



DCDC 2008-2009
Annual Progress Report

Decision Center for a Desert City
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Education and Outreach
Science and Policy
Modeling and Evaluation
Vulnerability
Water Demand and Decision Making

I. Introduction to DCDC

In 2004, the Social, Behavioral and Economics Division of the National Science Foundation (NSF) created a program entitled: Decision Making Under Uncertainty (DMUU). The premise of this program was that even the best climate science will be unable to eliminate uncertainty about climate change and that our society therefore needs to be able to make the best possible decisions even with persistent uncertainty. Arizona State University's Decision Center for a Desert City (DCDC) is a regional case study in decision making under uncertainty. We focused upon water-management decisions in the urbanizing desert of Central Arizona, although it was clear from the outset that water decisions in an urban environment are inextricably linked to land and energy decisions.

We structured DCDC as a boundary organization at the interface of science and policy and came to see it in a translational role, converting the products of climate science into tools for better decision making under uncertainty. This translational role involved integrating climate and hydrological research results into regional assessments of vulnerability, including factors such as population growth and land-use change, cultural attitudes, and the capacity for institutions and legal frameworks to respond to the uncertainties of climate change and human conditions. A series of self-reflective exercises involving stakeholder-scientist interactions (Crona and Parker 2008; White et al. 2008; White et al. in press) informed our translational efforts. More specifically, we: (1) produced a critical mass of basic research linking water, climate, economics, and urban form that resulted in more than 150 publications, establishing ourselves as a national center for the study of urban climate adaptation and decision making under uncertainty; (2) developed a dynamic water-simulation model called WaterSim that served as the basis for community engagement, the point of articulation for interdisciplinary research, and an experimental setting to study decision making under uncertainty; (3) built a network of relationships with regional water managers and resource decision makers; (4) organized the other DMUU centers into a collaborative network and laid the groundwork for a new generation of interdisciplinary scientists focused on decision making under uncertainty; and (5) received the Prince Sultan Bin Abdulaziz International Prize for Water in 2008, in recognition of our efforts in integrated modeling and water-resource management.

Research Activities:

Simulation Modeling: WaterSim

WaterSim is a hierarchical model that links sub-models representing supply from surface and groundwater sources and demand from residential, commercial, and agricultural sectors, incorporating the rules that govern reservoirs, aquifer use, and land-use change. It uses a XLRM framework with four primary components: (1) *exogenous uncertainties* are factors that decision makers cannot control; these are primarily associated with climate and water supply; (2) *policy levers* represent potential actions that decision makers could take, such as groundwater, land, and population-growth management; (3) *relationships* describe the mathematical associations among variables; (4) *measures for ranking success* consist of output displays showing water use across sectors and levels of groundwater depletion across the modeling period,

2007–2030. A systems model binds these elements into an executable entity. Our latest version, WaterSim 3.0, is a spatially explicit, water-management planning tool for the Phoenix area. It is linked to a 3-D groundwater model (MODFLOW) that simulates future shortage conditions at municipal levels, where decisions are made.

WaterSim is the point of focus for many DCDC research projects and serves as a basis for local, regional, national, and international engagement on urban-climate adaptation. It is not merely a static scientific product, but a dynamic tool that enables scientists and policy makers to expand knowledge, create tools, and improve visualizations. DCDC social scientists gained new insights into developing and applying models through this collaboration (White et al. 2008; White et al. in press; Gober et al. 2010).

Decision Science, Perception, and Policy: Building a Science-Based, Decision-Support Process

DCDC scientists studied the perceptions and attitudes of decision makers on climate change and other environmental risks. Climate-change issues are problematic because the potential impacts are long-term and uncertain. In their research, professors Dave White (School of Community Resources and Development), Elizabeth Corley (School of Public Affairs), and graduate student Margaret White observed that water managers defined climatic uncertainty in terms of interannual variations in climate conditions and were far more concerned with more-immediate uncertainties, such as economic and population growth, the legal status of Native American water rights, and endangered species legislation (White et al. 2008). Larson et al. (2009) documented differing attitudes about the risk of future water shortage and appropriate policy responses among the public, water stakeholders, and DCDC scientists.

Decision scientists Craig Kirkwood (W. P. Carey School of Business) and Robin Keller (University of California-Irvine) studied the conflicting objectives of water stakeholders, including city water managers, representatives from environmental agencies, and Native American communities (Keller et al. 2009). These objectives include environmental preservation, water security, water quality, and maintaining growth. Although all the groups agreed that water security (sufficiency of supply) was important, they disagreed on the relative importance of other factors. Environmental groups placed more weight on impacts on the natural/physical environment, and regulatory agencies expressed heightened concern about water quality. Understanding the aims and concerns of the various groups engaged in DCDC was critical in laying the groundwork for collaborative research and policy development.

An important challenge to emerge in DCDC's later years is understanding the reasons humans do not always act in a sustainable manner. Our team of evolutionary psychologists began to explore motives and incorporate ecological context into resource decision making. Psychologists Susan Ledlow, Ed Sadalla, and postdoctoral fellow Athena Aktipis addressed the question of why people's choices do not necessarily account for the tradeoffs inherent in contemporary resource decisions. Exploratory research about tradeoffs between indoor and outdoor water use show that, although both males and females regard indoor water use as a necessity and outdoor use as a luxury, males are more likely than females to consider outdoor use as a necessity.

Vulnerability, Resilience, and Risk

Vulnerability studies investigated how societal arrangements and coping mechanisms put some people and places at risk more than others. Given DCDC's interest in water and climate, two obvious risks emerged: (1) water shortage and (2) health-related problems stemming from the intensifying and expanding urban heat island (UHI).

Sociologist Bob Bolin, geographer Tim Collins, and ecologist Kate Darby used a political-economy perspective to examine vulnerability to drought and water shortage in the Central Arizona Highlands north of Phoenix. They used in-depth interviews, public-meeting transcripts, government documents, media accounts, and scientific reports to assess claims of environmental harm from groundwater development (Bolin et al. 2008). This research revealed that scalar politics impedes responsible policy formation to mitigate risk. While groundwater policy is established at the watershed and state scales, the effects of this policy are felt at more local scales. The short-term solution is for localities to seek out new “spatial fixes,” reaching out to new source areas of water, while ignoring issues of social equity, ecological integrity, and the long-term viability of this accumulation strategy.

Institutional paralysis emerged as a critical theme in interpreting vulnerability to water shortage. Gober (2007, 2009a, 2009b) documented the fragmented nature of water decision making and its potential consequences for water shortage. Various research teams used WaterSim to investigate the spatialized risk of shortage at the water-provider level. DCDC postdoctoral researcher Mohan Seetharan, sociologist Bob Bolin, geography graduate student Brian Pompeii, and Patricia Gober documented the importance of nonclimate stressors such as population growth and development patterns in placing communities at future risk of shortage (Seetharam et al. 2008). Pompeii (2009) asked whether water privatization led to higher prices and socially constructed scarcity, and Gober (under review) used WaterSim 3.0 to estimate water deficits under varying climate model-scenario combinations, assuming current levels per capita water use and anticipated portfolios of supply. Results of the spatial analysis of providers show that the risk of unsatisfied demand in 2025–2029 depends highly upon the growth status and water portfolios of providers.

Sociologist Sharon Harlan and geographer Anthony Brazel, joined by a team of ecologists and geoscientists, studied relationships between the biophysical characteristics of the city and human factors such as affluence and race (Harlan et al. 2008). They found that affluent residents tended to use irrigated vegetation to mitigate UHI effects, leaving economically and socially disadvantaged residents at higher risk of illness and discomfort from UHI effects. Climatology graduate student, Winston Chow, sustainability scientist Wen-Ching Chuang, and Patricia Gober analyzed population groups living above critical thresholds of heat vulnerability. Results revealed that landscapes of heat vulnerability changed substantially between 1990 and 2000, much to the detriment of minority populations living in the central and western parts of Greater Phoenix (Chow et al., under review).

Human-Climate Interactions in the City

A city's built environment (its urban geography) affects water demand and resource management. Because of the strong relationship between outdoor water use and building densities, we make de facto water decisions when we make land-use decisions. DCDC has explored these tradeoffs in coupled human-natural coupled systems, as in the forthcoming January 2010 issue of the *Journal of the American Planning Association*. In this article, Patricia Gober, Anthony Brazel, Soe Myint, and Susanne Grossman-Clarke, working with the City of Phoenix Water Resources Department, asked "How Much Water Will it Take to Cool Phoenix?" namely, what are the water consequences of using heavily irrigated trees, shrubs, and turf grass to cool the city?

DCDC research also has explored the climate sensitivities of different urban neighborhoods (Balling et al. 2008), effects of development patterns on the UHI (Brazel et al. 2007; Lee et al. 2008; Guhathakurta and Gober under review), and UHI impacts on residential water use (Guhathakurta and Gober 2007; Lee and Wentz 2008). Other research identified determinants of residential water use and spatial expression of these relationships (Wentz and Gober 2007; Lee et al. 2009). This line of research inspired a successful National Oceanographic and Atmospheric Administration (NOAA) proposal in the Sectoral Applications and Research Program to model climate sensitivities of urban neighborhoods in Phoenix and Portland.

Economist Kerry Smith and former postdoctoral fellows Aaron Strong, Michael Kaminsky, and

H. Allen Klaiber developed a model for estimating price elasticity of demand that meets policy needs and can accommodate current data limitations and the presence of increasing block-pricing structures. Their method uses temporal changes in rates and the distribution of responses. Using a quasi experiment, controlling for landscape and other influences on water demand, they were able to isolate a pure price response. The method was able to detect clear evidence that weather (precipitation) and price response interact.

Climate-Change Modeling: Fine Tuning and Evaluation

Our climate research helped to define the boundaries for future climate conditions and water supply in Phoenix. With respect to climate change, DCDC scientists downscaled model-scenario combinations to Central Arizona and imported results into a hydrological model to evaluate the implications of model uncertainty for water supplies (Ellis et al. 2008; Gober et al. 2010). Studies also dealt with the causes and characteristics of interannual variability and drought. Geographers Gregory Goodrich and Andrew Ellis (2006) standardized drought indices in order to compare spatiotemporal aspects of recent and historical drought; climatologists Robert Balling and Goodrich (2007) analyzed the influence of several teleconnections on drought indices; and Goodrich and Ellis (2008) studied the determinants and hydrological impacts of drought, including extreme seasonal precipitation reversals. The drought work resulted in a successful grant proposal to NOAA's Transition of Research Applications to Climate Services program, with costs shared by local DCDC partner, the Salt River Project, one of Arizona's largest water and power utilities. Such partnerships are a key facet of our role as a boundary organization.

In addition to considering climate as a determinant of future water supply, the climate team, augmented by social scientists, investigated the effects of climate on future water demand. Balling and Gober (2007) examined the sensitivity of municipal water demand to climate variation. Balling et al. (2008) studied the sensitivity of different urban neighborhoods to climate variation, and Balling and Cubaque (2009) estimated future residential water consumption based on simulated climate changes.

Environmental and Cultural History: The Context for Water Decision Making

An interdisciplinary team of DCDC scientists synthesized three decades of water-demand policy, revealing a systematic dismantling of regional water conservation programs in the face of weak political support, resistance from municipal water providers, and accommodations by regulators (Hirt et al. 2008). While maintaining rhetorical commitment to conservation, state authorities incrementally replaced outcome-based, water-use efficiency mandates with largely voluntary and other ineffective measures. In a follow-up study, the same research team argued that “custom-designed” conservation programs provided cover for the state agency charged with groundwater management to claim progress and due diligence, while the substantive goals of water conservation were not being met (Larson et al. 2009). Without command-and-control programs armed with incentives and penalties, the tragedy of the commons is perpetuated; cities have little incentive to conserve when they see neighboring jurisdictions maintain high consumption rates and benefit from not reaching their water-use targets. This body of work produced by historians and geographers contextualized the vulnerability to water demand and potential shortage for projects involving statistical, geospatial, and econometric modeling.

A team led by anthropologist Amber Wutich launched the Phoenix Ethnohydrology Study to follow-up the Central Arizona–Phoenix Long-Term Ecological Research (CAP LTER) and DCDC Phoenix Area Social Survey II (PASS II), a 40-neighborhood survey from 2006. Based upon respondents’ assessment of water quality in their neighborhoods in PASS II, they selected a sub-sample of four neighborhoods for an in-depth study. The project goal was to assess the public perception of water quality using new methods for anthropological analysis (Wutich 2009). The study team used cultural-consensus analysis to determine the existence of a shared core of cultural knowledge about water quality that varies from neighborhood to neighborhood, the population characteristics of people with low and high levels of cultural competence, and the closeness of a match between local ecological knowledge and expert analyses of water quality.

Education Activities

K-12 activities involved collaboration with a wide variety of formal and informal education partners to integrate DCDC research into learning materials and educational programs. In one example, they worked with University of Arizona’s extensive water-education programs (Project Wet, Cooperative Extension, and the Water Sustainability program) to deliver two-day Advanced Water Education Workshops on topics including

water management (2006) climate change and decision making (2007), water re-use (2008), and the energy-water nexus (2009). Each year, the workshop attracted approximately 25 participants from the region's water education community. DCDC served as the host agency, and each year several DCDC researchers participated in the event.

We also shared DCDC research products by delivering learning modules directly to students. These modules were based on WaterSim on the Web, the Southwest Water Information Project Atlas, and an urban-sustainability unit that challenges students to design an urban environment that mitigates UHI effects. DCDC also developed and implemented sustainability-learning modules in area high schools and partnered with ASU's School of Sustainability, which received NSF funding for K-12 activities from the Sustainable Schools Program. In February 2009, we developed and presented a user-friendly version of WaterSim at the NSF exhibit site at the AAAS meetings in Chicago. Over 100 visitors, including journalists, scientists, and leaders of other institutions, dropped by the booth to test-drive WaterSim and ask questions.

Activities for graduate and undergraduate students were integrated into DCDC research projects, and students were mentored by a DCDC faculty member. In addition, all graduate and undergraduate students were required to participate in the Community of Undergraduate Research Scholars (COURS) seminar taught by Margaret Nelson, Associate Dean of the Barrett Honors College. This seminar helped students integrate their disciplinary training with the knowledge and skills needed for interdisciplinary collaboration. More specifically, students were expected to: (1) craft a clear statement of the broader impact of their work, drawing from the many disciplinary perspectives; (2) build skills that enable them to think across disciplines and produce solution-based research; (3) conduct an original research project in conjunction with a faculty or postdoctoral mentor; and (4) present research in a capstone poster session at the end of each academic year. These poster sessions are held in conjunction with DCDC water-climate briefings and drew between 50 and 75 ASU faculty and community partners.

Graduate students worked as research assistants with faculty members and were required to participate in the interdisciplinary Community of Graduate Scholars (CGS) seminar taught by Associate Dean Nelson and DCDC staff member Katja Brundiers. The goals of CGS were to enhance interdisciplinary research and build collaborative work skills. In 2007, our CGS group organized a DMUU session at the AAAS meeting in San Francisco, which included representatives from all five DMUU centers. In 2008 and 2009, graduate students organized and ran two series of panel discussions that included colleagues from other DMUU centers, DCDC and other ASU researchers, and community partners. Topics included: (1) nature and functioning of boundary organizations, (2) ethics and effectiveness in decision making, (3) water law and policy, and (4) vulnerability and resilience in the face of water scarcity.

DCDC employed seven postdoctoral fellows: three geographers (Tim Collins, Mohan Seetharam, Darren Ruddell) a planner (Ariane Middell), an economist (H. Allen Klaiber), a civil engineer (Seung-Jae Lee), and a psychologist (Athena Aktipis). Our postdoctoral mentoring activities focused on professional and career development and were designed

to help fellows: (1) participate in community-based research about decision making under uncertainty, (2) deepen expertise in their discipline and in interdisciplinary collaborative research, (3) gain an understanding of the role of a tenure-track faculty member in an American university, (4) become an effective mentor for undergraduate and graduate students, (5) build a network of collaborators and coauthors, (6) establish an independent research program, and (7) participate in the social and cultural life of a Research I university. Postdoctoral fellows forged research programs with faculty members and students and produced a critical mass of research articles related to DCDC's mission. Tim Collins is now an assistant professor at the University of Texas at El Paso. Mohan Seetharam works at the Conservation Governance and Policy Ashoka Trust for Research in Ecology and the Environment in India. H. Allen Klaiber is an assistant professor in the Department of Agricultural Economics and Rural Sociology at Penn State. Seung-Jae Lee is a postdoctoral fellow at the National Renewable Energy Laboratory in Golden Colorado.

II. Findings of Research Activities

Geographers Patricia Gober, Robert Balling, Andrew Ellis, and Stephanie Deitrick, along with decision scientist Craig Kirkwood, used WaterSim to simulate “what-if” scenarios under varying policy decision and future climate (Gober et al. 2010). Results of simulation experiments suggest that: (1) current levels of per capita water consumption cannot be supported without unsustainable groundwater use under most climate/model scenarios; (2) feasible reductions in residential water consumption would allow the region to weather the most pessimistic of the climate projections; (3) delaying action reduces long-term sustainability groundwater resources under some climate scenarios; and (4) an adaptive policy with monitoring mechanisms to track groundwater would warn water managers that the need for use restrictions is approaching, thereby avoiding the need for drastic, ad hoc actions.

Geographers Andrew Ellis, Timothy Hawkins, Robert Balling, and Patricia Gober developed a water budget runoff model for the Salt and Verde river basins of Central Arizona and used the outputs of six global climate models (GCMs) and the Intergovernmental Panel on Climate Change's emission scenarios to estimate future runoff (Ellis et al. 2008). In this project, they used a statistical downscaling routine to refine the GCM outputs for the two basins and found all model–scenario combinations simulate a mean temperature rise in the study area of between 2.4 and 5.6°C (using estimation of greenhouse gas concentrations in year 2050). Mean changes in precipitation vary substantially among the models and scenarios, and, along with temperature increases, result in changes in runoff from 50 to 127% of historical levels. Assuming equal probabilities associated with each scenario and model run, the overall results suggest that runoff from the Salt and Verde will have approximately an 85% chance of decreasing, the certainty of which is related to consensus on warming in the study area. The large variability among predictions of precipitation trends introduces substantial uncertainty into the results.

Gober et al. 2010 compared results of the IPCC AR3 and AR4 model-scenario combinations and found that uncertainty about future runoff from the Salt/Verde

Watersheds increased between 2001 and 2007. The runoff estimates varied from 50 to 127% of historical averages for the AR3 scenario/model combinations released in 2001 and from 19 to 123% for the AR4 models released in 2007, reflecting the differences in model assumptions, definitions, data, and scale of analysis. These results underscore the mandate of making better decisions in the face of uncertainty. After many millions of dollars devoted to climate research, the bands of climatic uncertainty have actually increased over time.

Decision scientists Robin Keller and Craig Kirkwood and planner Nancy Jones used a Web survey to gather information about water stakeholder priorities (Keller et al. 2009). The analysis showed that stakeholder groups disagree on the importance of areas of concern. Although all the groups agreed that water security (sufficiency of supply) was important, they disagreed about the relative importance of other factors. Environmental groups placed a great deal of weight on impacts on the natural/physical environment, while regulatory agencies and Native American communities weighted water quality (health and safety) heavily, and private-water providers expressed particular concern for financial considerations (profitability). This information was critical in interpreting DCDC's relationships with stakeholders who do not, among themselves, agree on the major concerns for the Central Arizona water system.

Geographers Kelly Larson and Patricia Gober, sociologists Dave White and Sharon Harlan, and anthropologist Amber Wutich studied attitudes about the risk of water shortage among the public, water managers, and scientists (Larson et al. 2009). They found that all three groups expressed substantial concern for broad-scale water issues, especially drought. Residents were more prone to blame other people for water scarcity and more opposed to stringent conservation approaches such as water pricing. Policy makers were less concerned about high levels of consumption, displacing responsibility for shortage to supply constraints. Scientists stressed the need for demand management. Findings underscore the challenges of meshing different attitudes concerning climate change and future water shortage for collaborative research and policy making.

Geographers Elizabeth Wentz and Patricia Gober studied the determinants of small-area water demand and discovered that household size and lot size affected residential water demand and lot size, landscaping treatment, and the existence of a swimming pool (Wentz and Gober 2007). Moreover, they found that the effects of these variables differed spatially, such that the effect of adding a new household member had a greater effect on one part of the city than in another. This research informed the development of WaterSim, our water-simulation model of supply and demand, and inspired the use of spatially weighted regression techniques elsewhere in DCDC.

Geographers Anthony Brazel, Patricia Gober, and Brent Hedquist, along with climatologist, Susanne Grossman-Clarke investigated the spatiotemporal variation in June mean minimum temperatures for weather stations in and around Greater Phoenix, for the period 1990 to 2004 (Brazel et al. 2007). Temperature was related to synoptic conditions, location in urban development zones (DZs), and the pace of housing construction in a 1 km buffer around fixed-point temperature stations. June is typically clear and calm, and dominated by a dry, tropical air mass with little change in minimum

temperature. Significant temperature variation was explained by surface effects captured by the type of urban DZ, which ranged from urban core and infill sites, to desert and agricultural fringe locations, to exurban. Their results showed that an overall spatial urban effect, derived from the June monthly mean minimum temperature, is in the order of 2 to 4 K. The cumulative housing build-up around weather sites in the region was significant and resulted in average increases of 1.4 K per 1000 home completions, with a standard error of 0.4 K

Geographers Patricia Gober, Anthony Brazel, and Soe Myint, along with climatologist Susanne Grossman-Clarke and City of Phoenix water professionals, Ray Quay, Steve Rossi, and Adam Miller, investigated tradeoffs between water use and nighttime cooling inherent in public policy and private-development choices of urban form and land use. Using a simple LUMPS (Local-Scale Urban Meteorological Parameterization Scheme) model to simulate the temperature and water consequences of implementing urban-design scenarios focused on water use, they found that more irrigated landscaping results in lower nighttime temperatures, but that this relationship was not linear. The ratio of water use to temperature impact showed an efficiency “sweet spot” that varied with the density of vegetative surfaces. Beyond this point, increased outdoor water use resulted in diminishing returns; adding water had little impact on temperature amelioration (Gober et al. 2010). This article will appear in the January 2010 issue of the *Journal of the American Planning Association*.

Planner Subhrajit Guhathakurta and Patricia Gober asked whether the UHI affects residential water use (Guhathakurta and Gober 2007). Their statistical analysis demonstrated that increasing the daily low temperatures by 1° Fahrenheit is associated with an average monthly increase in water use of 290 gallons for a typical single-family unit. These results suggest that planners should consider effects on water demand as well as other environmental consequences when they evaluate growth strategies and use incentives to encourage efficiency and sustainability.

Sociologist Dave White, engineer Elizabeth Corley, and ecologist Margaret White interviewed water managers working at the science-policy interface in Phoenix. Qualitative analysis uncovered 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.

III. Training & Development

K-12 Education

In conjunction with the University of Arizona's Water Resources Research, DCDC hosted 33 teachers at the third annual “Advanced Water Education Workshop for Valley Educators” on June 16–17, 2009. The workshop focused on the water/energy nexus, covering four topics:

(1) the energy costs of transporting water in Greater Phoenix; (2) alternative-energy sources and their associated water costs; (3) the water cost of energy production; and (4) planning for the future in light of the water/energy nexus. This workshop series is highly regarded and has produced waiting lists the past two years.

Undergraduate Education

Throughout the life of DCDC, we have funded REU students to participate in the University's Community of Undergraduate Research Scholars (COURS) program sponsored by the ASU Barrett Honors College. Facilitated by DCDC investigator and Barrett Honors College Associate Dean Margaret Nelson, COURS included students from DCDC, the Southwest Consortium for Environmental Research and Policy, the Urban Ecology Integrative Graduate Education and Research Training program, the Biocomplexity project, and other NSF-sponsored projects. COURS students met weekly for multidisciplinary discussions of research, participated in a range of research activities related to their respective projects, and prepared research posters for presentation at a culminating event hosted by DCDC. The COURS program epitomized DCDC's goal of linking undergraduate education to research and decision making in a collaborative and interdisciplinary environment.

Graduate Education

A total of 43 graduate students from the School of Life Sciences, School of Geographical Sciences and Urban Planning, School of Sustainability, School of Human Evolution and Social Change, the Center for Science, Policy and Outcomes, and the departments of History, Political Science, Psychology, and Communications participated in DCDC projects. To facilitate greater collaboration among DCDC graduate students, we encourage participation in a one-credit graduate seminar; the seminar is aimed at sparking crossdisciplinary dialogues and perspectives among graduate students working on sustainability and water issues. One specific goal of the seminar was to organize panel discussions involving researchers for the other DMUU centers.

Postdoctoral Fellowships

Seven postdoctoral fellows were associated with research projects:

Darren Ruddell, a recent PhD recipient from the School of Geographical Sciences and Urban Planning, worked with the Vulnerability Team to examine the spatial and statistical relationships on physical and social data which should lend insight into social dimensions of heat stress and water use.

Ariane Middel received her PhD from the University of Applied Sciences in Bonn, Germany. She collaborated with the Climate/UHI group on research aimed at understanding the functional relationships between water data and the details of how these data may relate to land-cover thermal characteristics. This understanding facilitates the targeting of more effective UHI mitigate strategies.

H. Allen Klaiber received his PhD from North Carolina State University. He worked with Economist Kerry Smith to develop methods for evaluating and interpreting measures of the change in residential property value with spatially delineated amenities; developing a new method for measuring the responsiveness of residential water demand to prices using the Phoenix meter data; and developing a structural economic model of the role of land-use policy in lowering water demand. He is now an assistant professor in the Department of Agricultural Economics and Rural Sociology at Penn State.

Athena Akiptis is beginning work with Susan Ledlow and the evolutionary psychologists to investigate the reasons people do not always behave in ways that would maximize their long-term well-being.

Tim Collins, a postdoctoral fellow in 2005–2006 for Sociologist Bob Bolin on rural-vulnerability issues, is now an Assistant Professor of Sociology at the University of Texas El Paso.

Mohan Seetharam worked on rural and urban vulnerability issues in 2006–2007 and is now employed by Conservation Governances and Policy Asoka Trust for Research on Ecology and Environment in India.

Lastly, Seung-Jae Lee worked with Patricia Gober, Elizabeth Wentz, and Robert Balling during his tenure at DCDC. He coauthored four major research articles (Brazel et al. 2007; Lee et al 2008; Lee and Wentz 2008; Lee et al. 2009) using his expertise in Bayesian Entropy Maximum modelin. Lee is a now a postdoctoral fellow at the National Renewable Energy Laboratory in Golden Colorado.

Students won prestigious awards in the process of or as an offshoot of their DCDC research:

Brian Pompeii won Honorable Mention at the AAAS meetings in February 2009 for his poster, “Water Privatization and Socially Constructed Scarcity.” He also won the President’s Award for Outstanding Study Paper at the Association of Pacific Coast Geographers meeting in September 2008 for “Mapping Future Water Supplies in Phoenix, Arizona.”

Christopher J. Graham, a 2005 DCDC REU student working with Andrew Ellis, was awarded a Fulbright Fellowship to adapt his work on drought indices in the American Southwest to arid regions in Africa.

IV. Outreach

DCDC sponsored from four to seven Water-Climate Briefings each year. These events provide the opportunity for ASU faculty members and graduate students to mix socially and professionally with professional water managers and, more importantly to hear alternative points of view. We tried to divide the presentations, evenly between water professionals, academic scientists, and outside speakers to fulfill our mandate of being a neutral place where regional water issues could be discussed. During five years of funding, we have hosted 36 events and engaged more than 2,000 participants.

The program over the last 16 months included the following:

May 16, 2008, "Urban Climate Models and their Applications." Professor Sue Grimmond of Kings College, London spoke on understanding and predicting the impact of cities on climate. The large (and ever-increasing) fraction of the world's population living in cities, and the disproportionate share of resources used by these urban residents, especially in the global North, are key drivers of global environmental change

October 1, 2008, "Total Water Management." Trevor Hill, President and CEO of Global Water Resources, spoke on integrated systems, regional planning and the economics of water reclamation. Global water is a management company in Phoenix offering water utilities and management and specializing in the aggregation and consolidation of small and medium size water and wastewater utilities in the Southwest.

November 5, 2008, "Efficacy and Ethics in Decision Making Tools." DCDC graduate students initiated and organized a DMUU panel-discussion to integrate the DMUU sites. The panel consisted of Nichole Peterson, Center for Research on Environmental Decisions (Columbia University); Dave White, School of Community Resources and Development (ASU); and Mark Neff, Science Policy Assessment and Research on Climate (University of Colorado).

The discussion centered on developing and using decision-support tools in the context of climate change. The goal was to broaden our understanding of decision tools beyond a single approach while increasing communication among DMUU sites and promoting interdisciplinary research.

February 4, 2009, "Participatory Decision Making Under Uncertainty: Facilitating Successful Integration of the Community in the Decision Making Process." Panelists included Kelli Larson, School of Sustainability, School of Geographical Sciences and Urban Planning; Tim McDaniels, School of Community and Regional Planning, University of British Columbia; and Hallie Eakin, School of Sustainability. The panel sought to advance decision-making efforts by exploring:

(1) approaches in participatory decision making, b) determinants of success in participatory decision making, and (3) evaluating the effectiveness and success of decisions.

April 8, 2009, “The Role of Boundary Organizations in the Science-Policy Nexus.” Panelists included Daniel Sarewitz, Consortium for Science, Policy & Outcomes at ASU; David Groves, RAND Corporation; and Genevieve Maricle, Science Policy Assessment and Research on Climate, University of Colorado and Consortium for Science, Policy & Outcomes. The panel explored the conduct of science within boundary organizations and the translation of science into policy, asking: (1) How can boundary organizations reconcile the supply of knowledge by science with the demand for knowledge by policy/society? (2) How does research created within a boundary organization influence policy decisions? (3) Boundary organizations have created boundary objects to support policy making. Which have been effective/not effective?

September 2, 2009 “Sustainable Water and Energy: Can We Plan for One without Planning for the Other?” Panelists included Kris Mayes (Facilitator), Chairman, Arizona Corporation Commission; Sandy Bahr, Chapter Director, Sierra Club - Grand Canyon Chapter; Robert Lotts, Manager of Water Resources, Arizona Public Service; David McNeil, Environmental Services Administrator, City of Tempe; and Paul Westerhoff, Director, ASU’s School of Sustainable Engineering and the Built Environment. Discussions centered on exploring the impacts of the water-energy nexus on desert cities, particularly in Greater Phoenix. It highlighted the challenges and opportunities decision makers face when developing sustainable solutions.

October 7, 2009, “Water Law and Sustainability.” Panelists included Judith Dworkin Sacks Tierney, P.A.; William H. Swan Attorney, Consultant; John B. Weldon Salmon, Lewis & Weldon, PLC; and Dave White, School of Community Resources and Development, ASU. Discussions centered on the possible impacts of current water laws on the water supply of Arizona and other Western states, and how those impacts will affect the ability of Arizona’s water managers to maintain a sustainable water supply.

In 2009, in collaboration with the Arizona Water Institute, University of Arizona, and the Decision Theater at ASU, DCDC hosted a series of four workshops, with the goal of better understanding regional water supplies under future uncertainty. Workshop topics included a tutorial on climate model/scenario combinations, choosing climate models relevant to Arizona water planning, use of reconstructed flows to build planning scenarios addressing flood and drought and decision making under uncertainty. Participants numbered about 20 at each workshop and included representatives from the climate and hydrological sciences community from the University of Arizona, decision scientists from ASU, and representatives from Arizona cities (including Phoenix, Scottsdale, Chandler, and Tucson) and from the Bureau of Reclamation, Salt River Project, Central Arizona Project, and the Arizona Department of Water Resources.

NSF invited DCDC to participate in their exhibit at the American Association for the Advancement of Science Annual Meeting in Chicago. We developed and staffed a portable version of WaterSim using a touch-screen display in February 2009. More than 100 children and their families stopped by to out both to ask questions and experiment with WaterSim. In October 2009, we hosted a visit from the Chinese Academy of Sciences and held a workshop on urban climate adaption.

Presentations and Miscellaneous Activities

DCDC researchers regularly present DCDC research goals and results to community groups, students, and other local and international academic institutions.

2009

Brazel, A., P. Gober, S. Grossman-Clarke, S. Myint, R. Quay, A. Miller, S. Rossi and S. Grimmond. 2009. Mitigating urban heat island effects with water- and energy-sensitive urban designs. Paper presented at the 8th Symposium of the Urban Environment, American Meteorological Society, Phoenix, AZ. January 15, 2009.

Deitrick, S. 2009. Maps, climate change, and mediated knowledge: A review of mass media and (un)certain science. Presented at the Association of American Geographers Annual Conference, Las Vegas, NV. March 22-28, 2009.

Ellis, A.W. 2009. Drought index verification in the Colorado River Basin, USA. Paper presented at the Annual Meeting of the Association of American Geographers, Las Vegas, Nevada. March 24, 2009.

Gammage, G. 2009. Megapolitan: Arizona's sun corridor. Presented at 3 Valley locations. January-February, 2009.

Gammage, G. 2009. Arizona water-- the big picture. Presented at the Little Colorado River Watershed Conference, Show Low, AZ. January 30, 2009.

Gammage, G. 2009. Arizona water-- canalscape. Presented at the ASU Canal Scape Symposium, Phoenix, AZ. February 6, 2009.

Gammage, G. 2009. Arizona water issues. Presented at the UofA Water Resources Research Center, Tucson, AZ. March 17, 2009.

Gober, P. 2009. Water planning in Phoenix: Managing risk in the face of uncertainty. Presented at the 19th Annual Water Quality Workshop: Monitoring, Assessment, and Management. Boise, Idaho, January 7, 2009.

Gober, P. 2009. Decision making under uncertainty and scenario planning. Presented at the 11th Annual CAP LTER Poster Symposium. Arizona State University, Tempe, AZ, January 15, 2009.

Gober, P. 2009. The future of water in the American West: Decision making under uncertainty in Phoenix. Presented at the Presidential Plenary Session of the 2009 Annual Meeting of the Association of American Geographers, Las Vegas, NV, March 22, 2009.

Middel, A., B. Hagen, A. J. Brazel, and S. Myint. 2009. Simulation of possible scenarios for local scale energy balances in residential neighborhoods in Phoenix, AZ, USA. Paper presented at the 8th International Symposium (UPE 8) of the International Urban Planning and Environment Association, Kaiserslautern, Germany. March 23-26, 2009.

Middel, A., P.S. Olech, and B. Hagen. 2009. Re-tooling urban planners - Google Earth as a planning support tool. Paper presented at the 11th International Conference on Computers in Urban Planning and Urban Management (CUPUM 2009), Hong Kong, 2009.

Parker, J.N. and B.I. Crona. 2009. All things to all people: Boundary organizations and the changing University system. Presented at the Society for Social Studies of Science, Washington D.C. October 28, 2009.

Parker, J.N. and B.I. Crona. 2009. Tensions and challenges in University-based boundary organizations. Paper presented at the Pacific Sociology Association General Meeting, San Diego, CA. April 9, 2009.

Wentz, E.A. 2009. Computational spatial analysis techniques for better understanding urban water demand. Invited presentation to the Department of Geography at the University of California, Los Angeles. February 2009.

Wutich, A., A. Brewis and B.I. Crona. 2009. Cross-cultural approaches to studying climate change: Results from Arizona, Fiji, Bolivia, and New Zealand. Presented at the Society for Applied Anthropology 69th Annual Meeting, Santa Fe, New Mexico. March 17-21, 2009.

2008

Balling, R., P. Gober, and N. Jones 2008. Sensitivity of residential water consumption to variations in climate: An intra-urban analysis of Phoenix, Arizona. Presented at the 18th International Congress of Biometeorology, Tokyo, Japan, September, 2008.

Gammage, G. 2008. Megapolitan: Arizona's sun corridor. Presented at 9 Valley locations. May-October 2008.

Gammage, G. 2008. Unveiling of "Mountain Megapolitan". Presented at the Brooking Institute, Denver, CO. July 22, 2008.

Gammage, G. 2008. Megapolitan. Presented to the East Valley Partnership, Mesa, AZ. August 28, 2008.

Gammage, G. 2008. Arizona and the vision thing. Presented at the Urban Land Institute, Phoenix, AZ. September 9, 2008.

Gammage, G. 2008. Arizona housing issues. Presented at the Governor's Housing Forum, Flagstaff, AZ. September 10, 2008.

Gammage, G. 2008. Glendale's future. Panel member at the City of Glendale forum, Glendale, AZ. September 16, 2008.

- Gammage, G. 2008. Managing political issues. Panel member at the Bureau of Land Management National Training Institute, Phoenix, AZ. October, 22, 2008.
- Gammage, G. 2008. The aging of Arizona's population. Presented to the ASU Emeritus College, Tempe, AZ. November 1, 2008.
- Gammage, G. 2008. Arizona's proposition 207. Presented at the Georgetown Environmental Law and Policy Institute, Stanford University, CA. November 6, 2008.
- Gammage, G. 2008. Arizona's future. Presented to the ULI Young Leaders, Phoenix, AZ. November 20, 2008.
- Gammage, G. 2008. Mountain megas. Presented to the ASU Brookings Institute, Phoenix, AZ. November 21, 2008.
- Gammage, G. 2008. Regional land use. Presented to the Urban Land Institute, Tucson, AZ. December 3, 2008.
- Gammage, G. 2008. 411 Policy Talk with Senator Kyl. Presented at the ASU Morrison Institute, Phoenix, AZ. December 3, 2008.
- Gammage, G. 2008. Arizona forecasting. Presented to the National Association of Industrial and Office Properties, Phoenix, AZ. December 11, 2008.
- Gober, P. 2008. The inconvenient truth about Phoenix. Presented at the Spirit of the Senses Salon. July 2008.
- Gober, P. 2008. Intelligent use of water in Phoenix: DCDC and WaterSim. Presented at the Rainbird Intelligent Use of Water Summit IX. Arizona State University, Tempe, AZ, September 3, 2008.
- Larson, K.L. 2008. Comparative approaches to understanding environmental perspectives as human dimensions of water resource management. Invited presentation at the University of Washington, Seattle, WA. October 2008.
- Larson, K.L. 2008. People's understanding of water resources management issues and drivers of residents' landscaping practices. Presented to the Arizona Municipal Water Users Association, October 2008.
- Middel, A., R. Pahle, P.S. Olech, and H. Hagen. 2008. Policy-driven visualization of urban forms for planning support. Paper presented at the IEEE VisWeek 2008, Visualization, Columbus, Ohio. October 19-24, 2008.
- Neff, M., B. Cutts, K. Darby, E. Larson, T. Munoz-Erickson, A. Wutich and B. Bolin. 2008. Does truth flow like water? The role of social networks in the flow of scientific knowledge in an environmental governance dispute. Presentation at the Society for the

Social Studies of Science / European Association for the Study of Science and Technology joint meeting. August 23, 2008.

Pompeii, B. 2008. Mapping future water security in Phoenix, AZ. Paper presented to the Association of Pacific Coast Geographers Annual Meeting, Fairbanks, AK. President's Award for Outstanding Paper by a Master's Student. October 10, 2008.

Wutich, A. 2008. Anthropological approaches to studying climate science, policy, and perceptions in a desert city. Presented at the American Anthropological Association 107th Annual Meeting, San Francisco, California. November, 2008.

V. Contributions

Contributions within the Discipline

Systems Dynamics Modeling: WaterSim is an integrated collection of quantitative models that represent water consumption and availability in Central Arizona under scenarios of population growth, climatic uncertainty, individual behavior, and policy choices. WaterSim 3.0 is a spatially explicit model that allows analysis of the spatial distribution of risk from water shortage and experimentation with various cooperative strategies to equalize risk across the urban environment. WaterSim serves as a boundary object that can be used jointly by the scientific community and water managers for meaningful discourse about future water policy.

Boundary Science: DCDC links geography to the growing literature on boundary science as well as the field of science and technology policy more generally. Gober organized two sessions at the 2007 AAG meetings to showcase the application of boundary science in geography. The first session highlighted research that influences energy and environmental policy; the second was a panel discussion confronting the challenges of and opportunities for geographers working in policy-oriented fields.

Human-Natural Coupled Systems: DCDC has produced a critical mass of urban-environmental research that links physical and human geography. Although the discipline includes scientists, social scientists, and humanists, projects that bridge these aspects of the discipline are limited. DCDC efforts to interrelate climatic uncertainty, water-resource management, and human vulnerability create the imperative for collaboration. Examples of this work include studies on climate sensitivities of urban water use, investigations of relationship between residential growth patterns and the UHI, and simulation experiments of water shortage using different climate-model scenarios.

Data Uncertainty: A team of DCDC scientists used Bayesian Maximum Entropy (BME) to characterize Phoenix's UHI and demonstrate the utility of this technique for common geographic problems plagued by data uncertainty. Results demonstrated that BME increases mapping accuracy up to 35.3% over traditional linear kriging analysis. A subsequent synthetic case study confirmed that the increase in mapping accuracy occurs

when there are many cases missing or uncertain data. Study results were published in 2008 in the *Annals of the Association of American Geographers*.

Contributions to Other Disciplines

DCDC's mission as an interdisciplinary research center seeks to break down disciplinary boundaries in order to solve complex societal problems. As such, our primary goal was always to advance interdisciplinary knowledge. WaterSim provided disciplinary scientists the opportunity to work on inherently interdisciplinary topics, such as water-resource management, decision making under uncertainty, boundary science, policy analysis, climate adaptation, and vulnerability to risk. A substantial proportion of DCDC research projects involved collaborations of geographers, anthropologists, sociologists, engineers, ecologists, and decision scientists.

Our most successful collaborations occurred in our training programs at various levels. Building interdisciplinary thinking and learning was a major goal in both our Community of Undergraduate Research Scholars (COURS) and our Community of Graduate Scholars (CGS) programs. Students from the various DCDC research projects enrolled in formal coursework, attended weekly sessions to exchange information and cooperate on collaborative projects, and participated in a capstone poster session at the end of the year. Interdisciplinary thinking grew from exposure to concepts and approaches defined by a variety of disciplines and integrated to address common problems. Our experience in DCDC suggests that the new generation of students are open—indeed eager—to integrate different disciplinary perspectives. They do so by focusing on inherently interdisciplinary problems and collaborating on solutions.

Contributions to Human Resource Development

DCDC provided a framework for training graduate students, nourishing interdisciplinary projects, and contributing to the fields of geography, decision research, vulnerability analysis, and agent-based modeling. We are also committed to engaging undergraduate students and K-12 teachers, community organizations, government agencies, and the general public. Graduate students were drawn from a wide range of disciplines, including geography, geology, psychology, history, political science, family science, communications, plant biology, and microbiology.

Contributions to Resources for Research and Education

DCDC's setting within a large public institution has enhanced its ability to leverage research and outreach programs for educational benefit. A total of 43 graduate students have been engaged in DCDC research programs. DCDC is a founding partner and collaborator in the university's Community of Undergraduate Research Scholars (COURS) program. Preparation of the DCDC proposal provided the initial impetus for this innovative program, which integrates undergraduate students into research projects.

Contributions beyond Science and Engineering

DCDC's mission always included a significant community presence and active participation from the local water-management community. We hosted 36 Water-Climate Briefings; organized and facilitated workshops dealing with climate change, water conservation, and the UHI; and participated in myriad public events ranging from real-estate forums to informal salons and public gatherings. DCDC has become the most influential forum for public discussion of water problems in Central Arizona. Our Center is the place where science meets policy in search of sustainable solutions to the problems of climate change.

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Partner Organizations and DCDC Participants

Partner Organizations

Salt River Project: (Ongoing) SRP delivers nearly one million acre-feet of water to a service area in central Arizona and operates an extensive water-delivery system that includes reservoirs, wells, canals, and irrigation laterals. SRP has provided a wide range of information to DCDC scientists, including hydrological data, public attitude surveys that reveal household perception of drought and responsiveness to conservation messages, reports of water duties (usage rates) associated with different land uses, water delivery data, and irrigation coverage. SRP climatologists and water managers are among the most regular participants at the DCDC Climate/Water Briefings and SRP representatives gave presentations and sparked discussion at two monthly Water/Climate Briefings. SRP also partnered with DCDC and University of Arizona's Water Resources Research Center on a summer 2006 workshop for teachers held at DCDC.

City of Phoenix: (Ongoing) DCDC collaborates closely with the City of Phoenix's Water Services Department, sharing the results of different but complementary water modeling efforts. In addition, the City has provided an immensely useful data set that includes municipal water use by different types of users across census tracts between 1990 and 2005. City representatives presented two DCDC monthly Water/Climate Briefings.

University of Arizona: (Ongoing) DCDC collaborates with three University of Arizona (UA) research centers dedicated partly or wholly to water and climate research. Researchers from the Arizona Water Resources Research Center (WRRC) participate in the science and technology policy/boundary organization efforts, investigating public perception of drought and water management. DCDC also partners with Climate Assessment for the Southwest (CLIMAS), part of UA's Institute for the Study of Planet Earth on climate research. DCDC and UA's Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) are developing an online digital water-information system. SAHRA's experience with a broad spectrum of stakeholders (both public agencies and private organizations) enhances the relevancy of the project to decision makers.

Arizona Water Institute: (Ongoing) The Arizona Water Institute is a state-wide initiative to facilitate cross-university research about water resource management. Focus thus far is on developing the Arizona Hydrologic Information System.

Northern Arizona University: (2005-06) DCDC co-sponsored the Arizona Water Summit, held at NAU in August 2005, with the Center for Sustainable Environments. This event brought together the state, local, and tribal water management communities to discuss relevant science and policy issues related to water resource management.

East Valley Water Forum: (2004-05) The East Valley Water Forum consists of tribal, public, and private water agencies in the East Salt River Valley. They shared their groundwater-modeling output with DCDC so it could be integrated with agent-based models to produce visualizations for the Decision Theater.

Arizona Department of Water Resources: (2004-05) A DCDC-sponsored intern worked 20 hours per week at ADWR to retrieve data on the Phoenix area's water budget. The intern also developed metadata about how ADWR created the water budget.

INTEL: (2004-2005) The DCDC/Intel partnership pursued three areas of mutual interest: (1) sharing expertise and technology through education, training, seminars, and the Decision Theater; (2) working with industrial-sector water users to promote conservation measures and voluntary goals before mandatory water requirements take shape; and (3) researching the policy and technology driving water management.

Lincoln Institute for Land Policy: (2004-05) DCDC partnered with the Lincoln Institute for Land Policy on a land-use workshop that developed three K-12 education modules: (1) long-term climate change in Phoenix, (2) GIS interfaces to explore the urban heat island, and (3) a thermal-mapping activity.

Other Collaborators

Center for Science, Policy and Outcomes: (Ongoing) DCDC collaborates with ASU's Center for Science, Policy and Outcomes (CSPO), an internationally known organization involved in studying the linkages between science and technology and society. In fall 2006, CSPO convened a workshop of scientists actively studying water resource management in the Southwest with a goal of identifying the major stressors on the Phoenix metropolitan area water supply. Workshop results were used to help DCDC develop research priorities and to provide regional water managers with information regarding potential vulnerabilities. In spring and summer of 2007, CSPO will expand the geographic scope of their 2006 research. Specifically, CSPO will perform background research to identify key areas of uncertainty about water supply and assess the comprehensive picture of demand in the region to include the entire lower Colorado River Basin. They will produce a draft paper covering the current knowledge of stressors on this region's water supply and predictions about future changes. This paper will also create a ranking of stressors on the system.

Global Institute of Sustainability: (Ongoing) DCDC is administered by and closely collaborates with ASU's Global Institute of Sustainability (GIOS). GIOS serves as the bridge to other relevant NSF-sponsored projects, especially the Central Arizona Phoenix Long-Term Ecological Research (CAP LTER) project, the Urban Ecology Integrative Graduate Education and Research Training (IGERT) program, the cross-site Biocomplexity in the Environment project on Agrarian Landscapes in Transition, and the Sustainability Partnership Enterprise. As GIOS expands, international researchers are being asked to participate in its programs, including DCDC.

Decision Theater: (Ongoing) Founded simultaneously with DCDC, the Decision Theater at Arizona State University is a learning and decision space in which the latest understanding of complex social, economic, and natural processes and their interactions are visualized. DCDC works closely with DT to translate DCDC science and modeling into visualizations applicable for the general public and decision makers. DCDC's WaterSim is presented in the Decision Theater, and DT was used as the setting for a project to evaluate WaterSim as a decision support tool.

Central Arizona – Phoenix Long Term Ecological Research: (Ongoing) DCDC and the CAP LTER partnered in the design and implementation of the second round of the Phoenix Area Social Survey (PASS), a survey of 800 randomly selected Phoenix-area households. The survey asks respondents about their knowledge of, attitudes toward, and behaviors about a set of locally-relevant environmental issues, including urban sprawl, air quality, the urban heat island, and water scarcity. Results will allow DCDC researchers to test hypotheses about the interrelationships among environmental knowledge, attitudes and value systems, and ultimate behavior regarding water use and conservation practices. Closer collaboration between DCDC and CAP LTER, ASU's two large urban environmental research programs, offers the opportunity for integration of DCDC's inherently social science approach to urban modeling with CAP LTER's more ecological approach. A summer 2006 summit developed a research agenda to investigate human and ecological adaptations to future climate change. In 2007, DCDC and CAP LTER are expanding the PASS project to include GIOS scientists and public sector professionals.

University of California at Irvine Paul Merage School of Business: (Ongoing) Decision research at DCDC includes a partnership between L. Robin Keller (University of California at Irvine Paul Merage School of Business) and ASU faculty. The multi-objective decision analysis work performed in Year 1 is the foundation for developing decision-focused evaluation metrics for use with the models that are being developed within DCDC.

Community of Undergraduate Research Scholars: (Ongoing) ASU's Community of Undergraduate Research Scholars (COURS) provides opportunities for undergraduate students enrolled in the Barrett Honors College to contribute to DCDC research. In 2007, DCDC hosted the second annual COURS poster session, highlighting the interdisciplinary work of more than a dozen students. Faculty associated with DCDC, IGERT, the Southwest Consortium for Environmental Research and Policy (SCERP), CAP LTER and other NSF-funded projects oversaw the research presented.

Project Wet: (Ongoing) In 2006, DCDC partnered with University of Arizona's Project Wet and the Salt River Project to host a summer teacher training workshop, where 30 teachers from K-12 schools in the Phoenix Metropolitan area developed new learning materials based on local environmental issues such as water scarcity, water recycling, and the urban heat island. The new learning materials are based upon DCDC research, data sets, and outreach activities. A second "Advanced Water Educator's Workshop" is scheduled for July 2007.

ASU President's Office: (2006-08) DCDC and other university constituents, under the guidance of the Office of the University President, partnered with the Arizona Republic to create the Metropolitan Phoenix Indicators Project, a set of data presented in an impartial manner to illuminate the current state of the economic, social and cultural life of our region.

Other ASU research and academic units: (Ongoing) DCDC regularly co-sponsors lectures and symposia with other ASU research and academic units. These events bring together individuals from industry and multiple academic disciplines to explore and discuss topics such as robust decision making, historic perspectives of water in societies, visualization in environmental policy, and climate change in human-dominated systems.

Community Partners-Personnel Exchanges

City of Tempe: (Ongoing) City of Tempe supplies household-water-use data for DCDC analysis. Under DCDC's auspices and supervision, the Tempe Water Utilities Department sponsored an internship in 2006-07. The student investigated the potential water savings under various landscape water conservation scenarios.

City of Mesa: (2006-07) Under DCDC auspices and supervision, the City of Mesa Utilities Department sponsored an internship for an undergraduate student. The intern worked with a water resource specialists in the Resources Division of the Utilities Department. The intern assisted in research focused on scenario assessment for Mesa's long-term groundwater management plan.

DCDC Participants

Principal Investigators/Project Directors

Patricia Gober, School of Geographical Sciences
Charles L. Redman, Global Institute of Sustainability

Co-Principal Investigators

Bob Bolin, School of Human Evolution and Social Change
Grady Gammage, Jr., Morrison Institute for Public Policy
Thomas Taylor, Mathematics and Statistics

Senior Personnel: Manager

Bill Edwards, Executive Administrator

Senior Personnel: Core Scientists

John Anderies, School of Life Sciences
Brad Armendt, Philosophy
Richard Aspinall, School of Geographical Sciences
Robert Balling, School of Geographical Sciences
Anthony Brazel, School of Geographical Sciences
David Casagrande, Global Institute of Sustainability
Elizabeth Corley, School of Public Affairs
Andrew Ellis, School of Geographical Sciences
Monica Elser, Global Institute of Sustainability
Gregg Garfin, Institute for the Study of Planet Earth, University of Arizona
William Griffin, Family & Human Development
Corinna Gries, Global Institute of Sustainability
Suzanne Grossman-Clarke, Global Institute of Sustainability
Subhrajit Guhathakurta, School of Planning
Ed Hackett, School of Human Evolution and Social Change
Sharon Harlan, School of Human Evolution and Social Change
James Holway, Global Institute of Sustainability
Jana Hutchins, Institute for Social Science Research
Kathy Jacobs, SAHRA, University of Arizona; AWI
Donald Keefer, Supply Chain Management
L. Robin Keller, University of California-Irvine Graduate School of Management
Peter Killeen, Psychology
Ann Kinzig, School of Life Sciences
Craig Kirkwood, Supply Chain Management
Michael Kuby, School of Geographical Sciences
Tim Lant, Global Institute of Sustainability/Mathematics
Kelli Larson, School of Geographical Sciences/Global Institute of Sustainability
Peter McCartney, Global Institute of Sustainability
Margaret Nelson, Barrett Honors College
Joan McGregor, Philosophy
Rob Melnick, Global Institute of Sustainability/Morrison Institute for Public Policy
Ray Quay, City of Phoenix

Anshuman Razdan, Partnership for Research in Spatial Modeling
Jeremy Rowe, Information Technology
Charlene Saltz, University of Arizona
Daniel Sarewitz, School of Life Sciences
Kerry Smith, W.P Carey School of Business; Economics
Barbara Trapido-Lurie, School of Geographical Sciences
Elizabeth Wentz, School of Geographical Sciences
Dave White, School of Community Resources and Development
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Joseph Zehnder, Geography

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City of Phoenix
East Valley Water Forum
Arizona Department of Water Resources
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Arizona Town Hall

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Arizona Town Hall
ASU President's Office
American Indian Policy Center
Central Arizona–Phoenix Long Term Ecological Project (CAP LTER)

Center for Science, Policy and Outcomes (ASU)
Decision Theater (ASU)
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