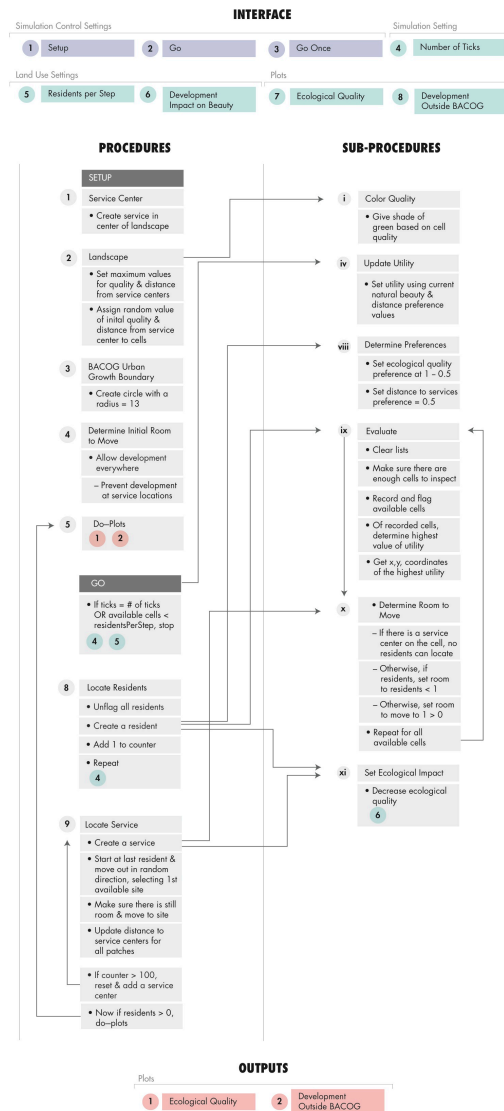

  



Tick	Population	BACOG population	Mean-Drawdown	Max-Drawdown	BACOG Mean-Drawdown	BACOG Max-Drawdown	Hhs in Deficit	BACOG Hhs in Deficit	Dry-wells
<input type="text"/>									

# Simple processes...

## BACOG's Stylized SOME Model: Meeting 1



# To detailed pr

## BACOG's Stylized SOME Model: Meeting 4

### EXTERNAL INPUT FILES

- |   |                                     |                        |              |
|---|-------------------------------------|------------------------|--------------|
| 1 Initial Natural Beauty                            | 4 Stylized Zoning & Maximum Density | 7 Initial Head Levels  | 10 Elevation |
| 2 Stylized Lake Michigan Water Supplied Communities | 5 Municipalities                    | 8 Head Boundary Levels | 11 Drawdown  |
| 3 BACOG Boundary                                    | 6 Stylized Land Use                 | 9 Recharge Rates       |              |

### INTERFACE

Display Buttons

1 Lake Supplied Areas	2 Recharge	3 Natural Beauty	4 Groundwater
-----------------------	------------	------------------	---------------

Simulation Control Settings

5 Setup	6 Go	7 Number of Ticks
---------	------	-------------------

Simulation Setting

Land Use Settings

8 Residents per Step	9 Development Impact on Beauty	10 Proximity-Beauty Tradeoff	11 Number of Showings
----------------------	--------------------------------	------------------------------	-----------------------

Groundwater Settings

12 Groundwater?	13 Development Impact on Recharge	14 BACOG Consumption	15 Consumption Outside of BACOG
-----------------	-----------------------------------	----------------------	---------------------------------

Policy Settings

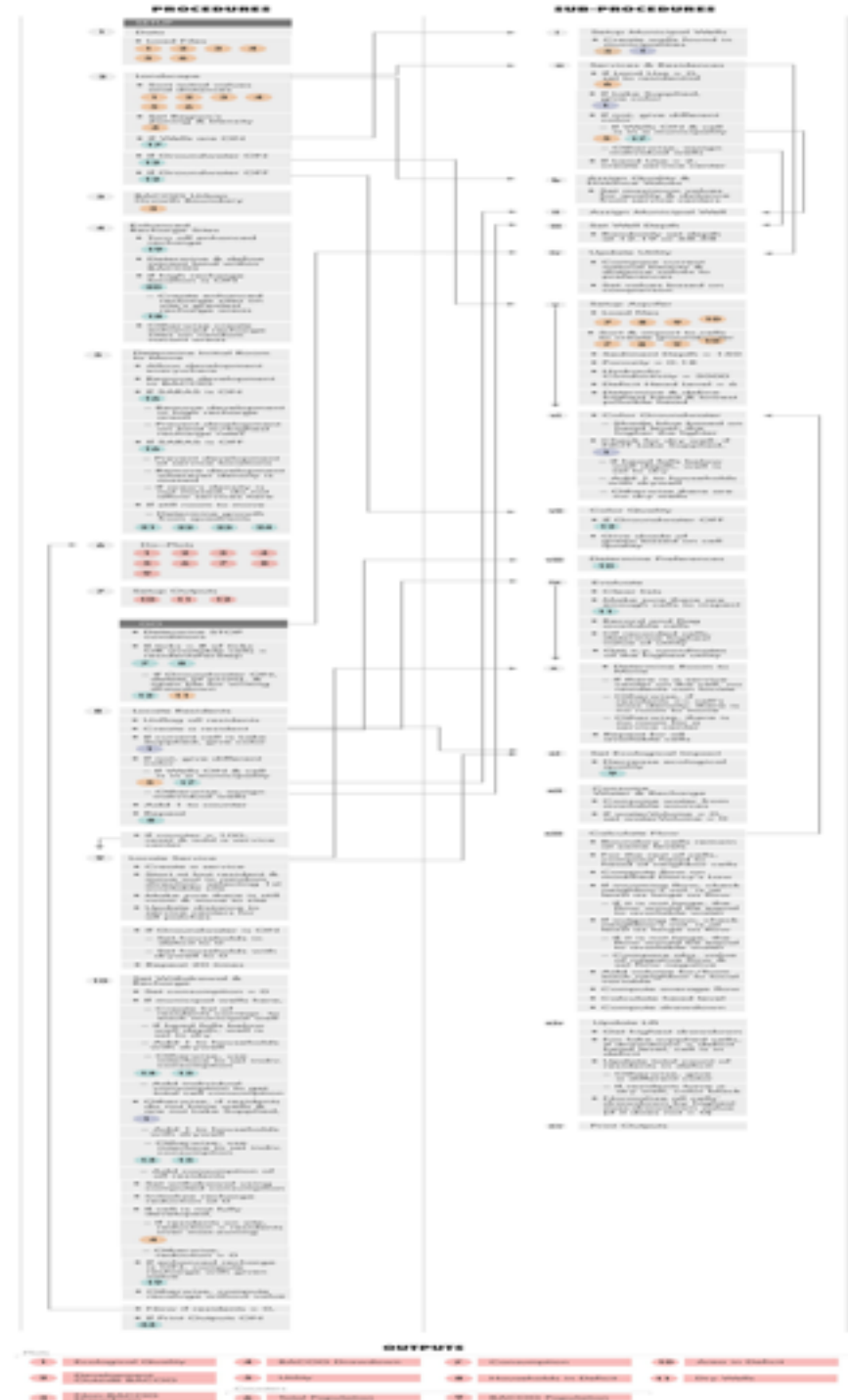
16 Preserve SARASR	17 Municipal Well?	18 Enhanced Recharge Sites	19 Enhanced Recharge
20 Choose High Recharge Location	21 NW - Growth	22 NE - Growth	23 SW - Growth
24 SE - Growth			

Plots

25 Ecological Quality	26 Development Outside BACOG	27 Utility	28 Consumption
29 Household in Deficit	30 Area in Deficit	31 Dry Wells	32 BACOG Drawdown
33 Non-BACOG Drawdown			

Outputs

34 Print Outputs	35 Total Population	36 BACOG Population
------------------	---------------------	---------------------



# Lessons

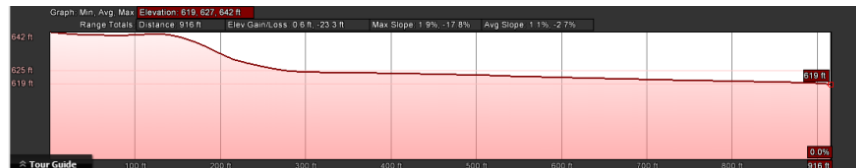
- Keep it simple
- Use intermediate tangible user interfaces (TUI)
- Interactive exercise versus instruction
- Start with more visible problems



# Making the invisible visible

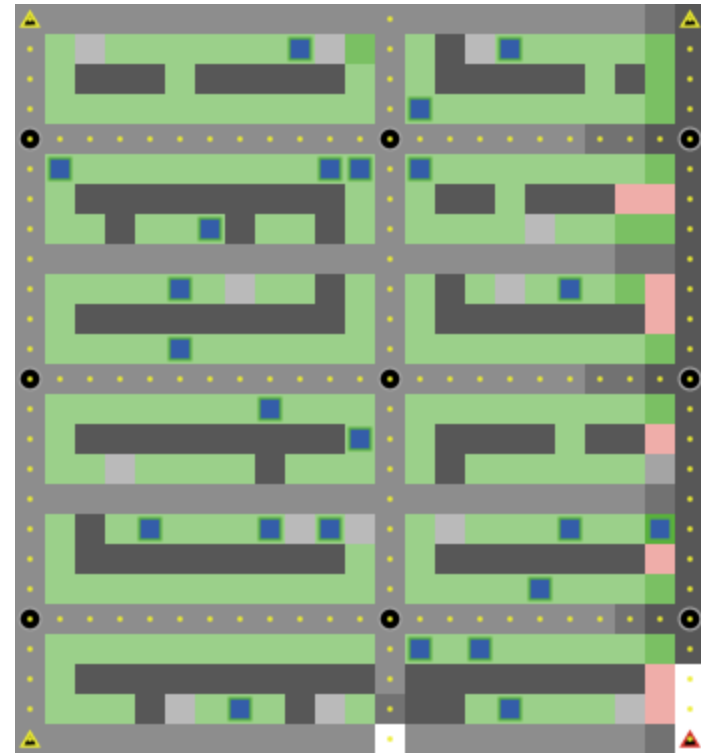
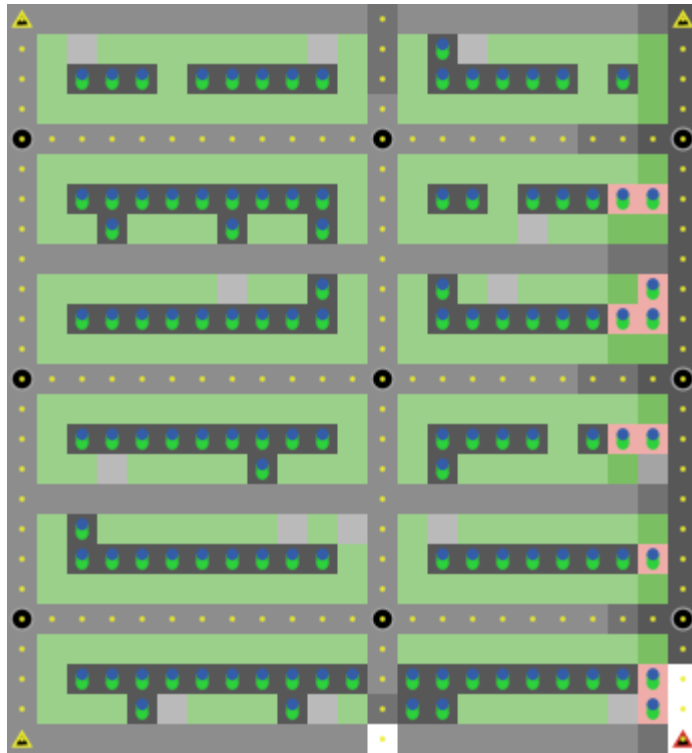
Flooding

# An illustration in flooding



L-Grid model  
(Zellner et al. 2016)

# An illustration: Rain barrels or bioswales?

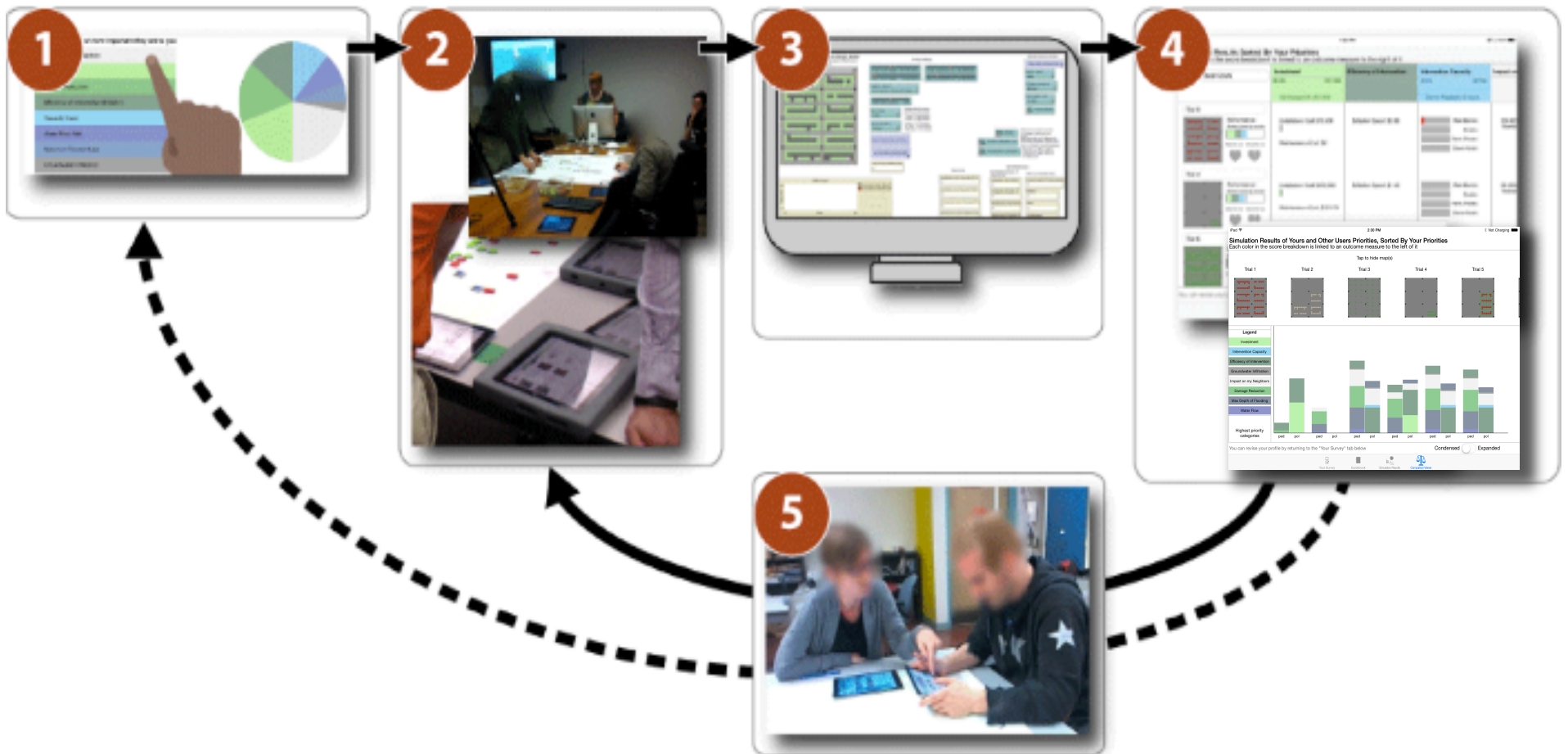


	Baseline	Rain barrels	Bioswales
Installation cost	\$0.00	\$14,250.00	\$350,168.79
Damages	\$39,062.90	\$38,837.74	\$34,495.24
Outflow	0.62	0.62	0.56

# Things to consider

- Simulations alone are not enough
  - Tradeoffs
  - Costs and distribution
  - Spatial constraints
  - Diverse stakeholder interests
- Solution-building AND compromise
  - Awareness of preferences
  - Addressing diverse needs
    - metrics, evaluation, exploration

# Workshop setup



(Zellner et al. in press)

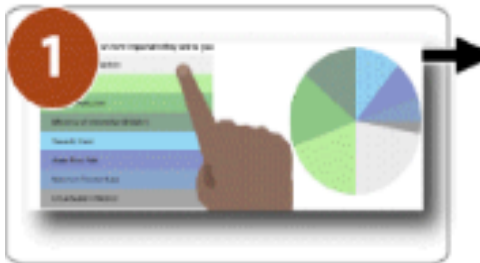
# Concern profile

iPad

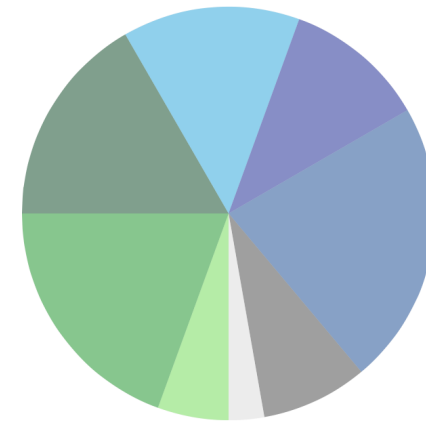
12:03 PM

100%

Sort the items based on how important they are to you



- Maximum Flooded Area
- Damage Reduction
- Efficiency of Intervention (\$/Gallon)
- Capacity Used
- Water Flow Path
- Groundwater Infiltration
- Investment
- Impact on my Neighbors



## Definitions

**Investment:** Cost to install and maintain new green infrastructure on both city and private property. Maintenance costs are in Present Value (PV) over 20 years, at 3% discount rate.

**Damage Reduction:** The amount of property damages reduced by the investment.

**Efficiency of Intervention: (\$/Gallon)** The amount of money spent per gallon of rainwater stored or infiltrated by green infrastructure installations.

**Capacity Used:** The percentage of capacity used by interventions over their total available capacity.

Enter Username

Profile Unlocked  Profile Locked

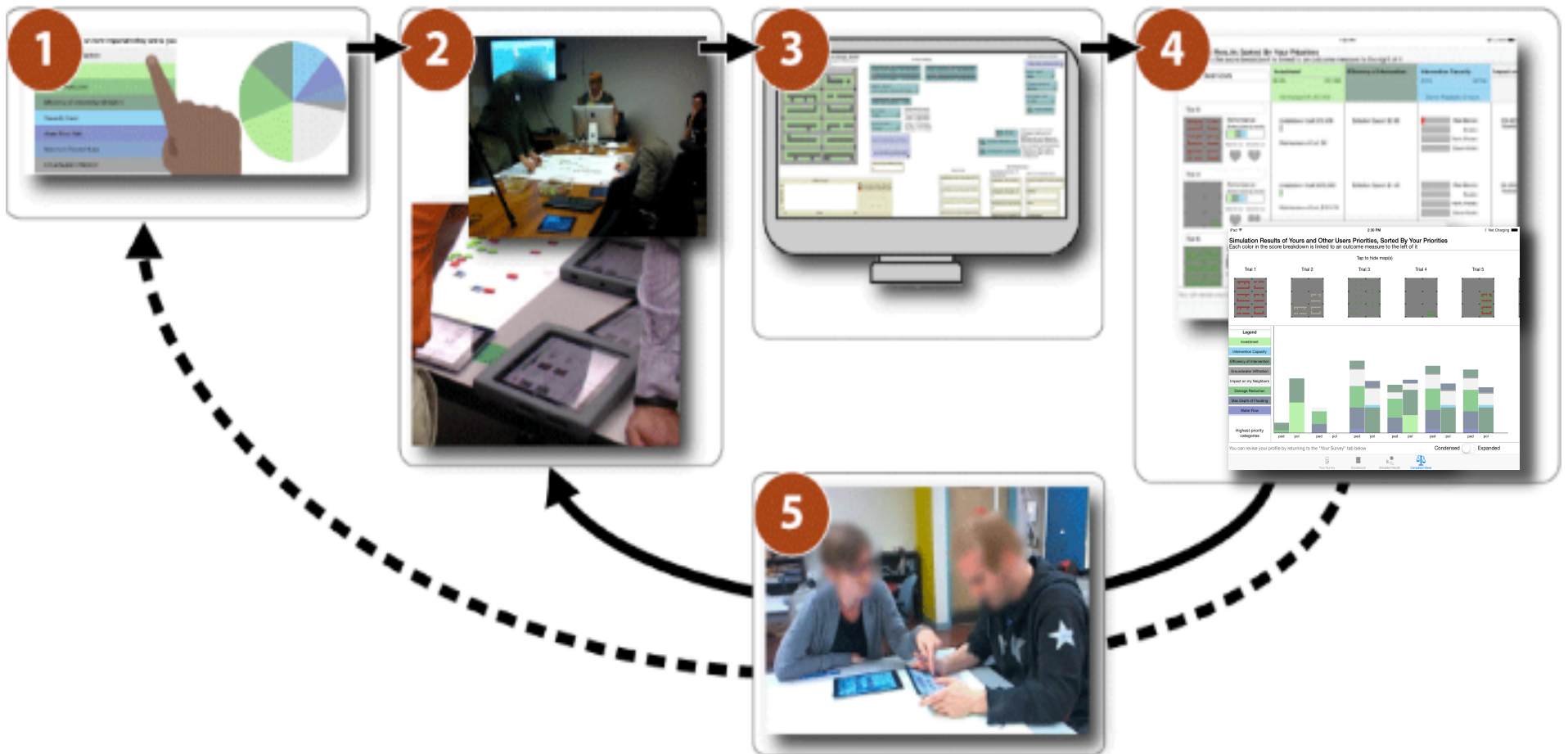
Your Survey

Guidebook

Simulation Results

Comparison Viewer

# Workshop setup

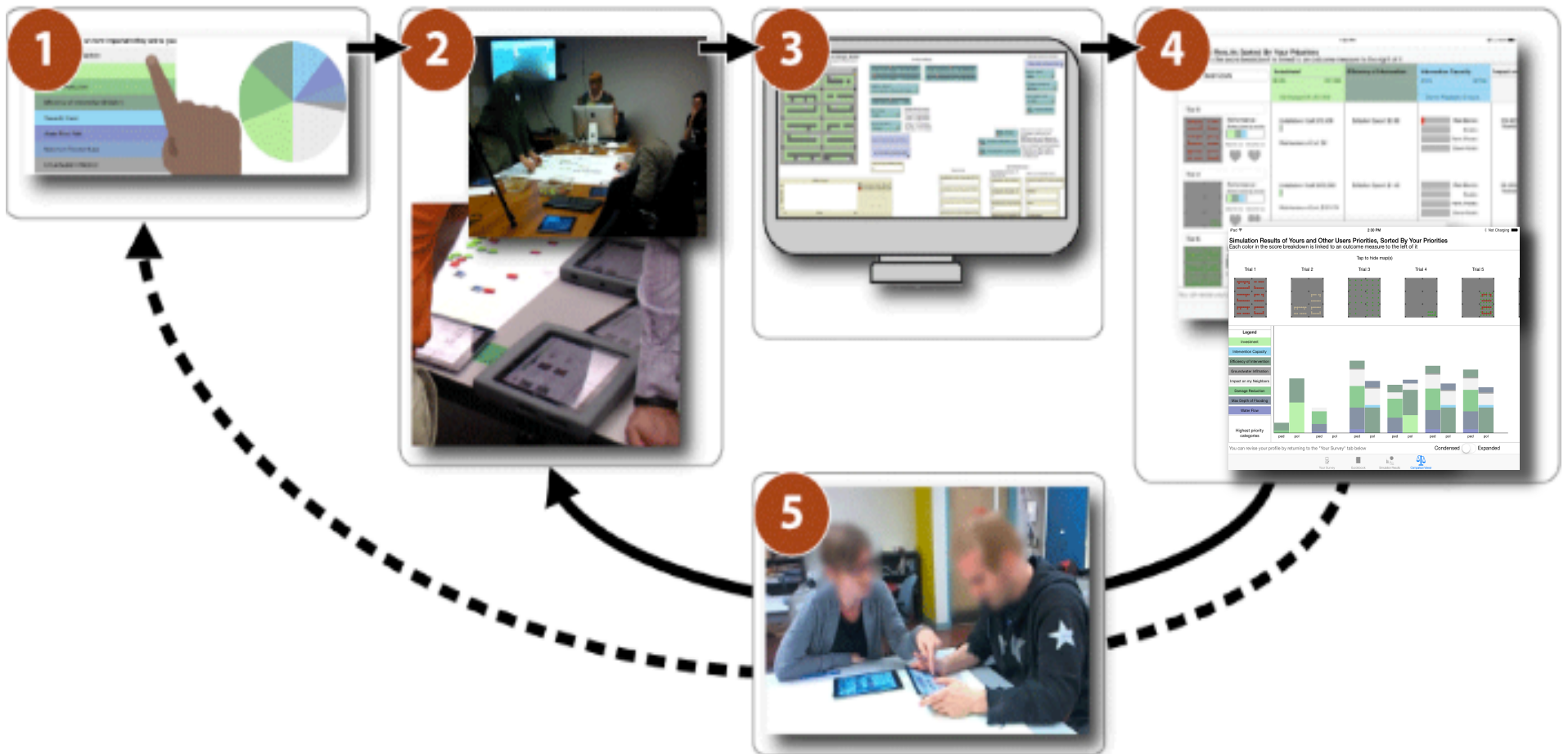


# Workshop setup





# Workshop setup



# Sorted simulation results

iPad

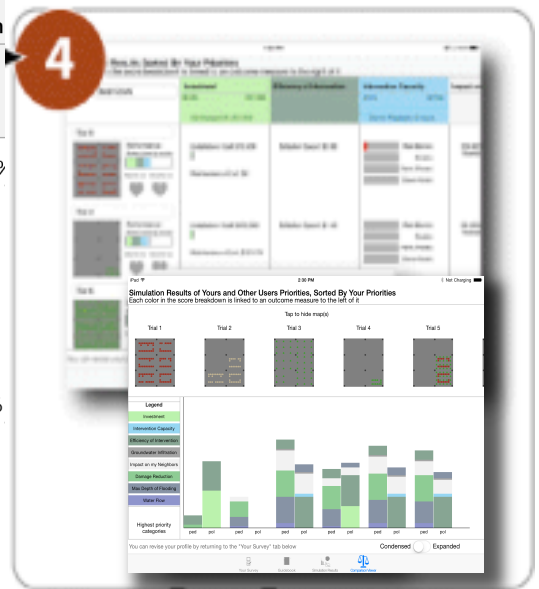
2:30 PM

Not Charging

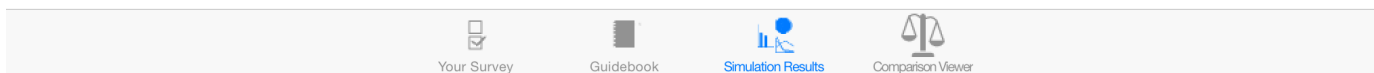
## Simulation Results Sorted By Your Priorities

The Performance score is broken down into colors corresponding to the outcomes on the right

Sort by	Water Flow	Max Depth of Flooding	Damage Reduction	Impact on
Trial Number	0 hrs <span style="float:right">48 hrs</span> Storm Playback: 21 hours			
<p>Performance: Broken down by source:</p> <p>Best for me Worst for me</p> <p>♥ ♥</p>			<p>Rain Damage: \$27,978</p> <p>Damaged Reduced by: 13%</p> <p>Sewer Load: 22.58%</p> <p>Storms like this one to recoup investment cost: 0</p>	100.00% flowed
<p>Trial 2</p> <p>Performance: Broken down by source:</p> <p>Best for me Worst for me</p> <p>♥ ♥</p>			<p>Rain Damage: \$18,475</p> <p>Damaged Reduced by: 61%</p> <p>Sewer Load: 18.74%</p> <p>Storms like this one to recoup investment cost: 147</p>	75.50% flowed
<p>Trial 3</p> <p>Performance: Broken down by source:</p> <p>Best for me Worst for me</p> <p>♥ ♥</p>			<p>Rain Damage: \$0</p> <p>Damaged Reduced by: 100%</p> <p>Sewer Load: 18.74%</p> <p>Storms like this one to recoup investment cost: 49</p>	7.84% c flowed



You can revise your profile by returning to the "Your Survey" tab below



# Social viewer

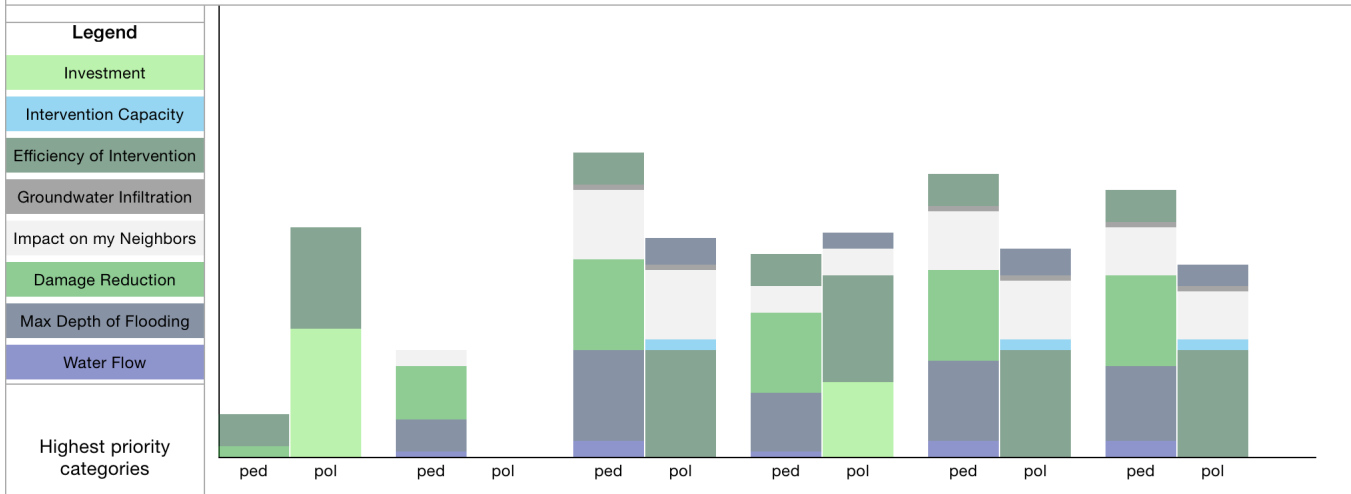
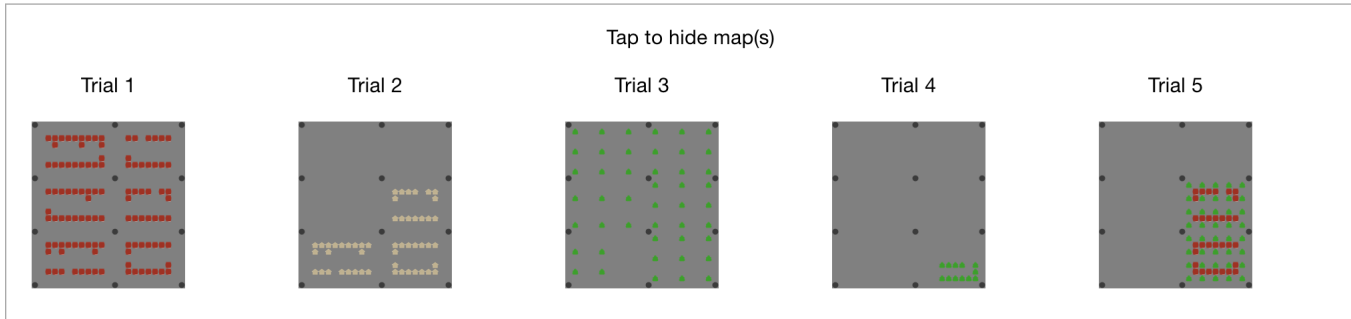
iPad

2:30 PM

Not Charging

## Simulation Results of Yours and Other Users Priorities, Sorted By Your Priorities

Each color in the score breakdown is linked to an outcome measure to the left of it



You can revise your profile by returning to the "Your Survey" tab below

Condensed  Expanded

# Social viewer

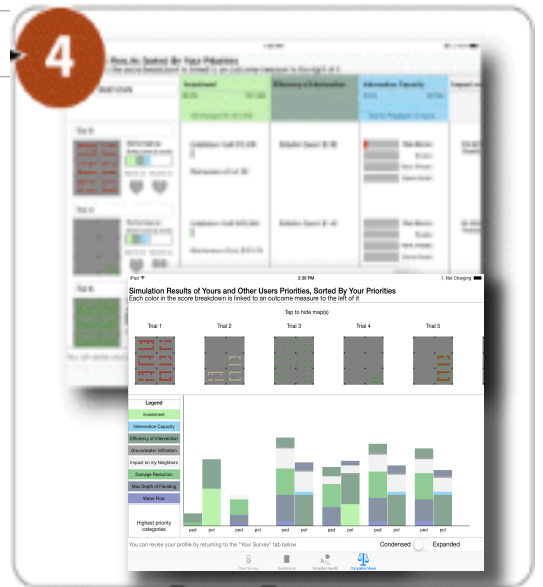
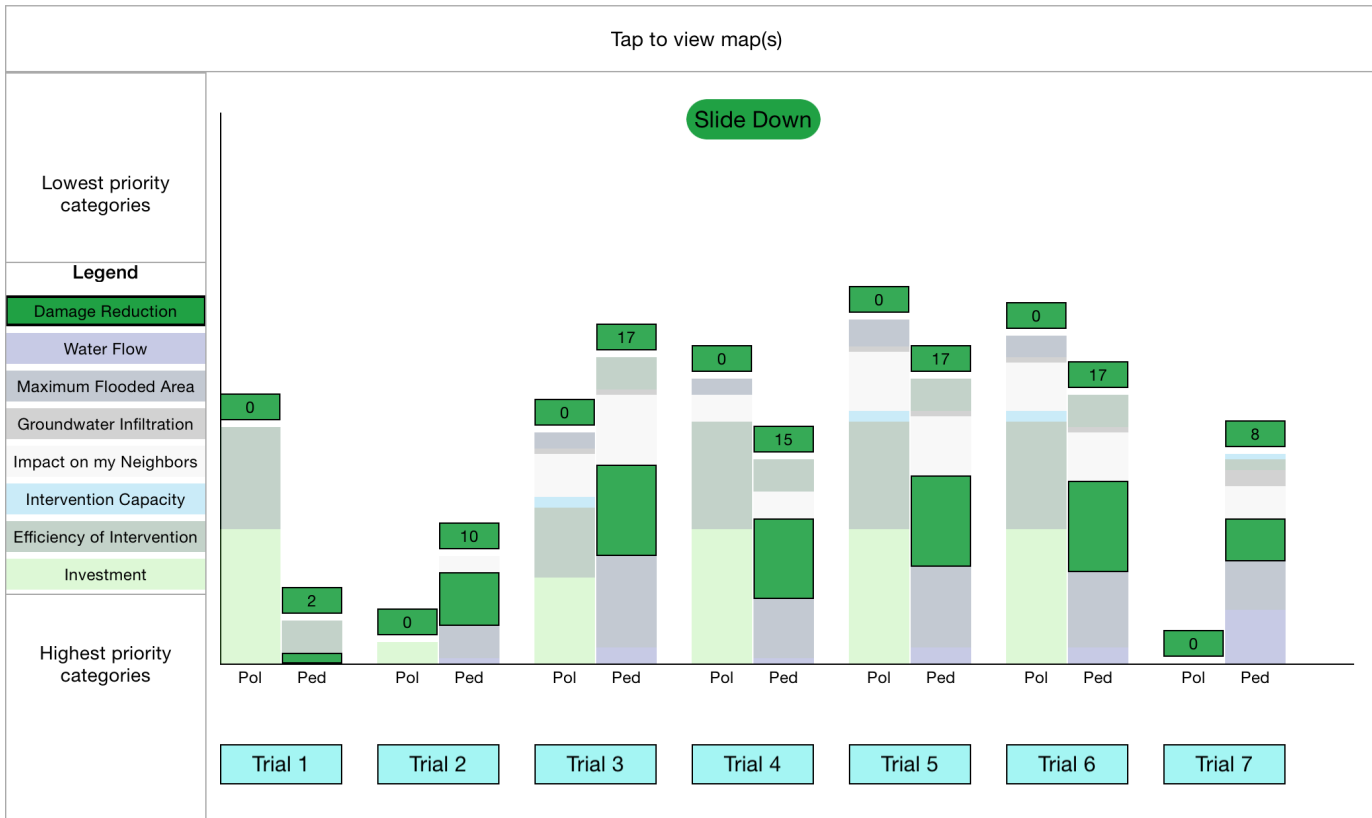
iPad

12:13 PM

100%

## Simulation Results of Yours and Other Users Priorities, Sorted By Your Priorities

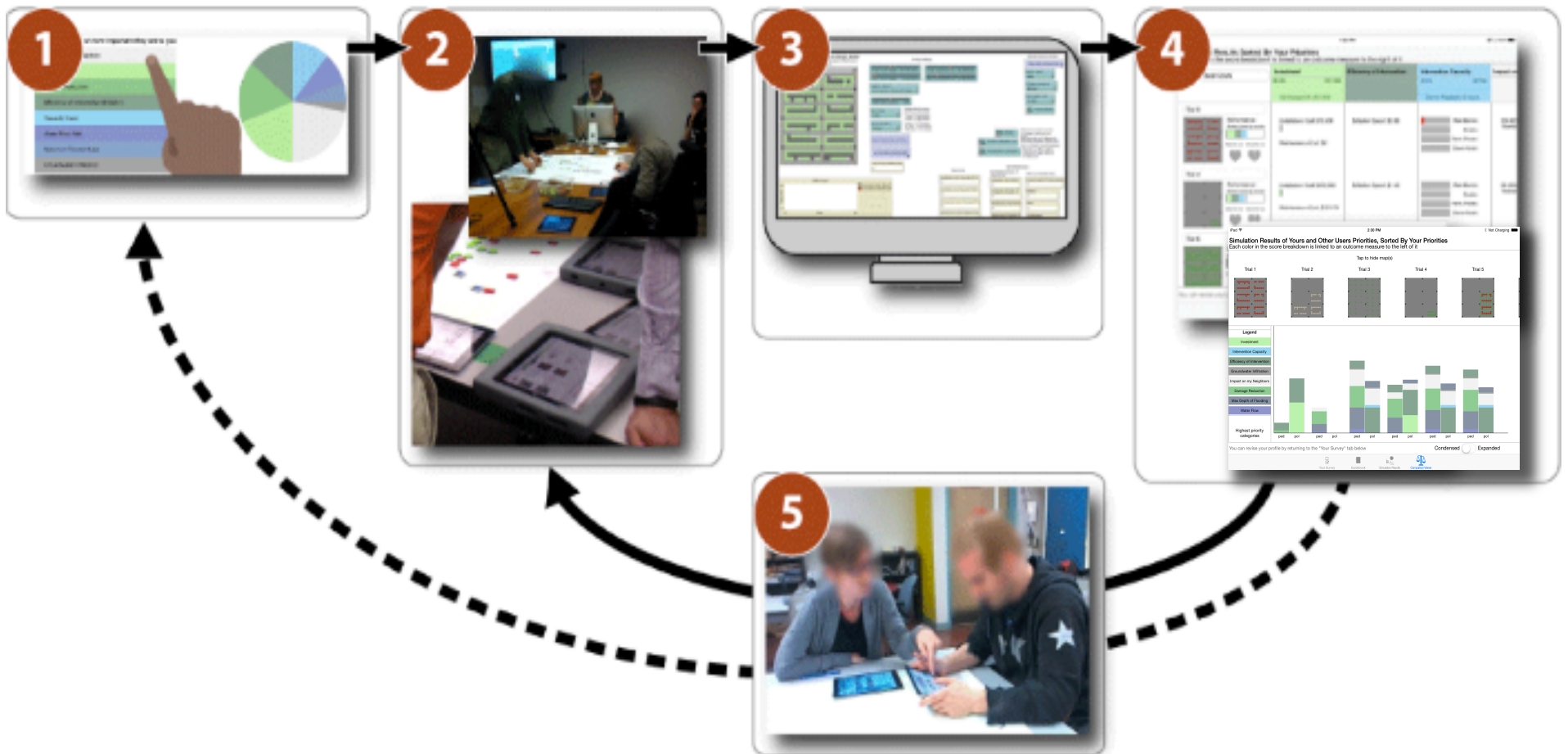
Each color in the score breakdown is linked to an outcome measure to the left of it



You can revise your profile by returning to the "Your Survey" tab below

Condensed  Expanded

# Workshop setup



# Learning, innovation, compromise

- Transparency of assumptions and tradeoffs

*Jo: “Oh wow, that ’s much better...for you.”*

*Nina: “I guess it matters what your priorities are!”*

*Kevin: “Damage was reduced by 87%...but we were over budget by 1.2 million.”*

- Systematic exploration

*“Let ’s start by going crazy, putting a lot of stuff on here, and then pare back from there.”*

*“We can run multiple simulations, so let ’s run this one and then try that ”*

- Gesturing and mental modeling

*Following the flow*

*Imagining different performance*

- Green infrastructure cannot locally solve the problem

*“Perhaps we need to think of moving the houses out of there ”*

*Green AND gray infrastructure*

*Coordination with other communities*

# Answers II: Tools for participation

- Collaborative design
- Facilitation for synthesis
- Consensus or compromise?
- Participatory modeling as a point of entry
  - to the problem,
  - to other tools,
  - to diverse interests
  - to other problems

APA Academic Tech Innovator Award 2017  
(Zellner et al. in press)

# Future plans

- Refining and extending participatory modeling and visualization
  - New domains: energy, food, air and water quality
  - New contexts: South America, Australia, Middle East
  - New tools and approaches: scaling up, data life cycle
- Contributing to communities
  - Scholarly: ComSES, CSDMS
  - Decision-making: US and State Congress, NCSE
- Interdisciplinary teaching



# Why do this?

- Changing established heuristics
- Supporting the evolution of understanding and valuation
- Technology as a prosthetic device for decision-making
- Innovation is critical for resilience and sustainability

# Acknowledgments

- Leilah Lyons, Dan Milz, Charles Hoch, Josh Radinsky, Ben O' Connor, Max Dieber, Andy Johnson, Emily Minor, Dean Massey, Justin Keller, Eric Boria, Jen Weizeorick, Jo Pena, Carl Kunda, Ethan Brown, Lissa Domoracki, April Schneider, Kelsey Pudlock, Joey Shelley, Brian Slattery, Lisa Cotner.
- Chicago region stakeholders
- Tim Loftus, Jason Navota, Nora Beck, CMAP
- Josh Ellis, Danielle Gallet, Sarah Cardona, MPC
- John Watson, Jim Yurik, Rich Fisher, Jack Chan, Annie Wright, MWRD
- Howard Reeves, USGS
- Al Wehrmann, Yu-Feng Lin, Scott Meyer, ISWS
- Urban Planning and Policy, Great Cities Institute, Institute for Public and Civic Engagement (UIC), UIC Chancellor Discovery Fund,
- National Science Foundation CI-TEAM and REESE programs.

# Thank you!

Moira Zellner

[mzellner@uic.edu](mailto:mzellner@uic.edu)

THE  
UNIVERSITY OF  
ILLINOIS  
AT  
CHICAGO

