Integrated socio-ecological models for decision-making

Addressing Big Questions with Data, Models, and Participatory Exploration

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THE UNIVERSITY OF ILLINOIS AT CHICAGO
UIC

Motivations

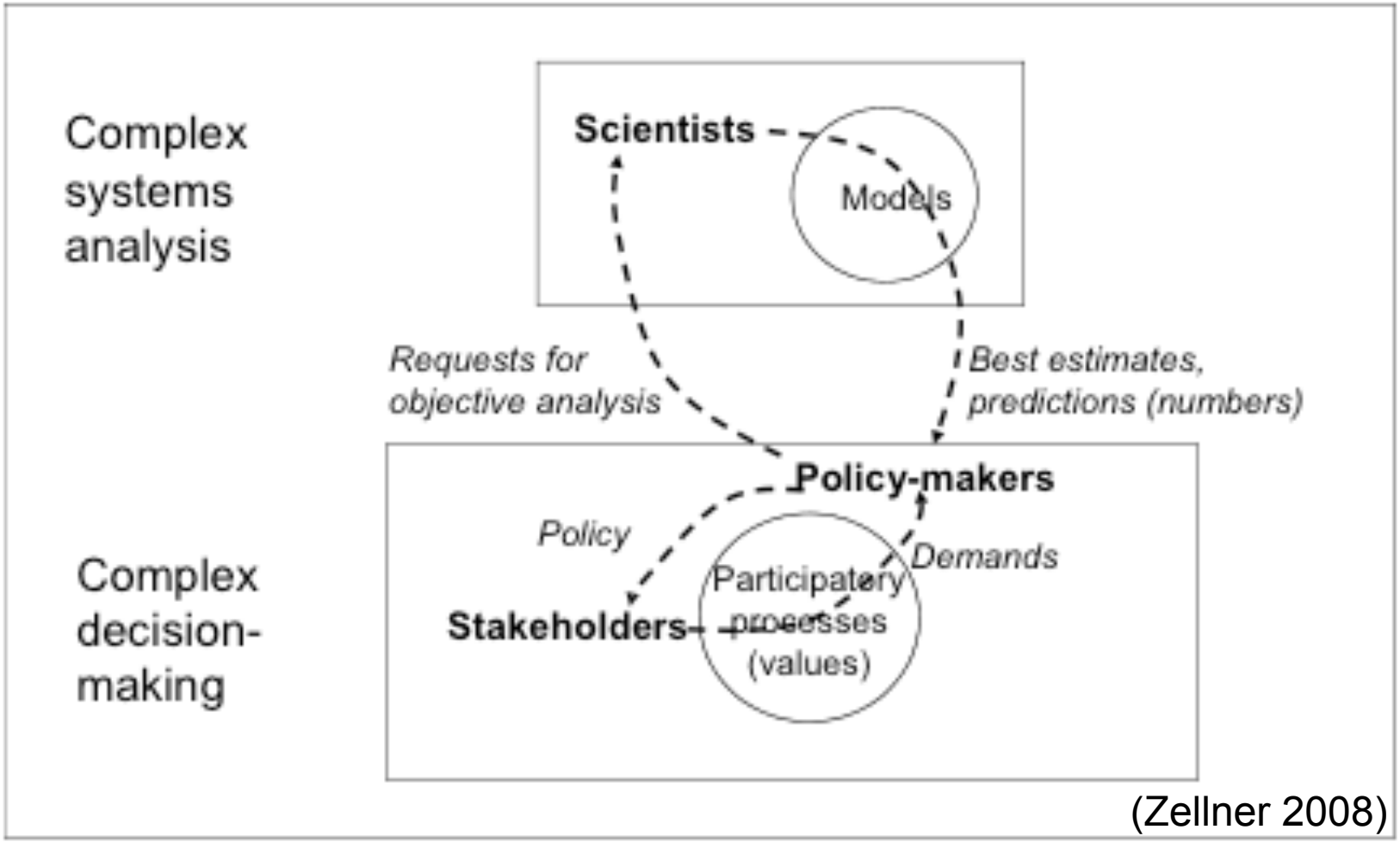
Source: sanfrancisco.cbslocal.com

Source: http://www.greenpeace.org

Coupled Human Natural Systems Modeling for Planning and Policy

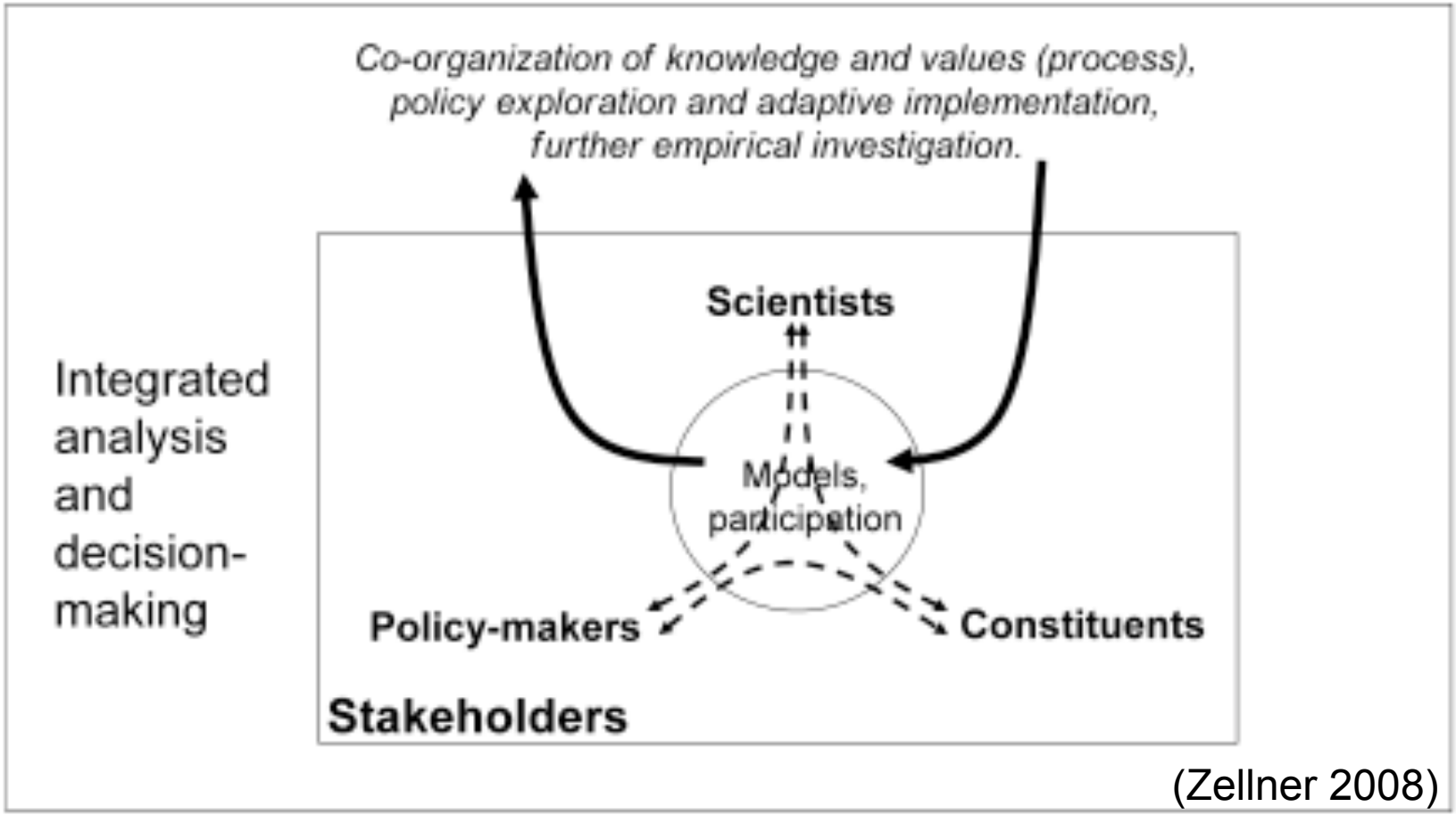
- Growth is not sustainable(.)
  - Zellner and Reeves (2012)
- Green infrastructure: Thresholds and layouts
  - Zellner et al. (2016)
- Collaborative conservation can arise under development pressure
  - Zellner et al. (2010)
- Adaptation can reduce crop losses but exacerbate flooding
  - Zellner et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

Conventional planning and modeling



(Zellner 2008)

"Unconventional" planning and modeling



(Zellner 2008)

Challenges

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

Questions: Tools for participation

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

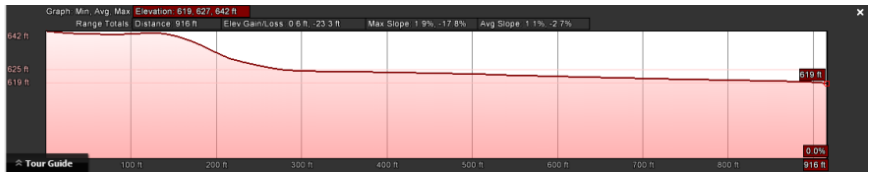
What we've learned

- It supports learning and innovation
- It's hard!
- It's deeply human
- An illustration:
  - Making the invisible visible

Making the invisible visible

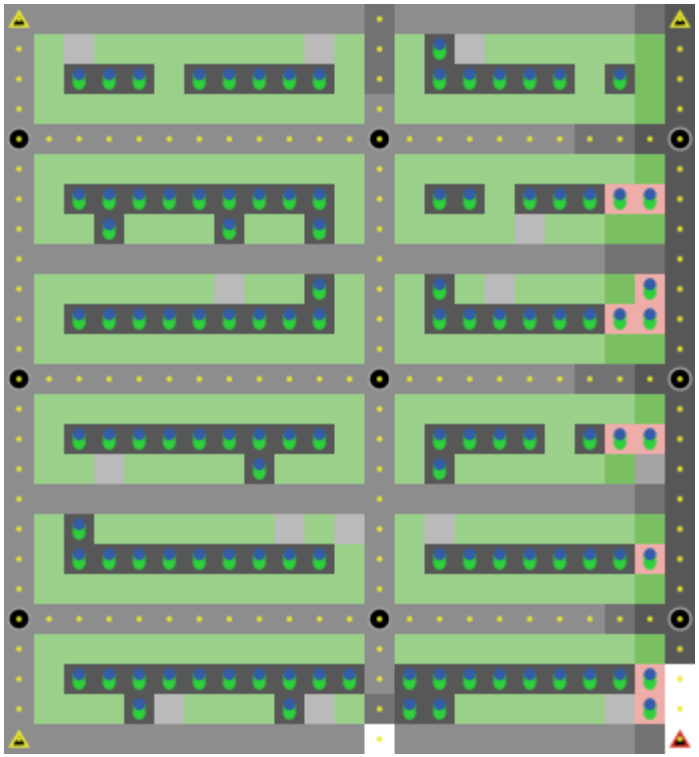
Flooding

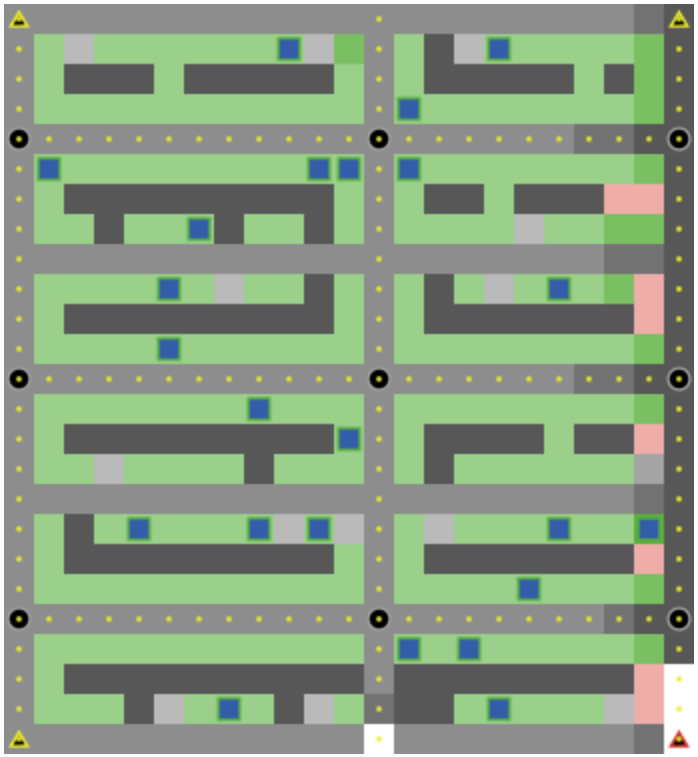
An illustration in flooding



L-GrID model
(Zellner et al. 2016)

An illustration:
Rain barrels or bioswales?



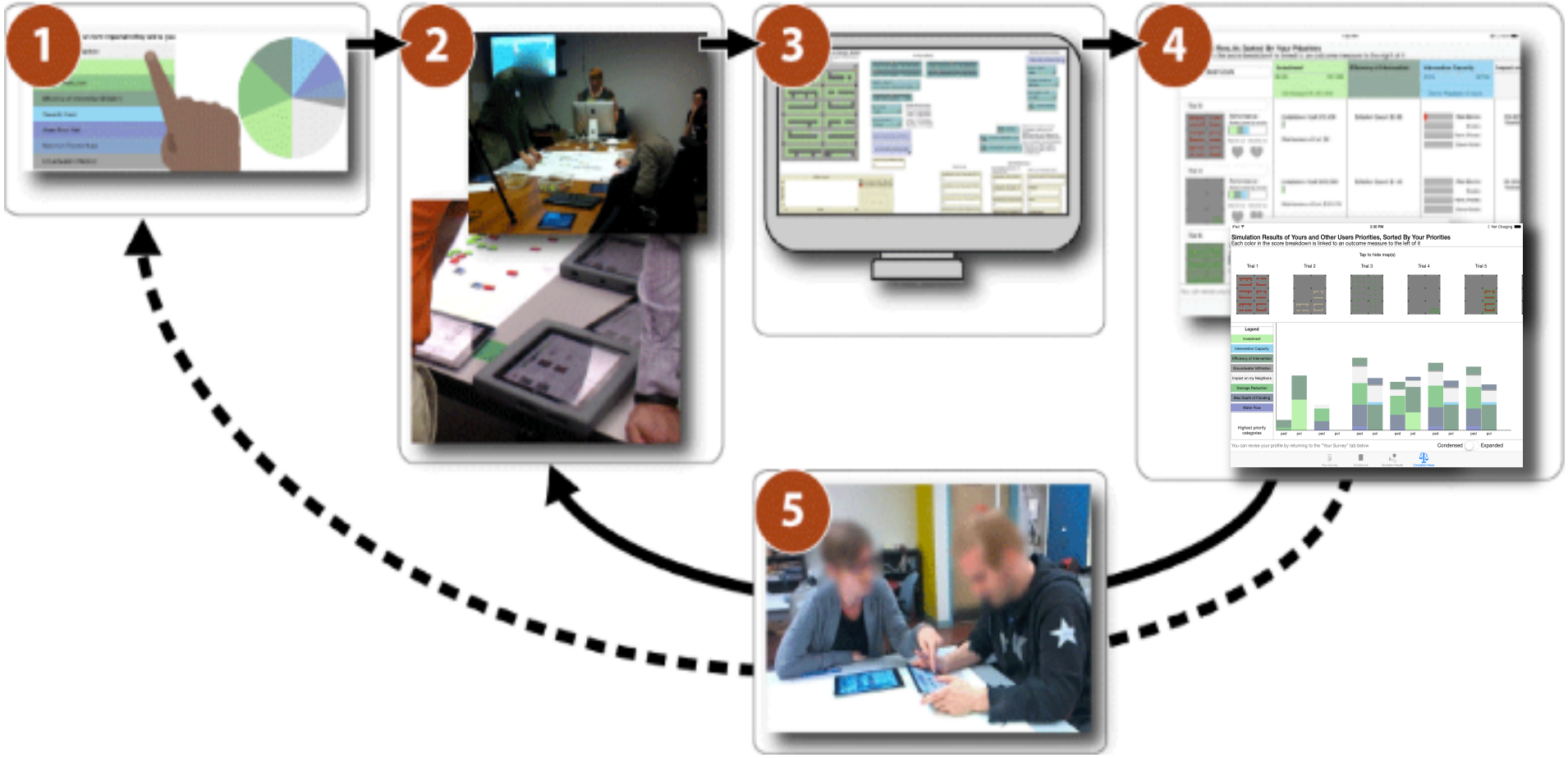


	Baseline	Rain barrels	Bioswales
Installation cost	$0.00	$14,250.00	$350,168.79
Damages	$39,062.90	$38,837.74	$34,495.24
Outflow	0.62	0.62	0.56

Things to consider

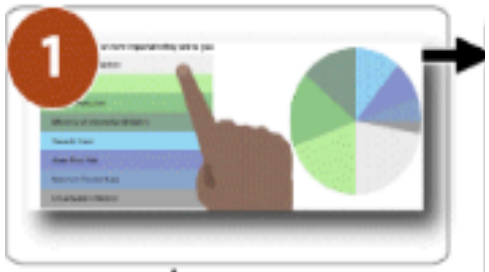
- Simulations alone are not enough
  - Tradeoffs
  - Costs and distribution
  - Spatial constraints
  - Diverse stakeholder interests
- Solution-building AND compromise
  - Awareness of preferences
  - Addressing diverse needs
    - metrics, evaluation, exploration

Workshop setup



(Zellner et al. in press)

Concern profile



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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

Enter Username

Profile Unlocked Profile Locked

Definitions

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

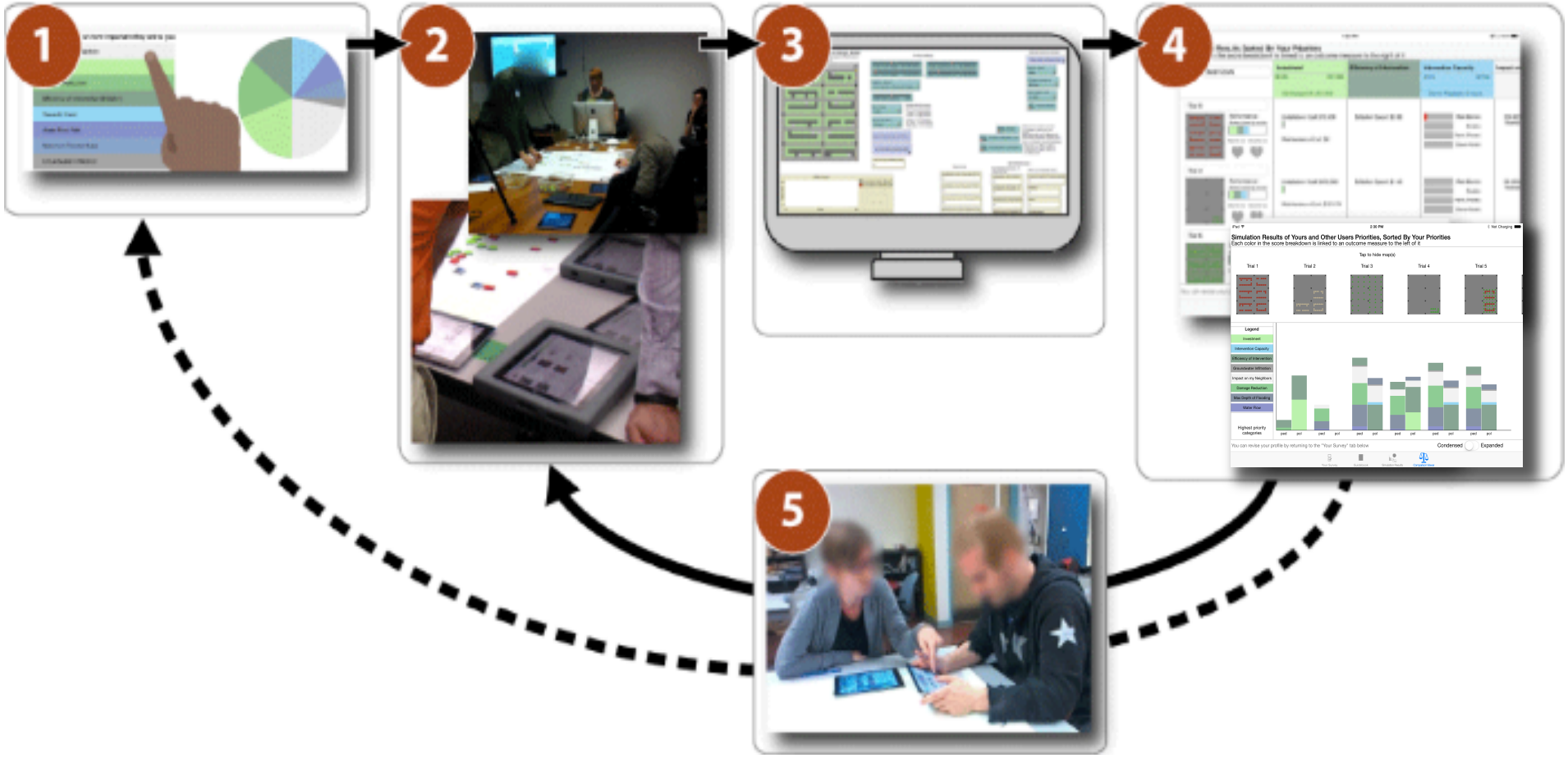
Damage Reduction: The amount of property damages reduced by the investment.

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

Your Survey Guidebook Simulation Results Comparison Viewer

Workshop setup



Workshop setup

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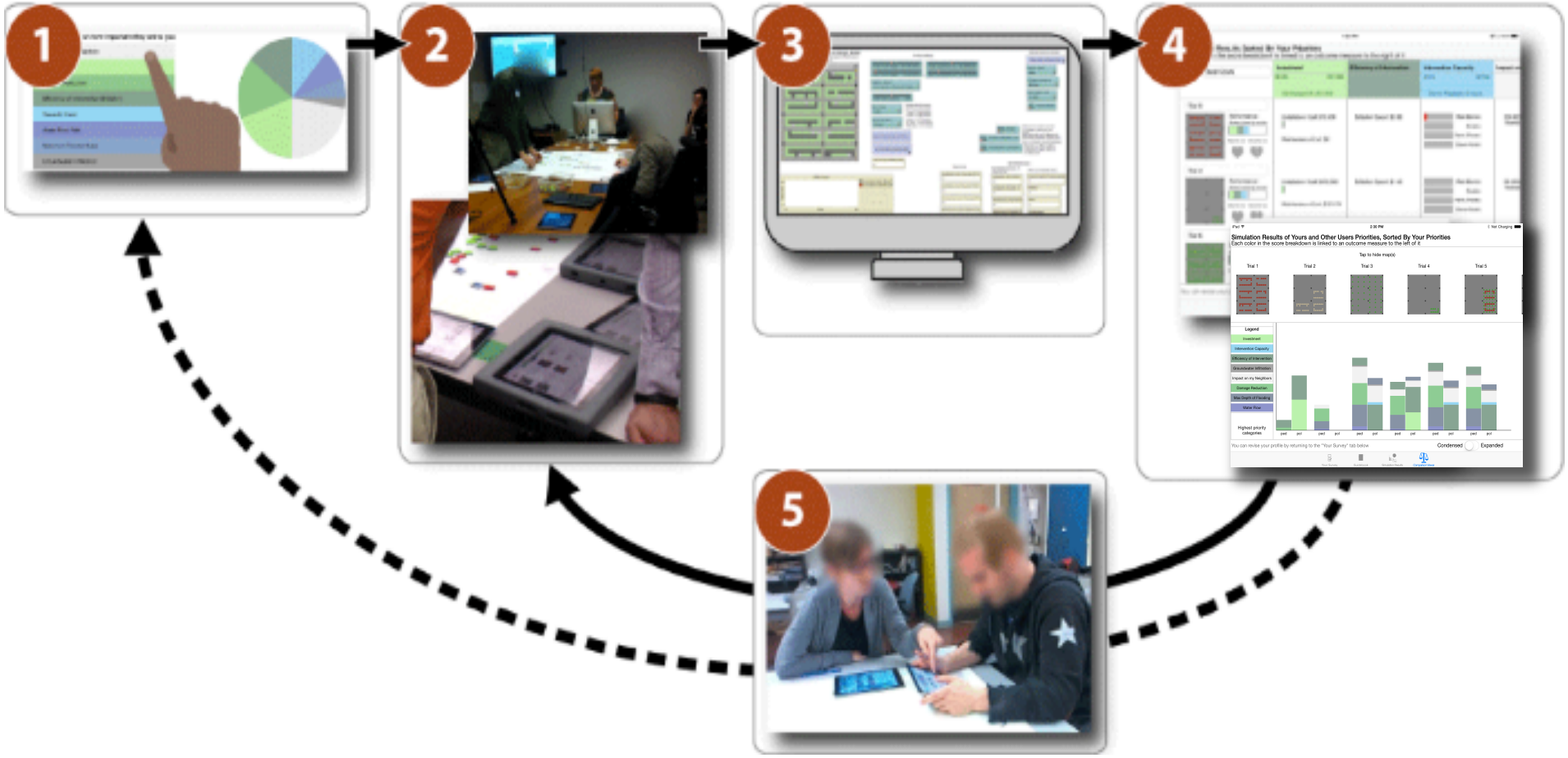

Sorted simulation results

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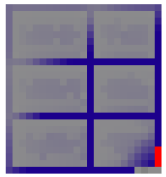
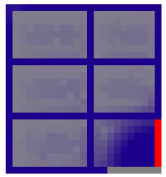
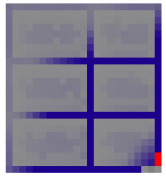
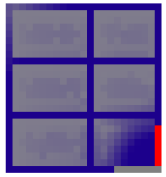
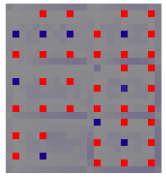
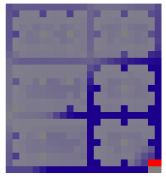
Simulation Results Sorted By Your Priorities

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

Sort by: Trial Number

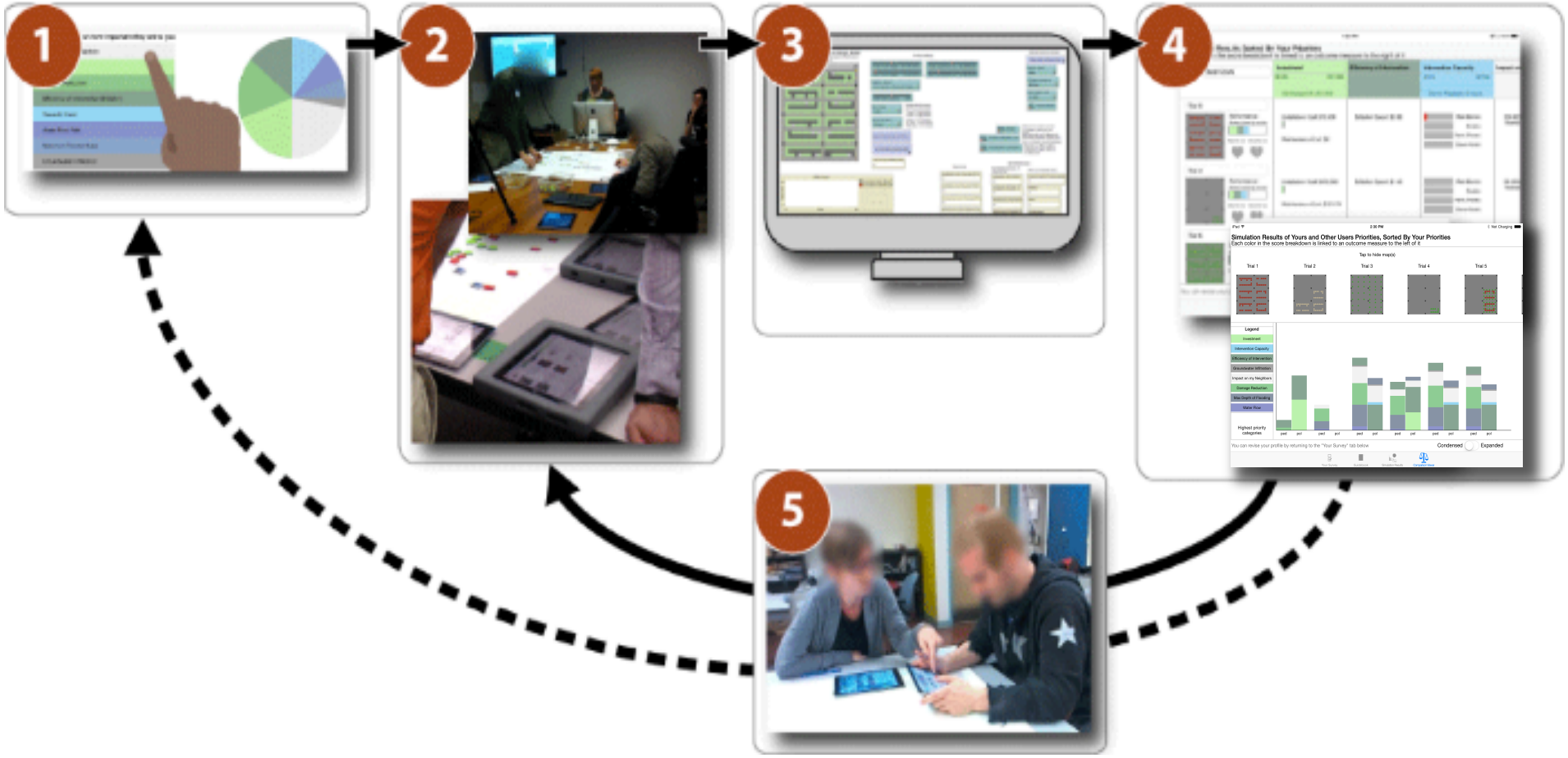
	Water Flow (0 hrs – 48 hrs; Storm Playback: 21 hours)	Max Depth of Flooding	Damage Reduction	Impact on
Performance: Broken down by source: Best for me / Worst for me			Rain Damage: $27,978 Damaged Reduced by: 13% Sewer Load: 22.58% Storms like this one to recoup investment cost: 0	100.00% flowed
Trial 2 Performance: Broken down by source: Best for me / Worst for me			Rain Damage: $18,475 Damaged Reduced by: 61% Sewer Load: 18.74% Storms like this one to recoup investment cost: 147	75.50% flowed
Trial 3 Performance: Broken down by source: Best for me / Worst for me			Rain Damage: $0 Damaged Reduced by: 100% Sewer Load: 18.74% Storms like this one to recoup investment cost: 49	7.84% c flowed

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

Your Survey | Guidebook | Simulation Results | Comparison Viewer

Social viewer

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

Takeaways

- 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 directions

- 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

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

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Thank you!

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