UA WRRC Brown Bag Seminar April 23, 2013

research update from the ASU Decision Center for a Desert City

Dave White
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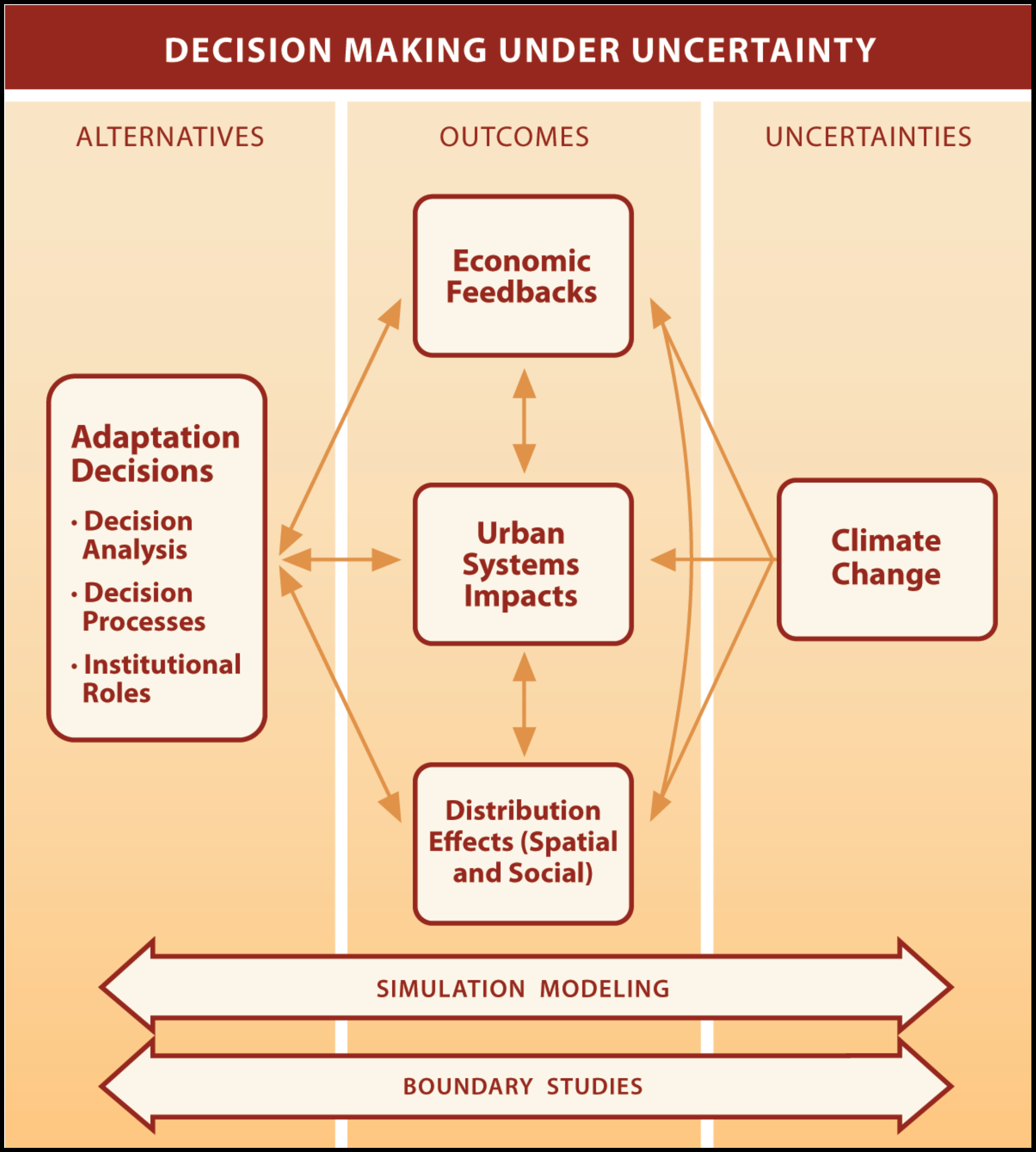
Global Institute of Sustainability
Arizona State University

DCDC is a transdisciplinary research center advancing knowledge, education, and community outreach about water sustainability and urban climate adaptation



how do we create and evaluate knowledge-action systems for effective environmental decision making?

specifically, how do we create and evaluate knowledge-action systems for water sustainability and urban climate adaptation in central Arizona?

main points

success of knowledge-action-systems depends in part on active boundary work

how stakeholders frame and reframe knowledge and action affects process and outcomes

models, scenarios, and other integrative tools can help structure knowledge-action-systems

institutions and networks can be (re)designed to support knowledge-action-exchange

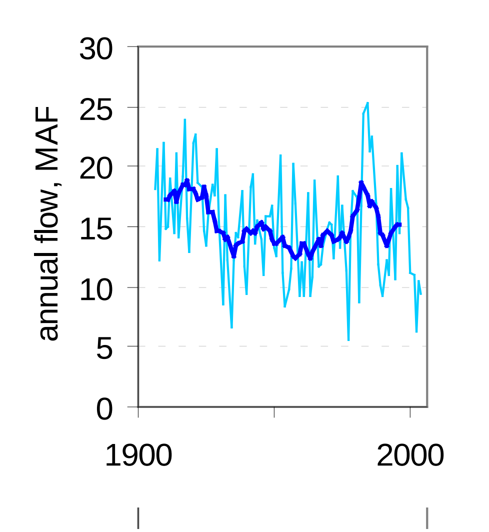
colorado river basin

central Arizona has a robust and resilient physical water system engineered to manage uncertainty and variability...

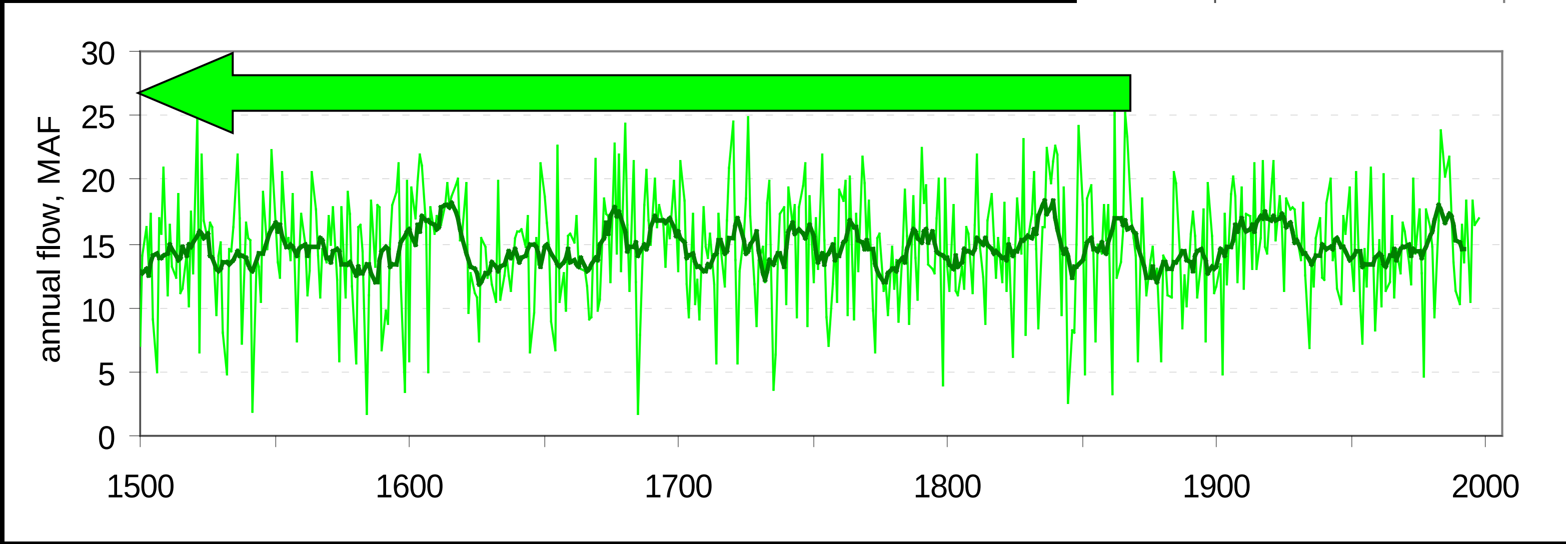
"The conclusion: there are tough choices ahead, but the water systems of the Sun Corridor were created to deal with uncertainty and change, are remarkably resilient, and can likely handle several million more people even without new supplies."

– Grady Gammage Jr., 2012

...but how representative is the recent historic record...



Colorado River at Lees Ferry, 1906-2004



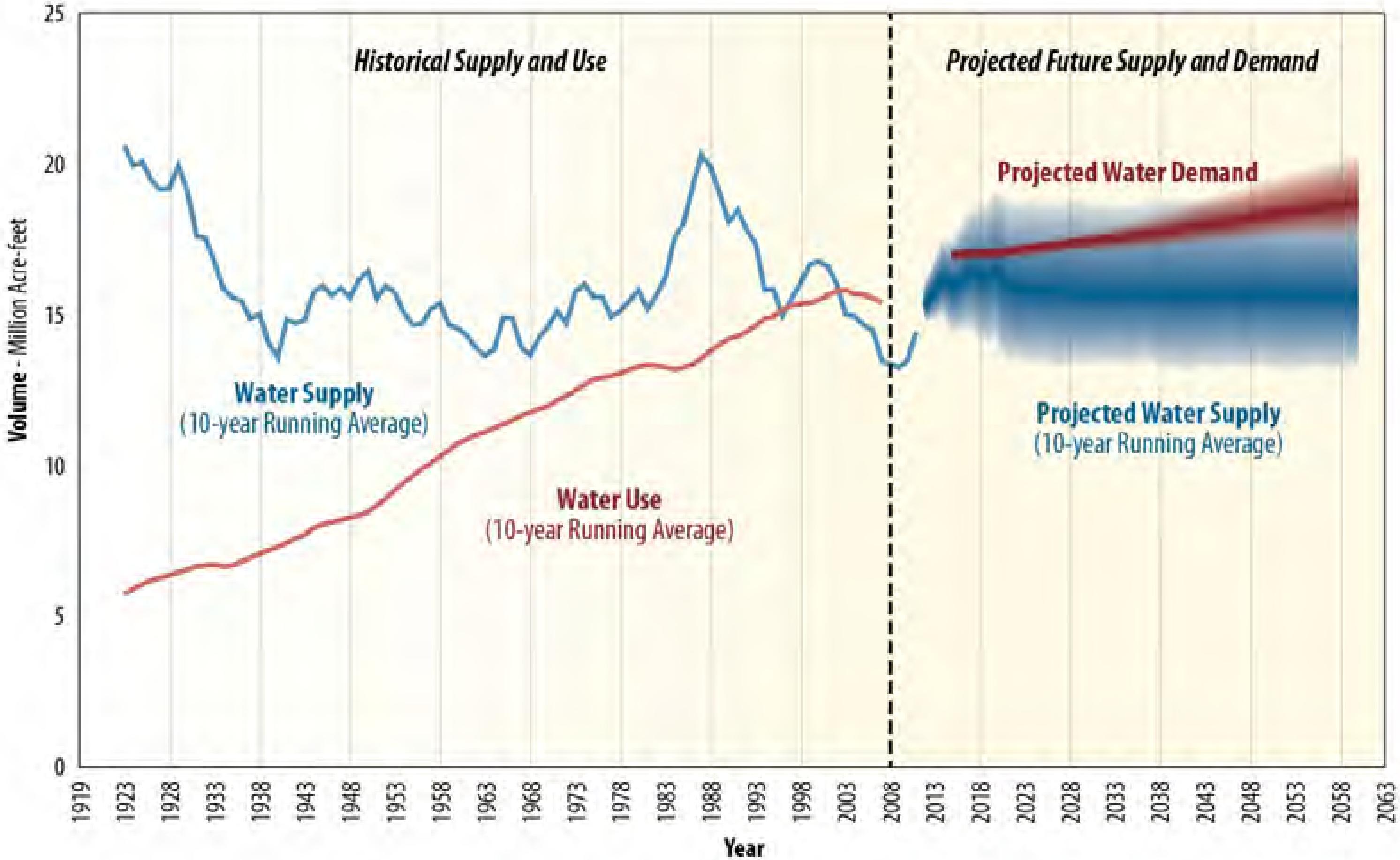
Tree-ring reconstruction of Colorado River, Lees Ferry, 1490-1997

Credit: Connie Woodhouse & Dan Griffin
School of Geography and Development & Laboratory of Tree-Ring Research, University of Arizona

...and the system is designed to operate under assumptions of a stationary climate with a known and predictable range of variability...

A 2010 issue of the Proceedings of the National Academy of Sciences devoted to the future of the Colorado River Basin (CRB) pointed to increasing aridity, more intense and frequent droughts, and increased forest and woodland mortality due to fires and pathogenic outbreaks (MacDonald, 2010)

FIGURE 2
Historical Supply and Use[1] and Projected Future Colorado River Basin Water Supply and Demand[1]



[1] Water use and demand include Mexico's allotment and losses such as those due to reservoir evaporation, native vegetation, and operational inefficiencies.

Bureau of Reclamation. (2012). Colorado River Basin Water Supply and Demand Study: Study Report (pp. 89). Boulder City, NV: U. S. Department of Interior, Bureau of Reclamation.

...and with a large hydrologic reach and little (deliberate) provisioning of water to environmental in-stream flows...

...and a complex governance system with priorities and incentives perhaps not suited to future challenges

"Metropolitan Phoenix is not governed by a single regional water authority but by 40 large water providers and 80 smaller ones; each maintains its own supply portfolio and responds to customers in its service area." Gober 2007

again: how do we create and evaluate knowledge-action systems for water sustainability and urban climate adaptation in central Arizona?

boundary work refers to activities of those seeking to mediate between knowledge and action

boundary work

knowledge co-production

governance arrangements w/ accountability

boundary objects

meaningful co-production of knowledge by multiple stakeholders

“Co-production of science and policy… requires substantial commitment to the three components we have identified: interdisciplinarity, stakeholder participation, and production of knowledge that is demonstrably usable.”

– Lemos and Moorehouse, 2005

governance arrangement such as **boundary organizations** provide accountability to relevant stakeholders

creation of boundary objects such as models, maps and scenarios that structure knowledge-action negotiation

"Model-based decision-support tools are one type of boundary object that has become increasingly popular for linking environmental science and policy in coupled human-ecological systems." White, 2013

how do key stakeholders perceive the dynamics of science-policy interactions within the knowledge-action system?

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Water Managers' Perceptions of the Science–Policy Interface in Phoenix, Arizona: Implications for an Emerging Boundary Organization

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A potential water supply crisis has sparked concern among policymakers, water managers, and academic scientists in Phoenix, AZ. The availability of water resources is linked to population growth, increasing demand, static supply, land use change, and uncertainty. This article examines the perceptions of water managers working at the science–policy interface in Phoenix and discusses the implications of their experiences for the development of an emerging boundary organization: the Decision Center for a Desert City. Qualitative analysis of data generated through in-depth interviews with water managers uncovers two understandings of the intersection of science and policy: One perspective is a traditional, linear model with sharp conceptual distinctions between the two spheres, and the other is a recursive model recognizing fluid boundaries. Managers describe uncertainty as inescapable, but manageable. A prescriptive model for the science–policy interface for Phoenix water management is presented.

Keywords climate change, drought, environmental policy, uncertainty, urban water resources, Western water management

According to the U.S. Bureau of Reclamation (2003), Arizona is at the center of a geographic region facing a potential water supply crisis by 2025: Existing water supplies may not be adequate to meet future demands for society or the environment. This potential crisis is tied to a convergence of factors including explosive population

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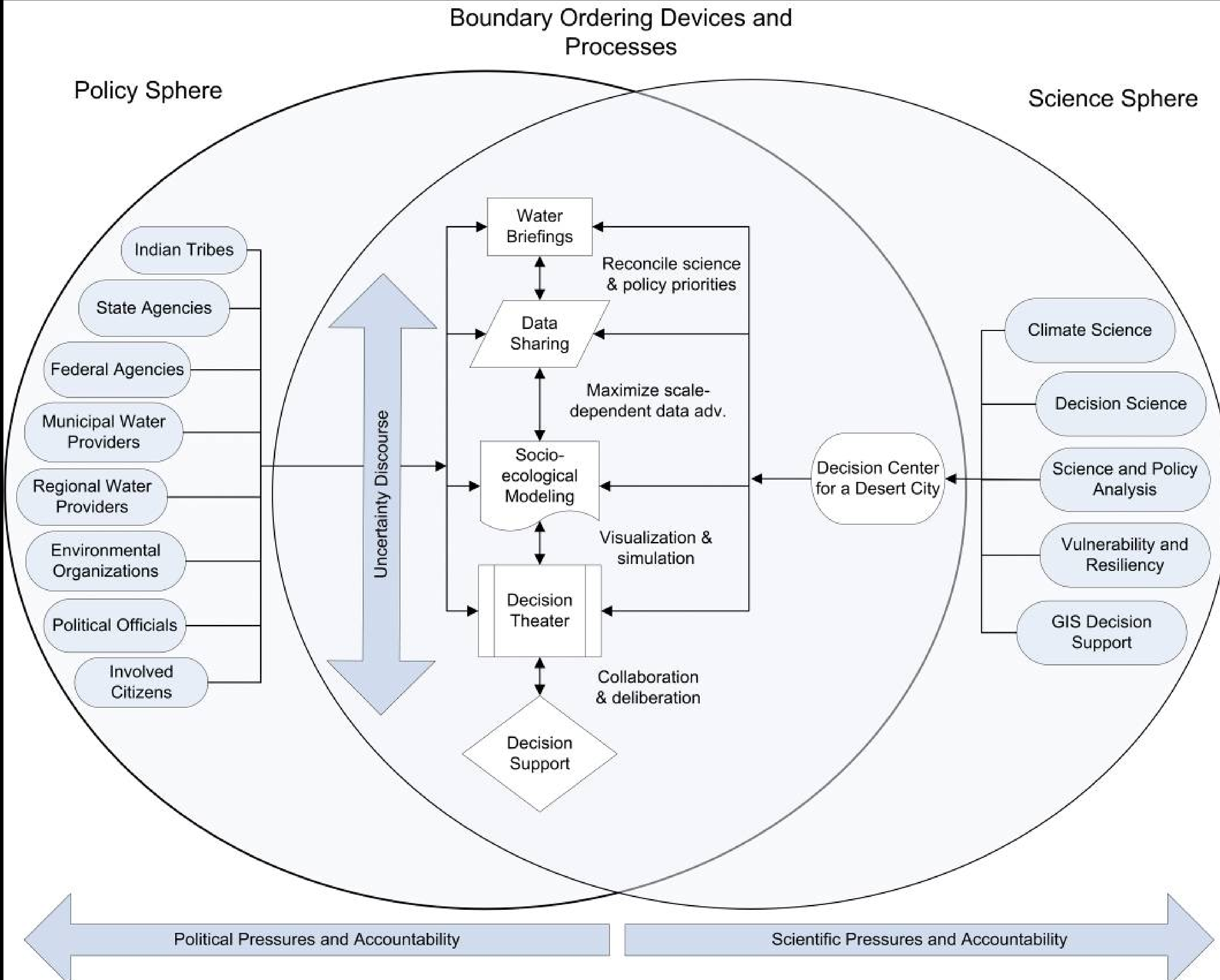
two understandings of the science-policy interface among Arizona water managers: one is a traditional, linear model with sharp conceptual distinctions between the two spheres; the other is a recursive model recognizing fluid boundaries

what are the most effective and efficient ways to initiate and run boundary organizations that link science and policy?


Boundary Ordering Devices and Processes
Policy Sphere
Science Sphere
Indian Tribes
State Agencies
Federal Agencies
Municipal Water Providers
Regional Water Providers
Environmental Organizations
Political Officials
Involved Citizens
Uncertainty Discourse
Water Briefings
Reconcile science & policy priorities
Data Sharing
Maximize scale-dependent data adv.
Socio-ecological Modeling
Visualization & simulation
Decision Theater
Collaboration & deliberation
Decision Support
Decision Center for a Desert City
Climate Science
Decision Science
Science and Policy Analysis
Vulnerability and Resiliency
GIS Decision Support
Political Pressures and Accountability
Scientific Pressures and Accountability

how do social networks affect knowledge utilization in a knowledge-action system?

Crona, B. I., and J. N. Parker. 2012. Learning in support of governance: theories, methods, and a framework to assess how bridging organizations contribute to adaptive resource governance. *Ecology and Society* 17(1): 32.
http://dx.doi.org/10.5751/ES-04534-170132

Synthesis

Learning in Support of Governance: Theories, Methods, and a Framework to Assess How Bridging Organizations Contribute to Adaptive Resource Governance

Beatrice I. Crona [1,2] *and John N. Parker* [3,4]

ABSTRACT. Humanity faces increasingly intractable environmental problems characterized by high uncertainty, complexity, and swift change. Natural resource governance must therefore involve continuous production and use of new knowledge to adapt to highly complex, rapidly changing social-ecological systems to ensure long-term sustainable development. Bridging and boundary organizations have been proposed as potentially powerful means of achieving these aims by promoting cooperation among actors from the science, policy, and management sectors. However, despite substantial investments of time, capital, and human resources, little agreement exists about definitions and measures of knowledge production and how this is achieved in bridging organizations and there is only meager understanding of how knowledge production and its use are shaped by social interactions, socio-political environments, and power relations. New concepts, methods, and metrics for conceptualizing and measuring learning in support of natural resource governance and testing the conditions under which it can be achieved are therefore badly needed. This paper presents an attempt at a holistic framework to address this, drawing on theory, methods, and metrics from three research areas: knowledge utilization, boundary organizations, and stakeholder theory. Taken together, these provide a solid conceptual and methodological toolkit for conducting cross-case comparisons aimed at understanding the social environmental conditions under which learning in such organizations does and does not occur. We use empirical data to show how the framework can be applied and discuss some of the practical considerations and important challenges that emerge. We close with a general discussion and an agenda for future research to promote discussion around the topic of how to erect systematic comparisons of learning in support of adaptive natural resource governance as it occurs in bridging organizations.

Key Words: *adaptive governance, bridging organizations, knowledge utilization, learning, networks*

INTRODUCTION

Humanity faces increasingly intractable environmental problems characterized by high uncertainty, complexity, and swift change (Ludwig 2001, Rockström et al. 2009). Adaptive natural resource governance therefore requires continuous learning among researchers, resource managers, and resource users (Folke et al. 2005). Moreover, bridging organizations, i.e., organizations designed to facilitate collaboration and knowledge coproduction among these groups, have been suggested as a way to promote such continuous learning (Carr and Wilkinson 2005, Schultz et al. 2007, Berkes 2009). Despite increasing interest in this topic, however, little is known about the conditions that foster learning and how, specifically, bridging organizations facilitate this process. One reason is that the concept of bridging organizations, as well as the actors, social groups, and collaborative processes involved in them, remains poorly articulated. Existing research also suffers from vagueness surrounding the concept of learning, the processes entailed, and what is actually learned. Put simply, to date there is: (1) no consensus regarding the definition of learning or how to measure it (Armitage et al. 2008, Muro and Jeffrey 2008); (2) poor understanding of how social interactions influence learning (Muro and Jeffrey 2008, Crona and Parker 2011); (3) vague notions of how social environments shape learning (Schusler et al. 2003, Allan et al. 2008, Armitage et al. 2008); and (4) a meager appreciation of how learning is affected by power and conflict dynamics (Allan et al. 2008, Armitage et al. 2008, Muro and Jeffrey 2008). New concepts, methods, and metrics for conceptualizing and measuring learning in support of natural resource governance and testing the conditions under which it can be achieved are therefore badly needed (Reed et al. 2010, Crona and Parker 2011).

Fortuitously, science policy studies offer concepts, methods, and metrics for conceptualizing aspects of learning, measuring it, and understanding when, how, and why it occurs. Work on knowledge utilization, boundary organizations, and stakeholder theory is particularly salient in this respect. Knowledge utilization studies provide a clear means of conceptualizing and measuring some aspects of learning, and for examining how it is affected by different types of social interactions (Armitage et al. 2008, Reed et al. 2010, Crona and Parker 2011). Boundary organization studies examine the importance of different social environments for facilitating learning (Miller 2001, McNie 2007), whereas stakeholder theory offers an unambiguous method of identifying the

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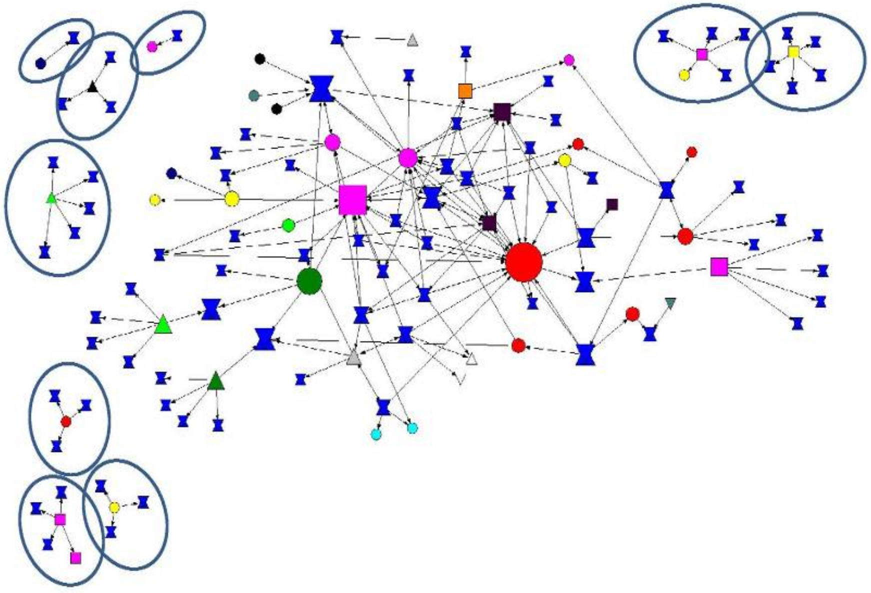
Figure 1. Network of interaction between DCDC affiliates and policy makers



“Policy makers with greater numbers of contacts with academics participating in the bridging organization were more likely to utilize information produced within DCDC to govern water resources.”

how do social groups in the knowledge-action system differ in terms of environmental concern, risk perceptions and policy preferences?

ENVIRONMENTAL SCIENCE & POLICY 12 (2009) 1012–1023

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Divergent perspectives on water resource sustainability in a public–policy–science context

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decision making
Water resource geography

ABSTRACT

Diverging perspectives toward environmental problems, their causes, and solutions can exacerbate controversy in participatory decision making. Past research has examined the lay–expert divide in perceptions about diverse risks, but relatively few studies have examined multidimensional perspectives on water scarcity across expert groups with different knowledge systems. We address this gap by examining conflicting perspectives across 'lay' residents and academic and policymaking 'experts' in Phoenix, AZ. We analyze ecological concern about water issues, risk perceptions regarding the factors contributing to scarcity, and policy attitudes pertaining to resource management alternatives. All three groups expressed substantial concern for broad-scale water issues, especially drought. Residents exhibited a heightened tendency to blame other people for water scarcity, in addition to opposition toward stringent approaches such as water pricing. While strongly supporting the acquisition of more supplies, policymakers exhibited lower concern about regional water use rates while displacing blame away from anthropogenic causes compared to both residents and academic experts. Scientists, on the other hand, stressed the need for stricter regulation of water demand. Findings point to the challenges of meshing different knowledge systems for collaborative research and policy making.

1. Introduction

Water scarcity is a critical challenge to sustaining social, economic, and environmental amenities around the world. Global recognition of water scarcity reached an apex in 2003 when the United Nations declared 2005–2015 the International Decade for Action with its Water for Life initiative (UN, 2008, or visit http://www.un.org/waterforlifedecade/). Even in developed nations with substantial water supplies and infrastructure, water scarcity threatens food production, population growth, and ecosystem health. Throughout the United States, physical shortages are most severe in the arid deserts of the Southwest (IWMI, 2006), where projected climate changes will likely contribute to warmer, drier conditions in the future (Ellis et al., 2008). Water scarcity, however, is not only a function of physically available supplies, but also factors such as the quality of water, the efficiency of various uses, and the institutional capacity to meet rising demands (USGS, 2008). To better understand diverse perspectives toward water scarcity and resource governance in the American Southwest, this paper examines multifaceted human-ecological perspectives across the public–policy–science arenas.

Disputes over water resources commonly occur in the face of mounting demand and dwindling supplies, with problems

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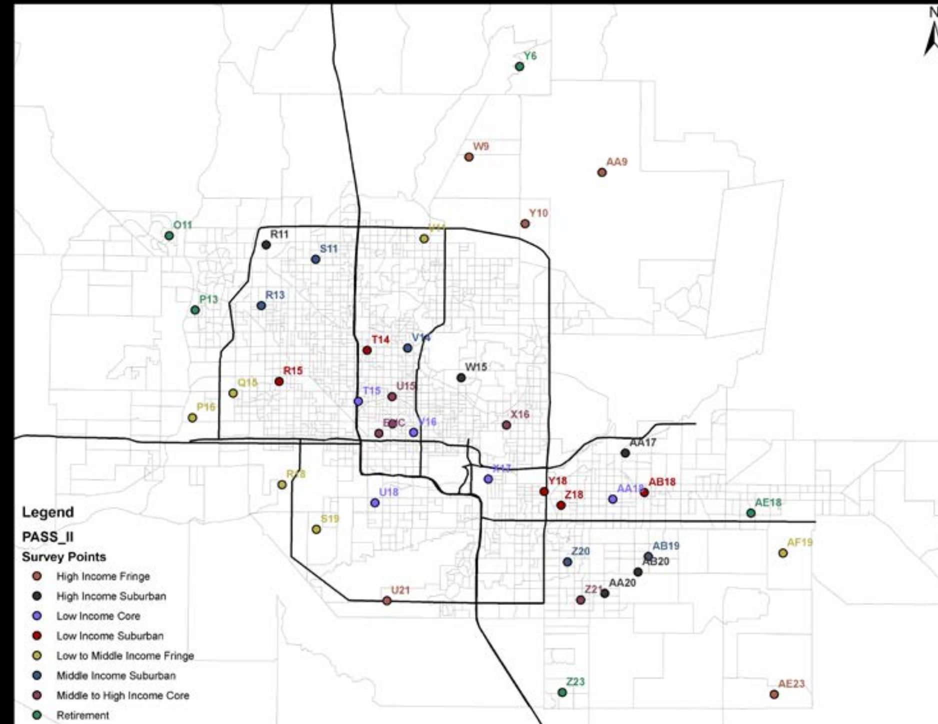
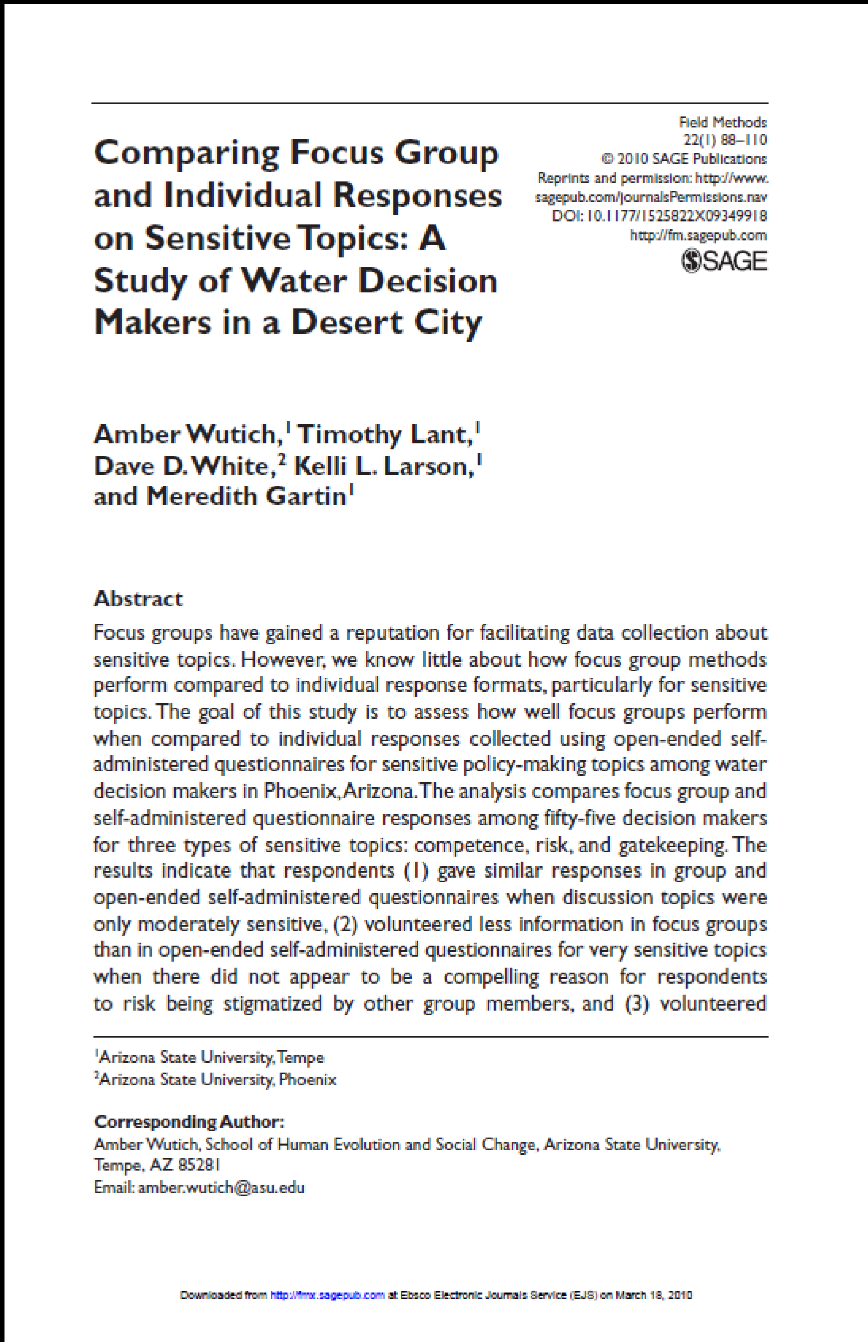


which techniques are most conducive to eliciting feedback from stakeholders on sensitive topics?


Field Methods
22(1) 88–110

DOI: 10.1177/1525822X09349918
http://fm.sagepub.com
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Comparing Focus Group and Individual Responses on Sensitive Topics: A Study of Water Decision Makers in a Desert City

Amber Wutich,[1] Timothy Lant,[1] Dave D. White,[2] Kelli L. Larson,[1] and Meredith Gartin[1]

Abstract

Focus groups have gained a reputation for facilitating data collection about sensitive topics. However, we know little about how focus group methods perform compared to individual response formats, particularly for sensitive topics. The goal of this study is to assess how well focus groups perform when compared to individual responses collected using open-ended self-administered questionnaires for sensitive policy-making topics among water decision makers in Phoenix, Arizona. The analysis compares focus group and self-administered questionnaire responses among fifty-five decision makers for three types of sensitive topics: competence, risk, and gatekeeping. The results indicate that respondents (1) gave similar responses in group and open-ended self-administered questionnaires when discussion topics were only moderately sensitive, (2) volunteered less information in focus groups than in open-ended self-administered questionnaires for very sensitive topics when there did not appear to be a compelling reason for respondents to risk being stigmatized by other group members, and (3) volunteered

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Interactive focus groups allow for collaborative deliberation on very sensitive topics if there is a **clear problem-solving focus**

how does framing affect the development of boundary objects such as model-based decision support systems?

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Society and Natural Resources, 0:1–9

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Insights and Applications

Framing Water Sustainability in an Environmental Decision Support System

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This case study applies the theoretical concepts of frame and framing processes to identify and describe the diagnostic and prognostic frames for water sustainability expressed through an environmental decision support system. The research examines the development of WaterSim, a computer simulation model of water supply and demand in central Arizona. Qualitative data were generated through semistructured individual and group interviews, participant observations, and document analysis. The analysis identified a diagnostic frame defining the water sustainability problem as uncertain and long-term water supply shortage caused by prolonged drought, climate change impacts, and population growth. The prognostic frame for water sustainability defined the solutions to be urban residential water demand management, retirement of agricultural lands, and conversion of agricultural water to municipal uses to achieve safe yield of groundwater. The results of the study are discussed in terms of implications for decision support systems (DSS) design.

Keywords Arizona, climate change, modeling, water resources management

Environmental scientists and policymakers are increasingly turning to decision support systems (DSS) to address sustainability challenges. Generally, DSS synthesize information from environmental and social datasets for analysis, simulation and visualization to evaluate alternatives and scenarios (Matthies et al. 2007). Early water management DSS employed multi-objective optimization methods to evaluate economic costs and benefits (Serrat-Capdevila et al. 2011). Contemporary DSS model system dynamics, feedbacks, and uncertainties while incorporating economic, social, and ecological factors. It is now common for DSS developers to incorporate users' perspectives to enhance relevance and usability (Cliburn et al. 2002). Recent research has examined stakeholders' perspectives on model and visualization

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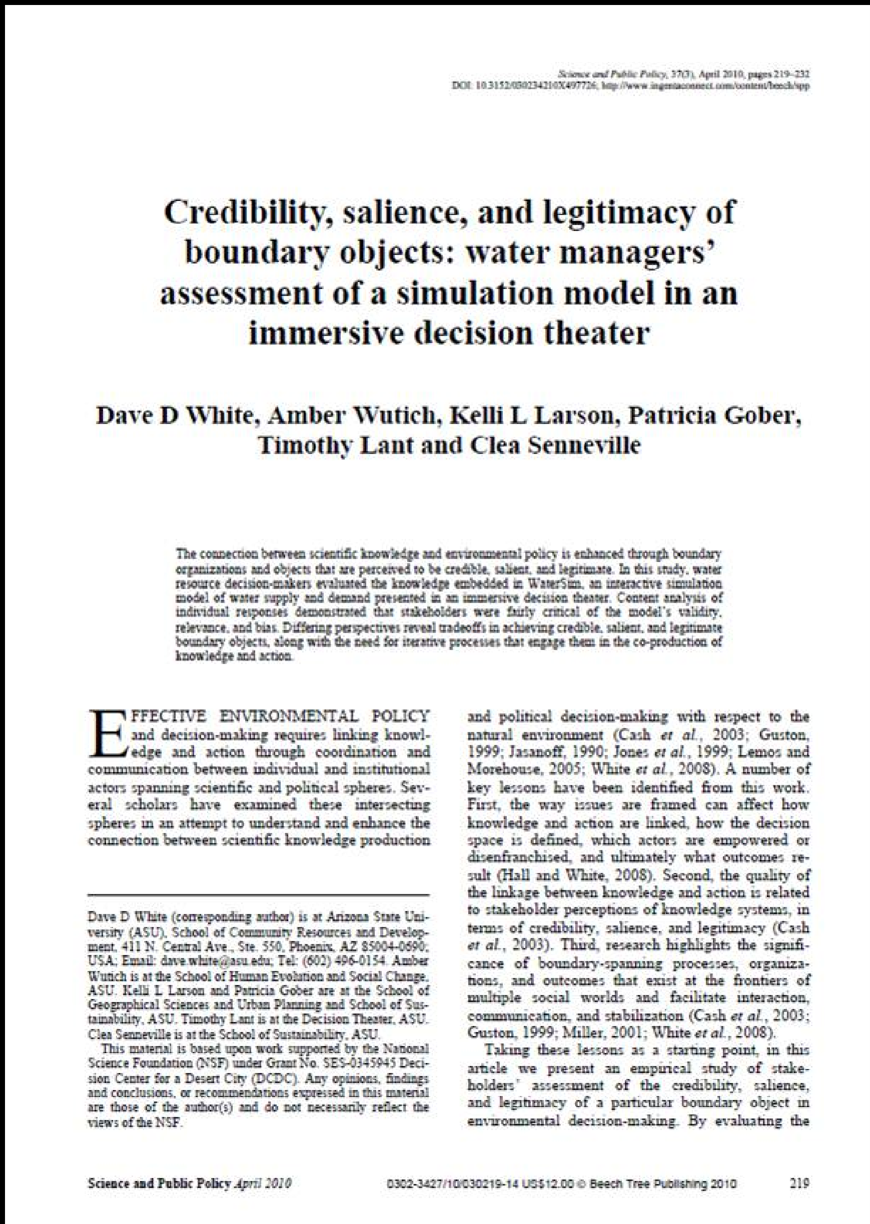
"One implication of this study is that a sustainability frame in and of itself is not necessarily a mechanism for recasting policy discourse in novel ways, unless sustainability itself is defined in comprehensive terms."

how do stakeholders perceive the salience, credibility, and legitimacy of boundary objects such as simulation models?

http://dcdc.asu.edu/watersim/



Science and Public Policy, 37(3), April 2010, pages 219–232
DOI: 10.3152/030234210X497726; http://www.ingentaconnect.com/content/beech/spp

Credibility, salience, and legitimacy of boundary objects: water managers' assessment of a simulation model in an immersive decision theater

Dave D White, Amber Wutich, Kelli L Larson, Patricia Gober, Timothy Lant and Clea Senneville

The connection between scientific knowledge and environmental policy is enhanced through boundary organizations and objects that are perceived to be credible, salient, and legitimate. In this study, water resource decision-makers evaluated the knowledge embedded in WaterSim, an interactive simulation model of water supply and demand presented in an immersive decision theater. Content analysis of individual responses demonstrated that stakeholders were fairly critical of the model's validity, relevance, and bias. Differing perspectives reveal tradeoffs in achieving credible, salient, and legitimate boundary objects, along with the need for iterative processes that engage them in the co-production of knowledge and action.

EFFECTIVE ENVIRONMENTAL POLICY and decision-making requires linking knowledge and action through coordination and communication between individual and institutional actors spanning scientific and political spheres. Several scholars have examined these intersecting spheres in an attempt to understand and enhance the connection between scientific knowledge production and political decision-making with respect to the natural environment (Cash *et al.*, 2003; Guston, 1999; Jasanoff, 1990; Jones *et al.*, 1999; Lemos and Morehouse, 2005; White *et al.*, 2008). A number of key lessons have been identified from this work. First, the way issues are framed can affect how knowledge and action are linked, how the decision space is defined, which actors are empowered or disenfranchised, and ultimately what outcomes result (Hall and White, 2008). Second, the quality of the linkage between knowledge and action is related to stakeholder perceptions of knowledge systems, in terms of credibility, salience, and legitimacy (Cash *et al.*, 2003). Third, research highlights the significance of boundary-spanning processes, organizations, and outcomes that exist at the frontiers of multiple social worlds and facilitate interaction, communication, and stabilization (Cash *et al.*, 2003; Guston, 1999; Miller, 2001; White *et al.*, 2008).

Taking these lessons as a starting point, in this article we present an empirical study of stakeholders' assessment of the credibility, salience, and legitimacy of a particular boundary object in environmental decision-making. By evaluating the

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This material is based upon work supported by the National Science Foundation (NSF) under Grant No. SES-0345945 Decision Center for a Desert City (DCDC). Any opinions, findings and conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.

boundary work requires integration of scientific and policy concerns to construct, deconstruct, and reframe models

how can simulation models be used to **explore future scenarios, anticipate and adapt?**

WaterSim 5.0

The Decision Center for a Desert City announces the release of a new version of WaterSim. WaterSim 5.0 represents an adaptation and upgrade of WaterSim 4.0 for stakeholders, researchers and educators.

The current version incorporates the water portfolios for 33 water providers that vary in size from small municipalities to major metropolitan communities. WaterSim 5.0 runs on an annual time-step where simulations can be interrupted annually by the interface enabling runtime changes to policy levers or input specifications. Model downloads and documentation can be found in related sub-directions on this site.

Background

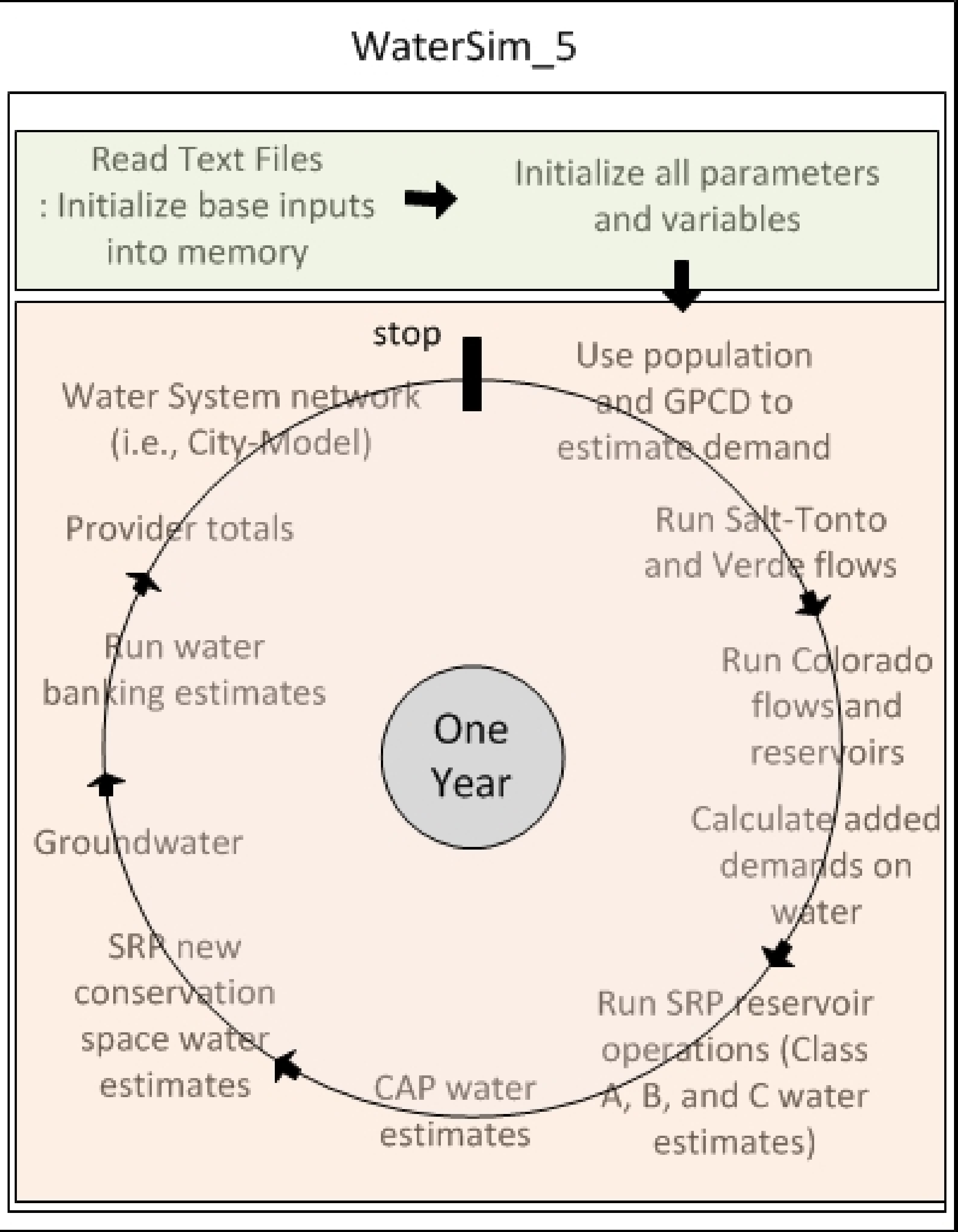
WaterSim 3.0, implemented in Powersim is the version used for WaterSim on the Web. This version was developed to analyze the potential effects of future climatic conditions, population growth, land-use change, and policy options on water supply and water demand for Maricopa County, Arizona. Gober et al. (2011) used the model to examine potential climate change impacts on residential consumptive use under various climate change and policy-driven scenarios. Annual outputs from the model generally focus on the total amount of groundwater drawdown over a simulation period and gallons per capita per day (GPCD) forecast for residential users at the metro-wide scale.

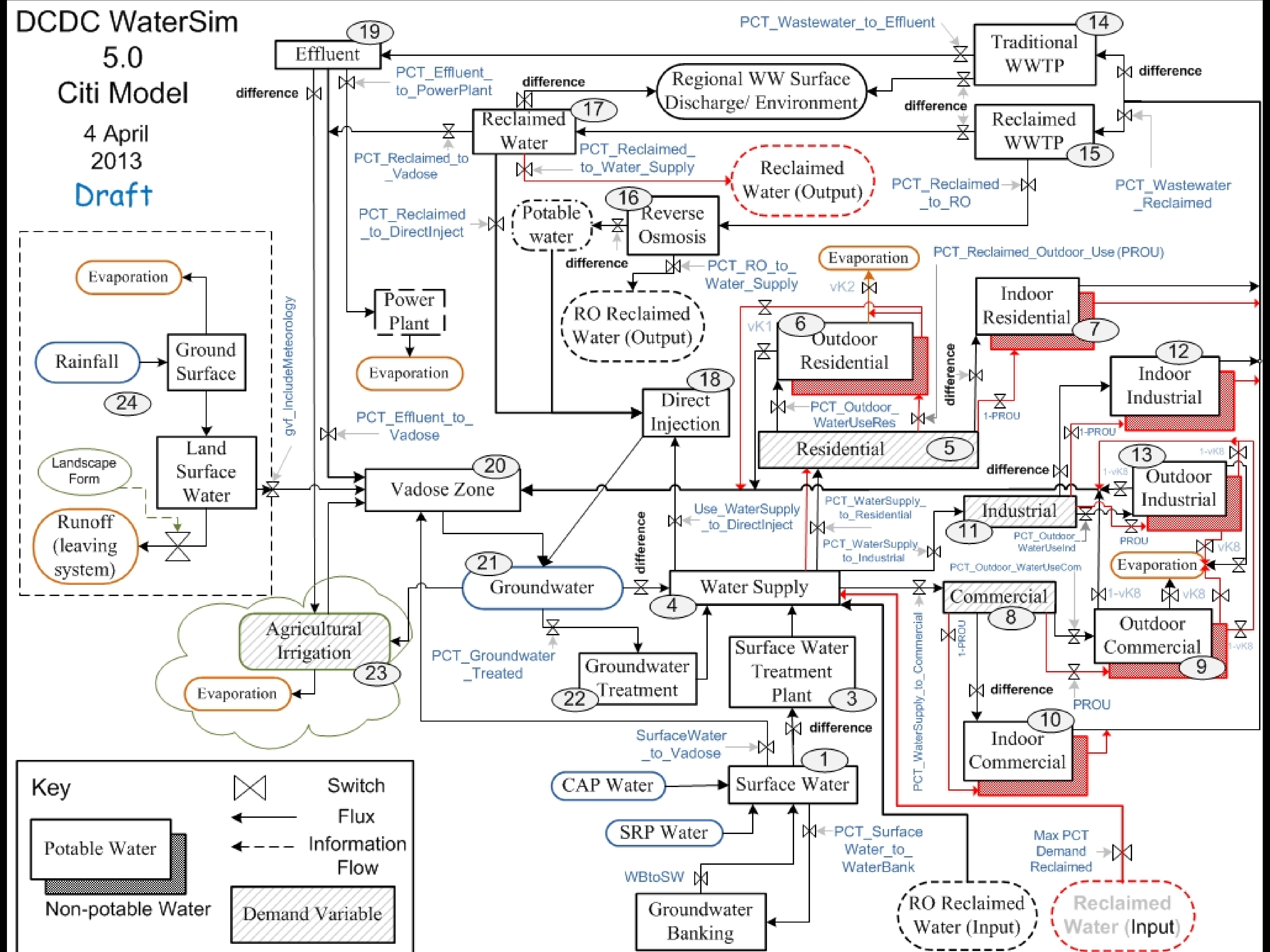
The Decision Theater and the Web Version of WaterSim were developed in PowerSim. This allowed development in a visual model building tool, but this limited use of the model and to some extent its complexity. Version 4.0 of the model was rebuilt in a Fortran model.

Version 5.0

Version 5.0 includes modifications to the Fortran to expand the number of urban water system components with a C# application interface that makes the model usable by anyone using a Windows .Net platform. This version of the model includes spatially explicit system urban system models for 33 of the water providers within the region that allows systems and policy modeling of each water provider. Working with local water resource manager the model was developed with a number of system and water resource management options not implemented in the PowerSim version. The provider urban models include groundwater, surface water, wastewater, reclaimed water, banked water, and aquifer recharge.

There is currently no visual interface to this model. An application programming interface (API) that can be used with Visual Basic or C# in a .Net managed framework is provided. This API provides access to read and set model parameters, run the model in year increments, and output model results into a database. Assemblies for the interface and a DLL for the model are provided. Source code for an application that implements


WaterSim_5
Read Text Files
: Initialize base inputs
into memory
Initialize all parameters
and variables
stop
Use population
and GPCD to
estimate demand
Run Salt-Tonto
and Verde flows
Run Colorado
flows and
reservoirs
Calculate added
demands on
water
Run SRP reservoir
operations (Class
A, B, and C water
estimates)
CAP water
estimates
SRP new
conservation
space water
estimates
Groundwater
Run water
banking estimates
Provider totals
Water System network
(i.e., City-Model)
One
Year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Draft
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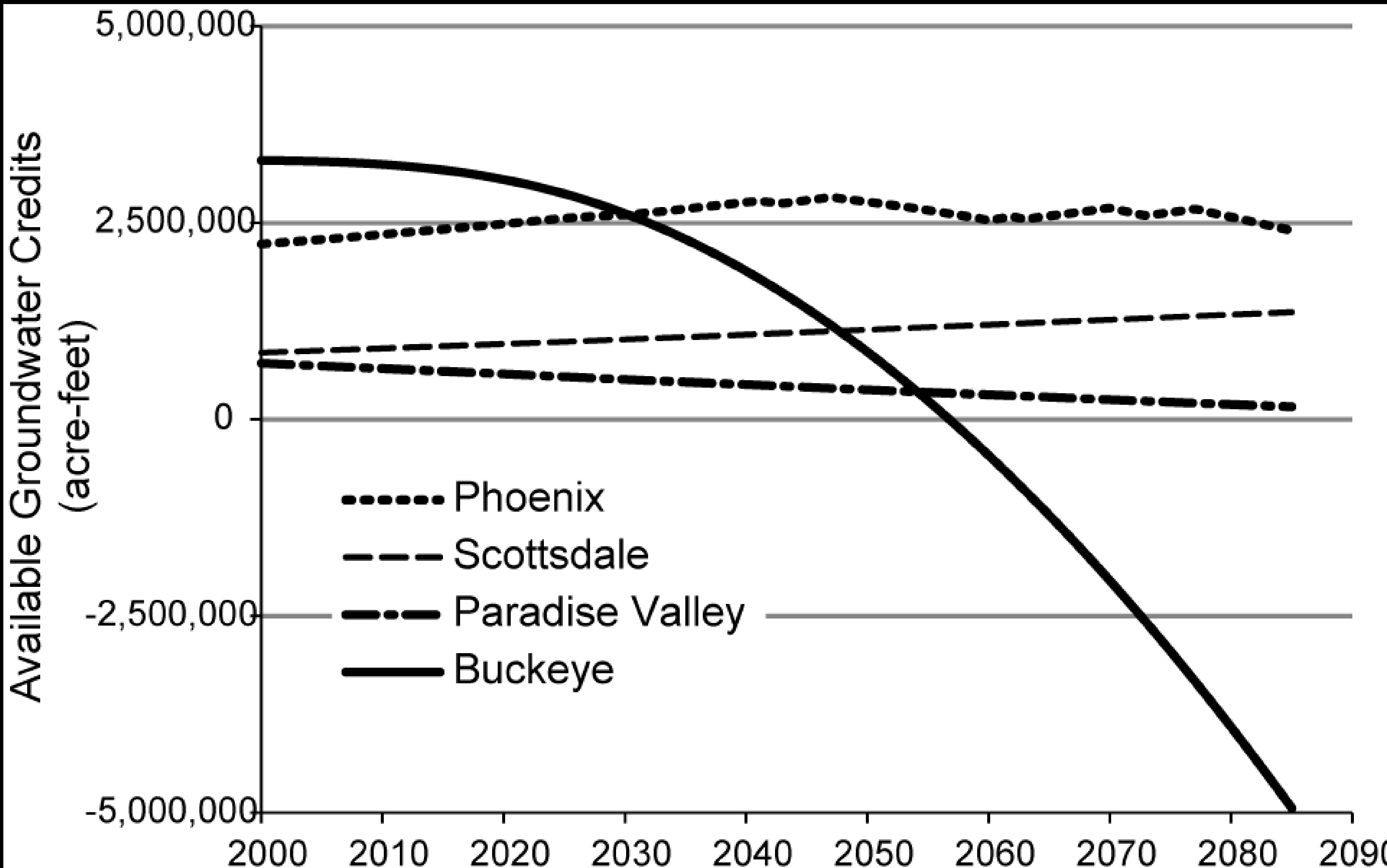
Regional WW Surface Discharge/ Environment
PCT_Effluent_to_PowerPlant
Reclaimed Water
17
Reclaimed WWTP
15
PCT_Reclaimed_to_Vadose
PCT_Reclaimed_to_Water_Supply
Reclaimed Water (Output)
PCT_Reclaimed_to_RO
PCT_Wastewater_Reclaimed
PCT_Reclaimed_to_DirectInject
Potable water
Reverse Osmosis
16
PCT_RO_to_Water_Supply
RO Reclaimed Water (Output)
Evaporation
vK2
vK1
PCT_Reclaimed_Outdoor_Use (PROU)
Indoor Residential
7
Outdoor Residential
6
Rainfall
Ground Surface
24
Power Plant
gvf_IncludeMeteorology
Landscape Form
Land Surface Water
Runoff (leaving system)
Direct Injection
18
PCT_Outdoor_WaterUseRes
Residential
5
1-PROU
Indoor Industrial
12
PCT_Effluent_to_Vadose
Vadose Zone
20
Outdoor Industrial
13
1-vK8
Use_WaterSupply_to_DirectInject
PCT_WaterSupply_to_Residential
Industrial
11
PCT_WaterSupply_to_Industrial
PCT_Outdoor_WaterUseInd
PROU
vK8
Groundwater
21
Water Supply
4
PCT_Outdoor_WaterUseCom
Commercial
8
Outdoor Commercial
9
Agricultural Irrigation
23
PCT_Groundwater_Treated
Groundwater Treatment
22
Surface Water Treatment Plant
3
Indoor Commercial
10
PCT_WaterSupply_to_Commercial
SurfaceWater_to_Vadose
Surface Water
1
CAP Water
SRP Water
PCT_Surface_Water_to_WaterBank
Max PCT Demand Reclaimed
WBtoSW
Groundwater Banking
RO Reclaimed Water (Input)
Reclaimed Water (Input)
Key
Switch
Flux
Information Flow
Potable Water
Non-potable Water
Demand Variable

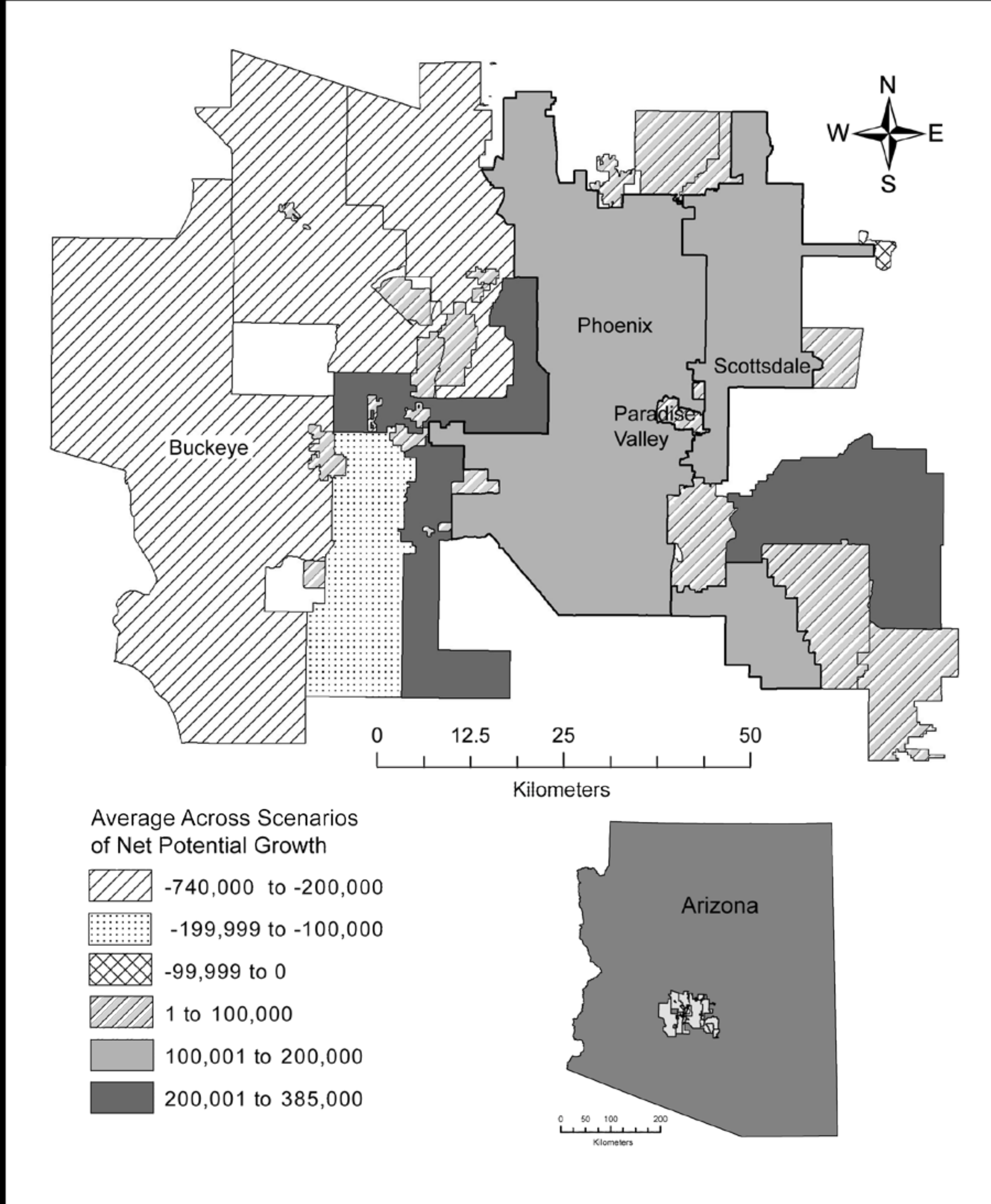
WaterSim Modeling for Policy Analysis

- Goal: analyze effect of 1980 GMA assured water supply (AWS) rule
  - No new policy interventions to manage demand or supplies
- Seventy five year simulations of normal surface water conditions (replication of past conditions) using WaterSim 5.0
- Revealed four patterns of groundwater management exemplified by the communities of Buckeye, Paradise Valley, Scottsdale, and Phoenix


Available Groundwater Credits (acre-feet)
5,000,000
2,500,000
0
-2,500,000
-5,000,000
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
Phoenix
Scottsdale
Paradise Valley
Buckeye

WaterSim Modeling for Policy Analysis

- Analysis extended to explore effects of reduced surface water allocation on geographical consequences of enforcing AWS rule to disallow development if community lacks 100-year supply
- Total of 72 scenarios tested varying patterns of flow in the Colorado and Salt Verde systems over 75 years including
  - Different types of Inter-annual wet and dry periods
  - Possible impact of climate change
- Ran WaterSim for each scenario and recorded net shift in population for each city (potential population growth lost or gained)
  - Net change across 72 scenarios averaged for each city


N
W
E
S
Phoenix
Scottsdale
Paradise Valley
Buckeye
0
12.5
25
50
Kilometers
Average Across Scenarios of Net Potential Growth
-740,000 to -200,000
-199,999 to -100,000
-99,999 to 0
1 to 100,000
100,001 to 200,000
200,001 to 385,000
Arizona

what lessons have we learned?

main points

success of knowledge-action-systems depends in part on active boundary work

how stakeholders frame and reframe knowledge and action affects process and outcomes

models, scenarios, and other integrative tools can help structure knowledge-action-systems

institutions and networks can be (re)designed to support knowledge-action-exchange

what challenges remain?

measurement

operationalization

visualization(s)

reflexivity

knowledge integration

effects on *decisions*

challenges

institutional analysis and design

exploring multiple boundaries

generalizability / transferability

stakeholder fatigue

UA WRRC Brown Bag Seminar April 23, 2013

research update from the ASU

Decision Center for a Desert City

Dave White
Co-Director
Decision Center for a Desert City
Arizona State University

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