

# **All Things to All People: Boundary Organizations & the Contemporary Research University**

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*For though I be free from all men, yet I have made myself a servant unto all, that I might gain the more...I am made all things to all men, that I might try by all means to save some.*

### **First Corinthians, 9:19-23**

The environmental challenges presently facing humanity are becoming increasingly complex. More often than not, seemingly local issues spill over and affect other resources, sectors and interest groups, resulting in what some have referred to as 'wicked problems' characterized by high uncertainty and complexity (Rittel and Weber, 1973; Ludwig et al., 2001). Though policy makers are urgently calling for research to inform environmental management decisions, significant mismatches between the current supply of scientific information and the knowledge requirements of policy makers remain (Sarewitz and Pielke, 2007; Klerkx and Leeuwis, 2008a; Shanley and Lopez, 2009). New organizational mechanisms for better linking scientific understanding to environmental policy and natural resource management are badly needed.

Boundary organizations, organizations designed to facilitate collaboration and information flow between the research and public policy communities, have been advanced as a powerful means of achieving such reconciliation (Guston, 1999, 2001). However, little is known about how to create successful boundary organizations, how they relate to their constituents, and the types of boundary management approaches and on-the-ground strategies which work best. Furthermore, while research universities provide an obvious place in which to house boundary organizations, they differ significantly from the ideal environment assumed by boundary organization theory, involving varied interest groups wielding different levels of influence and having multiple, often competing demands. The quote introducing this article serves to illustrate this point. Where traditionally academic research organizations have focused on the production of basic scientific knowledge and been "free from all men [sic]," those involved in university-based boundary organizations are asked to be all things to all people. This article examines the challenges which these organizations face and addresses how, despite these challenges, university-based boundary organizations might succeed in their goals.

Our first goal is to reconceptualize boundary organization theory by combining it with insights and findings from other areas of organizational, science policy and science and technology studies, thereby bringing it into greater alignment with the realities of the current academic environment. Our second goal is to provide grounded, detailed insights into the practice of managing boundary organizations. Though boundary organizations have received considerable attention, our understanding of how those working in these organizations actually facilitate collaboration between researchers and public policy makers, coordinate relationships among them, and meet their diverse needs is meager at best. We employ an in-depth, qualitative research approach to provide high-resolution data on the challenges faced by boundary organization participants, the counter-posed demands and pressures which they must manage, and the strategies, methods and negotiation tactics by which these are accomplished. Our third goal is to develop a new heuristic model for conceptualizing boundary organizations and boundary management in complex, dynamic environments more generally, and to provide concrete suggestions for improving their performance.

Section one reviews the concept of boundary organizations and reconceptualizes their functioning and management within the current university environment. Section two describes our case study boundary organization, data and methods. Section three presents our analysis. We characterize the social setting in which our case study operates, noting the incommensurable demands placed on it by its constituents and their differential abilities to influence its activities. This situation results in four sets of management tensions which boundary organization participants must continually negotiate. We illustrate each of these tensions and analyze four specific instances of boundary management in detail. The final section presents a new heuristic model for understanding the organizational ecology of boundary organizations in complex, dynamic settings and provides practical suggestions for enhancing their efficacy.

## **RECONCEPTUALIZING BOUNDARY ORGANIZATIONS**

Boundary organizations are formal organizations designed to exist at the interface of the research and policy communities and facilitate communication and collaboration between them (Guston, 2001: 399-401). They are characterized by three criteria. First, they provide the opportunity and often incentives for the creation and use of boundary objects. Boundary objects are objects (artifacts, conceptual models, classification systems, etc.) that allow members of different communities to interact and coordinate despite their sometimes divergent perceptions of the object (see e.g. Star and Griesemer, 1989). Second, they involve participation by actors from both the policy and research communities, as well as professionals serving as mediators between these groups. Third, they exist at the frontier of the science and policy communities but are accountable to both. As originally conceived, boundary organization theory is predicated on principal-agent theory (cf. Eisenhardt, 1989). Policy makers are considered ‘principals’ seeking goods in the form of scientific information from ‘agents’ in the research community. Likewise, researchers are viewed as principals seeking incentives from agents in the policy community. The boundary organization sits between these principals, acting as agent to each. By providing dual accountabilities to both communities the boundary organization operates to stabilize the boundary between science and politics. A successful boundary organization will thus “succeed in pleasing two sets of principals and remain stable to the external forces astride the internal stability at the actual boundary” (Guston, 2001: 401).

Early studies of boundary organizations focused on their ability to link science and policy in applied research settings (e.g., Guston, 1999; Guston et al., 2000; Keating, 2001; Cash, 2001; Agrawala et al., 2001). Research building on these initial insights examined the discursive practices used in boundary organizations (Davenport et al, 2003), examined whether the work they perform could provide a disciplinary foundation for ‘post-academic’ science (Hellstrom and Jacob, 2003), and integrated boundary organization research and collaboration studies (Rod and Paliwoda, 2003). More recent work has investigated the ability of boundary organizations to commensurate the interests of diverse groups (O’Mahony and Bechky, 2008), the conditions under which they are likely to be successful (Schneider, 2008), and the tensions which arise from delegating authority to networks mediated by a research council functioning as a pseudo boundary organization (Klerkx and Leeuwis, 2008b). In-depth studies of the management of university-based boundary organizations are absent from this literature.<sup>1</sup> Research by Rod and Paliwoda (2003) and Klerkx and Leeuwis (2008b) come closest in this respect. In the following

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<sup>1</sup> Though a few studies have considered boundary organizations with ties to academia, they have not considered boundary organizations which are housed in such environments and the complexities and challenges which result.

section we combine findings from their research with insights from organizational studies and science and technology studies, reconceptualizing boundary organization theory to better align it with the reality of the current university environment.

### ***University-based Boundary Organizations***

Understanding university-based boundary organizations begins with an appreciation of how the current university environment differs from the ideal situation described by Guston (1999). Boundary organization theory first assumes the existence of two clearly separated groups of principals occupying distinct positions within either the scientific or policy community. While true of the applied research settings used to develop boundary organization theory, this assumption does not correspond to the reality of most current university settings on two counts. First, it is problematic in assuming a clear distinction between the science and policy communities. Universities are increasingly linked to both politics and industry (Bozeman and Crow, 1990; Etzkowitz and Leydesdorff, 1998; 2000; Gibbons et al., 1994; Nowotny et al., 2001). While these transitions in university culture and environment are often more complicated than proponents indicate (e.g., Tuunainen, 2002, 2005a, 2005b; Vestergaard, 2007; Tuunainen and Knuuttila, 2009), academic, political and industrial activities can and do overlap considerably. As such, university-based boundary organizations are more realistically conceived of as occupying a 'hybrid space' where science and politics co-mingle and constituents embody elements of both (cf. Miller (2001:481-486).

The second element of this assumption, that boundary organizations serve only two constituents, is also problematic. This bilateral approach, characteristic of principal-agent theory, cannot address the complexities of boundary organizations serving three or more constituents (Klerkx and Leeuwis, 2008b). However, this is often the case for hybrid organizations operating within universities. For instance, university-based "multipurpose, multidiscipline research centers" attend to the interests of the university, industry, and outside funding agencies (Bozeman and Boardman, 2004; Boardman and Bozeman, 2007). Likewise, Tuunainen (2002, 2005a,b) has shown that the efforts of other hybrid research organizations can be complicated by distinct accountabilities to university administration, academic departments, and private industry. As with these examples, university-based boundary organizations are also likely to be beholden to several different constituents. To adjust boundary organization theory to account for relations involving three or more constituents we adopt a stakeholder perspective (see Rod and Paliwoda, 2003). This allows for analyses of boundary organizations serving more complex arrays of constituencies, and offers a clear means of determining each stakeholder's ability to influence boundary organization activities. We return to stakeholder theory in the analysis section.

The second major assumption of boundary organization theory is the existence of equivalent accountabilities between the organization and each stakeholder. This is unlikely to be true for university-based boundary organizations. University rewards systems are far from monolithic, and decoupling of rewards and expectations can occur between and within university administration and academic departments (Geisler, 1989: 44-49). Boundary organizations operating in this environment will likely find that their accountabilities are skewed, with some stakeholders better able to influence their activities and agendas than others. The likelihood of skewed accountabilities is further increased given additional stakeholders, such as outside funding agencies and the public policy community.

At the level of the individual researcher, the focus of boundary organization studies on applied research settings fails to appreciate the potential for researchers to experience role-strain as a consequence of their boundary organization affiliation. Role strain occurs when individuals are subject to competing demands placed upon them by different groups or people with whom they are affiliated (Box and Cotgrove, 1966). In more complex research settings such as academia the potential for role-strain is greatly increased. For example, academic researchers collaborating in multipurpose university research centers can experience significant levels of role-strain when the expectations of these research centers diverge from those of researchers' home departments (Boardman, 2006). Role-strain theory thus contributes to boundary organization studies by acknowledging the existence of role tensions at the individual level, potentially translating into difficulties for their boundary organization in fulfilling multiple demands. It also highlights the fact that role-strain can arise from competing expectations created by different stakeholder groups operating within the same organization (i.e. the university).

The third assumption of boundary organization theory is that all stakeholder groups can be satisfied and lasting stability achieved between their counter-posed demands. Existing research fails to recognize that stakeholders can have conflicting, often incommensurable needs. Even work recognizing the existence of conflict within boundary organizations assumes that all stakeholder demands can be met fully and symmetrically (O'Mahony and Bechky, 2008). This contravenes other research documenting the ubiquity of tensions and paradoxes in scientific work and scientific management. This stream of research demonstrates how inconsistent demands placed on research groups and organizations can create incommensurable sets of tensions between desired goals (Hackett 1990, 1997, 2005). For instance, in analyzing the scientific peer review system Hackett notes multiple tensions deriving from 'diverse stakeholders, and the inconsistent demands they place on it' (1997: 55). Among these is the tension deriving from the desire to have peer review which is effective (thorough and accurate) while also being efficient (expeditious). Maximizing one alternative necessarily diminishes the ability to maximize the other, forcing choices among alternative outcomes. We contend that the competing demands which stakeholders place upon a boundary organization can create similar sets of tensions, forcing choices among incommensurable sets of outcomes, and shaping its, research trajectory, social composition, and organizational structure.

Our final amendment to boundary organization studies is methodological rather than conceptual. Existing research fails to analyze the process of boundary management in sufficient detail. First, there has been insufficient attention paid to the temporal dimensions of boundary management. Boundary management tends to be treated as an act rather than a process, and as a result analyzed in terms of idealized relationships between the boundary organization and its stakeholders (c.f. Miller, 2001: 481-486). Grounded considerations of how boundary management decisions are actually made amid changing circumstances are severely lacking. Second, in addition to coordinating relations among stakeholders, boundary management involves making strategic decisions about the internal structure and inner workings of the boundary organization itself. To date, these internal elements of boundary management have gone unconsidered. In sum, research has fallen short on explaining what it means to 'manage the boundary' (McNie, 2007: 31-32). A finer degree of empirical resolution is needed. To this end we apply an in-depth, qualitative research approach to examine the processes of boundary management over time. We also consider both internal and external forms of boundary management.

Taken together, our readjustment of boundary organization theory for the university environment leads to a fundamental reconceptualization of boundary organizations and boundary management. It suggests that university-based boundary organizations will exist in a hybrid space in which they are likely to serve highly heterogeneous stakeholder groups embodying elements of both science and politics. These stakeholders, in turn, wield differential abilities to influence the activities and goals of the boundary organization, shaping both its internal structure and its management of relations among its stakeholders. In this context boundary management is not the act of stabilizing the ‘boundary’ between abstract sets of principals in either the science and policy domains. Rather, it is a continuous process of negotiating multiple tensions deriving from inconsistent sets of demands placed on the boundary organization by multiple, diverse stakeholders. This perspective, in tandem with detailed qualitative data, allows for an examination of boundary management over time. We test the utility of this model through our analysis, demonstrating that this perspective and research approach lend a measure of verisimilitude to boundary organization studies, allowing for more dynamic analyses of their functioning, and providing a valuable framework for examining boundary management processes in complex institutional environments more generally.

### **CASE STUDY AND RESEARCH CONTEXT**

Arizona State University’s Decision Center for a Desert City (DCDC) serves as our case study. Funded in 2004 through the U.S. National Science Foundation’s program on Decision Making Under Uncertainty, DCDC was explicitly designed as a boundary organization with the goals of contributing to basic research on decision making under uncertain conditions while also working closely with resource managers and policy makers to enhance long-term decision making about water resources in an arid, rapidly growing metropolitan area. DCDC meets the criteria for a boundary organization. It (1) involves collaborations between scientists and policy makers, (2) produces boundary objects which facilitate communication between these groups, and (3) participants have specific accountabilities to both the scientific and policy communities. DCDC is a strategic site for understanding boundary organizations in the contemporary university context because it is housed in Arizona State University, a university transforming itself along the lines identified by science and technology studies. ASU leaders contend that the traditional universities cannot adequately respond to the knowledge demands of the 21<sup>st</sup> century (e.g. Crow, 2007) and have initiated the creation of a ‘New American University’ emphasizing the practical use of the knowledge it produces, embracing interdisciplinarity, and speaking to the information needs of its local community (<http://newamericanuniversity.asu.edu>).

#### ***Data and Methods***

Data for this study are drawn from in-depth interviews and documentary analysis. A total of 33 interviews were conducted from August 2007 through March 2008. Of these, seventeen were with DCDC leaders, research scientists and staff, and sixteen with affiliated water managers and policy makers. Each interview session lasted between forty-five and ninety minutes. Our sampling strategy involved identifying and interviewing multiple key informants from diverse perspectives within DCDC and the water policy community (Kumar et al. 1993), followed by snowball sampling. This allowed for identification of individuals most knowledgeable about DCDC and its interaction with the policy community, as well as for an appreciation of the

diversity of their experiences and opinions. Interview questions were designed to capture (1) respondents' opinions about and experiences with DCDC boundary work, (2) their opinions about science-policy relations more generally, and (3) suggestions as to how the DCDC might better facilitate interaction among its stakeholders. All interviews were recorded and transcribed.

To compliment, ground, and cross-validate our interview data, we gathered and analyzed all important documents related to DCDC's functioning and assessment. These included proposals, proposal addendums, annual progress reports, external assessments, internal memos, strategic planning documents, DCDC newsletters, and the DCDC website. In all, we analyzed twenty-two documents. Additionally, we regularly visited DCDC, observing its operations and engaging in formal ethnographic observations of conferences and research briefings involving members of both the research and public policy communities. All interview, documentary, and observational data were analyzed using ethnographic content analysis, an iterative, reflexive method designed to uncover meaningful concepts and variables and verify relationships among them (Altheide, 1996). This method was facilitated by the use of qualitative analysis programs (AtlasTI and QWeftQDA) used to systematize subject coding, sort and index interviews, observations, and documents, and allow for word searches across documents. Thematic coding categories were collapsed or expanded according to their relevance as coding progressed. The authors coded all data independently, cross-checking results to test for inter-coder reliability.

## ANALYSIS

Our analysis proceeds in three parts. We first describe the competing demands of DCDC stakeholders and the relative ability of each to demand that its needs receive priority over those of others. Second, we describe and empirically illustrate four boundary management tensions resulting from these competing demands. Finally, we detail four specific instances of internal and external boundary management, describing strategies used by DCDC leaders to meet their stakeholders' competing demands and demonstrating the importance of also adjusting the organizational structure and research focus of the boundary organization in response to these tensions and divergent pressure from stakeholders.

### *DCDC Stakeholders*

DCDC serves four distinct stakeholders desiring different outcomes and wielding differential abilities to demand that their needs receive priority. To assess stakeholder influence on boundary organization activities we adopt Mitchell et al.'s (1997) model of stakeholder saliency. Stakeholder salience refers to the degree to which the desires of some stakeholders are given priority over those of others as determined by the extent to which each is viewed as powerful, legitimate, and their claims urgent. *Power* is the extent to which a stakeholder can "gain access to coercive, utilitarian, or normative means, to impose its will in the relationship" (p.865). *Legitimacy* is "a generalized perception or assumption that the actions of an entity [i.e. stakeholder] are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (p.866). *Urgency* is "(1) when a relationship or claim is of a time-sensitive nature and (2) when that relationship or claim is important or critical to the stakeholder" (p.867). These three attributes combine to produce a typology of seven possible types of stakeholders (See *Appendix A*). Stakeholder salience is predicted to be low when only one attribute is believed to exist, moderate where two are believed to exist, and high where all

three are present. DCDC's four stakeholders and their respective stakeholder types are as follows:

- 1) **The New American University** is DCDC's first stakeholder, represented by top level university administration. Since its inception DCDC has been viewed as an exemplar of the vision towards which ASU is striving, and is one of the university's flagship organizations. ASU leaders have a vested interest in its success. The New American University expects DCDC to produce high quality, interdisciplinary basic research while also providing the water policy community with information relevant to its needs.

*Stakeholder type:* Top level university administrators working towards the New American University are certainly considered legitimate. However, in terms of formal power administrators have relatively little ability to influence DCDC research or the careers of individual researchers, and their demands are relatively non-urgent. The New American University is a *discretionary stakeholder*.

- 2) **The Academic Research Community** is DCDC's second stakeholder. Specifically, this refers to the academic departments within the university providing full time appointments to DCDC researchers. More broadly, it includes their professional societies and academic research networks. The academic community expects DCDC affiliated researchers to produce traditional academic outcomes in the form of basic research contributions to home disciplines.

*Stakeholder type:* The academic community is viewed as legitimate. Unlike university administrators, the academic community has real power to affect the research and career trajectories of DCDC researchers. The demands of the academic community are urgent in that DCDC members must meet them in a timely manner to ensure their own career success. The academic community is a *definitive stakeholder*.

- 3) **The Water Policy and Management Community** is DCDC's third stakeholder. This includes city-level water managers and water policy makers, and those with broader political jurisdictions such as representatives from the Bureau of Reclamation. This policy community thus spans multiple jurisdictional scales. For the purposes of this study we refer to this broad group collectively as 'the water policy community.' The water policy community expects DCDC to produce information of relevance to their needs as water managers, policy makers, and heuristic devices for conceptualizing alternative water management decisions.

*Stakeholder type:* The demands of water policy community are viewed as legitimate. Its demands are also the most urgent as it requires information at relatively short timescales. However, the water policy and management community has relatively little power to sanction DCDC if their demands are not met. The policy community is a *dependant stakeholder*.<sup>i</sup>

- 4) **The National Science Foundation** is DCDC's final stakeholder. It is the primary funding body for the organization and regularly conducts formal assessments of its progress. The goal of NSF's Decision Making Under Uncertainty program is to improve

understanding of decision making processes under climatic change and other uncertain long-term environmental changes. It primarily expects DCDC to produce interdisciplinary basic research contributing to understanding of these issues, and secondarily to provide relevant information to the water policy community.

**Stakeholder type:** As DCDC's primary funding body, NSF is viewed as legitimate and it also wields real power as it may discontinue funding should DCDC not meet its mandates. The outcomes which NSF desires from DCDC are also urgent in that regularly scheduled updates are needed to maintain funding and basic academic research is expected to be produced at a regular pace. NSF is a *definitive stakeholder*.

Table 1 summarizes these different stakeholders' relative levels of power, legitimacy and urgency and relates them to their stakeholder types. While stakeholder theory allows for the identification of three levels of salience, for our purposes we treat each stakeholder types as having either high or low salience.

[INSERT TABLE 1 ABOUT HERE]

#### ***Four Management Tensions***

DCDC stakeholders' demands diverge in four main ways: 1) the extent to which DCDC research is expected to be interdisciplinary, 2) the rate at which information is expected to be produced, 3) to the relative focus of DCDC research on basic as opposed to applied knowledge production, and 4) the degree of decision latitude expected of researchers (Table 2). These divergences result in four management tensions which boundary organizational leaders must continuously negotiate. Each tension is outlined in turn, and exemplified with illustrative quotes.

[INSERT TABLE TWO ABOUT HERE]

##### *Tension One: Disciplinarity versus Interdisciplinarity [CONSIDER RE-ARRANGING]*

The first tension is between providing discipline specific versus interdisciplinary research products. NSF explicitly requires that all Decision Making Under Uncertainty projects maintain an interdisciplinary approach. Similarly, ASU's vision of the New American University emphasizes interdisciplinarity. However, interdisciplinarity runs contrary to the traditional scientific rewards system and thus the desires of the academic community. The water policy community is indifferent regarding interdisciplinarity, so long as research speaks to their resource management needs.

...the New American University encourages teaching and research that is *interdisciplinary, transdisciplinary, and post-disciplinary, leading, where appropriate, to a convergence of disciplines, an approach that might be more accurately described as intellectual fusion* (ASU report, emphasis in original).

There is some [disciplinary integration], I would say. I think there could be more. But, again, it goes back to the scientific awards system. Unless there's a paper being published, it doesn't necessarily facilitate that. So I think part of the challenge is just the scientific awards system which is just above and beyond what DCDC can control. (DCDC research scientist)

##### *Tension Two: Long-term versus Real-time Knowledge Production*

The second tension is between short-term versus long-term knowledge production. The policy community desires DCDC to supply real time information specific to rapidly changing circumstances. In contrast, the academic community desires research outcomes which typically take longer periods of time to realize, involving the creation and maintenance of long-term projects, papers and collaborations. The New American University desires DCDC to work at both time scales, providing policy makers with real time information while building long-term projects generating traditional academic publications. NSF has noted the need for the production of both real time and long-term research, though in DCDC reviews it has emphasized the production of long-term, basic science projects over short-term, policy relevant projects.

The people who make real-world management and policy decisions work on a different time scale than many of my colleagues and I work on. We work in months and years to figure out things. They need to know what's going on next week. (DCDC leader)

The timescale issue, the [DCDC water] model flow, the groundwater models are [on] monthly, yearly time increments, where our actual distribution system and wells operate on a minute-by-minute basis. (City water manager)

### *Tension Three: Basic versus Applied Research*

The third tension is between producing basic versus applied research. The policy community desires applied research speaking to their resource management needs. The academic community desires the opposite, valuing basic contributions to home disciplines. The New American University's twin goals of academic excellence and community embeddedness lead it to value both basic and applied research. NSF's DMUU protocol also calls for producing both basic and applied research, but in DCDC reviews has expressed a preference for basic over applied research.

Your pressure is to publish and so I think you're just inherently going to come up with different products ... academics have to look at things theoretically, especially to get published ... we [policy makers] got [sic] politics and you can have the best theoretical model [laughs], [but]it's applicability to the real world is always going to be inherently limited. (City water manager)

Often times it's [applied research] not done because it's not part of our reward system. We don't really get rewarded in the academic institutions for disseminating the information, despite the claims that it's important on the behalf of the NSF and ... the New American University. (DCDC research scientist)

### *Tension Four: Autonomy versus Consultancy*

The final tension is between autonomy versus consultancy. The traditional model of academic research is one of high autonomy, and remains the dominant professional orientation within academia. Meeting policy makers' needs, however, necessarily involves some level of consultancy. As the New American University, ASU expects DCDC to fill both roles. This is also the stated goal of the National Science Foundation's DMUU protocol, but in DCDC reviews the agency has expressed a preference for traditional academic practice.

They [the policy community] keep telling us "what you're doing, we're not really interested in it," they keep telling us that we should be doing a "needs assessment." We ought to go out and ask them all what they need and then meet their needs. That's what consultants do..." (DCDC research scientist)

Research activities that the [resource] managers would find interesting, a lot of us would consider consulting research ... researchers have a very much of a pure science – an empirical — collect data,

investigate interesting scientific questions point of view. But this idea of doing science directly in support of policy isn't something that most people are interested in." (DCDC research scientist)

These four management tensions derive from the divergent demands which stakeholders of different salience levels place on the boundary organization. In the next section we show how DCDC leaders have managed these tensions over time.

### *Meandering the Line: Boundary Management*

Boundary management is typically considered to be the process of coordinating and facilitating collaborations and interactions between stakeholders (O'Mahony and Bechky, 2008: 425). However, as noted above, boundary management also requires making strategic decisions about the internal structure of the organization and its research focus. It is thus the dual process of managing relations among stakeholders while also managing the structure and inner workings of the organization itself. These internal and external elements of boundary management occur in parallel and interact with one another. Here we analyze four instances of boundary management in relation to stakeholders' divergent demands and their differential levels of saliency. Internally, we examine how DCDC's organizational structure and research focus has been managed over time. Externally, we analyze the construction of DCDC's flagship boundary object and the organization's efforts to achieve interdisciplinarity. In so doing we show how these demands and saliencies shape both the inner workings of the organization and their ability to facilitate stakeholder interactions. We further demonstrate boundary management to be an ongoing, adaptive process of navigating these dynamic tensions over time.

#### *Changes in Organizational Structure*

DCDC was originally designed with a governance structure aimed at creating dual accountability to, and oversight by, the academic and policy communities. This dual accountability was assured by creating two discrete governance bodies. The first, the 'External Advisory Council,' was comprised of eight high-profile academicians. The second, the 'Stakeholder Advisory Council,' consisted of seven water managers and policy makers at the city, tribal and regional levels. From the original proposal,

The DCDC management plan is aimed squarely at the timely flow of new knowledge and tools related to decision making under uncertainty associated with climate change and variability. To achieve this goal, the organizational structure of the Center will emphasize interdisciplinary perspectives, openness to multiple, often competing, approaches, and close interaction among academics, practitioners, and citizenry ... an endeavor of this scale and complexity requires clear lines of responsibility and an adequate infrastructure. (Pp.16)

This structure was designed to stabilize relations among stakeholders and ensure the representation of both academicians and policy makers in DCDC decisions. However, salience differentials among stakeholders produced very different results.

On May 12, 2005, DCDC received its first review from its joint governance body. Overall, the center was praised for its well-conceived plan. The Stakeholder Advisory Council, however, was less enthusiastic about DCDC outreach activities, noting,

There needs to be a more explicit and systematic way of soliciting ideas from local water providers, regulators and decision-makers concerning what kinds of information/research they would most like to see. *This is important to ensure research is demand-driven* (Pp. 2, our emphasis).

The review also called for assessments of which water-related decisions were most important to the policy community, a greater appreciation of the political climate of water management, and the development of more credible boundary objects.

The review caused immediate difficulties for DCDC leaders, who quickly came under pressure from NSF reviewers during their first site visit. Worried that DCDC research could become unduly influenced by the Stakeholder Advisory Council, reviewers instead recommending it primarily focus on basic science. As one DCDC leader said,

It was a colossal disaster, a mess. Those stakeholders said “we want to know what you’re doing for us now.” It was absolutely clear that they wanted us to do low level applied research consulting projects. NSF hears that and says “wow, what did we get ourselves into?” and we took a serious beating that first year... I remember [an academic researcher] got up and the [the Stakeholder Advisory Council] just crucified him. It was at that moment that I realized that the money came from NSF and NSF is interested in refereed journal articles.

And another,

Part of it is we got some pushback from the NSF... frankly, what’s happened is we shifted the advisory committee ... When we originally constituted it, it was half [policy] community people and half scientists, and NSF reacted poorly to that. We had [local stakeholder X] and [local stakeholder Y], we had a bunch of really good local people and we basically replaced them with a fully science advisory group. There’s been some pushback from NSF on this.

In short, DCDC leaders decided to respond to pressure from NSF by altering the composition of their governance body. Within a month the Stakeholder Advisory Council was disbanded while the External Advisory Council remained, now including a few of the more regionally focused, academically oriented Stakeholder Council members. Within four months a second round of re-shuffling occurred, removing the remaining Stakeholder Council members and replacing them too with academicians.

Having made concessions to one of their most salient stakeholders, DCDC leaders developed alternate strategies for incorporating the water policy community’s perspective. This first involved hiring a well known water policy expert to act as liaison between DCDC and the water policy community.

He’s a boundary player. Classic... He has a Ph.D., he’s done some publishing. He’s spent his life as a bureaucrat in the [City of Phoenix] Department of Water Resources. He has a rolodex that’s very thick ... we see him as a facilitator of relationships, of networks ... He was hired to do that, he does that explicitly.

According to DCDC leaders this liaison has been critical for building relationships with the water policy community and providing rapid feedback from policy makers. DCDC also worked to build these connections by supplying city water departments with graduate interns and hosting regular research symposiums, called ‘Water and Climate Briefings’, involving both academicians and the policy community. In these ways DCDC remained attuned to policy makers’ desires and orientations while allowing formal power to remain in the hands of NSF and the academic community.

In sum, DCDC leaders were forced to make important decisions regarding its governance structure due to the conflicting demands of its stakeholders. They resolved this conflict by making concessions to one of its most powerful stakeholders. However, meeting the policy communities’ needs and maintaining credibility required alternate means of retaining their

perspective. By creating a liaison position, employing interns and holding joint symposiums DCDC managed to maintain its accountability to policy makers while assuaging the NSF's concerns. While this concession might be viewed as moving away from the dual accountability assumed by boundary organization theory, it is doubtful if DCDC could otherwise have pleased any stakeholder given the stalemates between equally valid advisory groups. There was also the real potential for funding to be cut were leaders not willing to acquiesce. In reconstructing the organization and finding alternate means for incorporating the policy communities' needs and opinions DCDC thus managed to maintain its funding while remaining relevant and accountable to less salient stakeholders. In doing so they effectively managed the tension between autonomy and consultancy, and between basic and applied research.

### *Shifting Research Focus*

Concomitant with changes in DCDC's organizational structure was a shift in research focus. DCDC leaders initially anticipated working on basic and applied research simultaneously and putting in equal effort on both.

We propose to build a "boundary organization" that bridges research on climatology, vulnerability analysis, resilience theory, and decision science with the institutions and individuals making water-management decisions in the American West. The overarching aim is to reduce vulnerability to environmental risk by improving the adaptive capacity to prepare for and respond to uncertain climate events and their effects. (Original proposal, Pp. 2)

Four years later perceptions differed. There had been steady pressure from NSF and colleagues in academic departments to produce traditional academic products. Though significant investments continued to be made in supplying information to the policy community, DCDC members now acknowledged that their main focus was on basic science. This sentiment was ubiquitous among interviewees. As voiced by one,

I think DCDC has stayed more academic and I even see the tension there where [DCDC leaders] will try to be more applied and NSF will come in and think that we're being too applied. We need to be more scientific and so there's this tug and push and pull to go back and forth... (DCDC research scientist)

When asked why DCDC had not attempted to publish a finding of practical use in water conservation, a researcher replied,

Because the world is huge, and we're still basic science. If I publish an article [on whether or not to use a swimming pool cover], I'd have to publish it in the Wal-Mart Journal. I'm not going to publish it anywhere NSF's going to care about. So you're driven by that, not just by the NSF but by faculty and collegial pressure not to really do it from that end ... It makes it hard. (DCDC research scientist)

As these excerpts demonstrate, while DCDC was initially designed to work equally on basic science and policy, its priorities temporarily shifted over time in the direction of basic science. These quotes clearly illustrate the reason for this shift: DCDC's most salient stakeholders, the National Science Foundation and the academic community, demanded it. While still working to meet the needs of the policy community and the directives of the New American University, DCDC has consistently managed the tension between basic science and applied research by erring on the side of its most salient stakeholders.

By all reports DCDC has now demonstrated its capacity for producing high-quality basic science. Having satisfied this imperative, leaders have turned to developing innovative ways to

produce policy relevant research while simultaneously addressing the intellectual interests of the academic community and NSF. For instance, by developing research that addressed the scales relevant to both the academic and policy communities, thus striking a profitable balance between autonomy and consultancy.

Keep in mind that we didn't take the cheap route of doing consulting work ... We could not do that with the NSF mandate and I've argued that isn't the way a university -- why should we replicate what's already taking place in the private sector? ... We need to think ahead about bigger issues. We need to think at regional scale, we need to think at longer time scales. We need to think about bigger [policy related] issues like climate change and the demographic change.

Effectively managing DCDC's research focus involved an initial period in which the demands of NSF and the academic community were prioritized over the needs of less salient stakeholders (the policy community and the New American University), indicating the importance of strategic timing for successfully meeting the needs of all stakeholders. It also involved finding novel ways in which DCDC research could address the needs of both sets of groups.

### *Boundary Object Negotiations*

Boundary objects are a primary point of interface between boundary organizations and stakeholders, examining their construction thus provides a valuable window into external forms of boundary management. The construction of DCDC's central boundary object involved managing the tensions between autonomy and consultancy and between long-term and short-term knowledge production. It also demonstrates the necessity of continually adapting boundary management strategies to successfully meet stakeholder demands.

From its inception, a primary DCDC goal was to construct "a comprehensive, interdisciplinary model of the coupled human-natural system", to act as a boundary object (Pp. 7, Original proposal). Once constructed, the model was to be assessed by policy makers to enhance its use in informing water policy decisions. Early attempts at model construction were grounded in agent-based modeling<sup>ii</sup>. However the construction was interrupted when, in its first review of the center the External Advisory Committee/Stakeholder Advisory Council failed to see its relevance for practical decision making.

While agent-based modeling [ABM] certainly has potential uses, the overall objectives and value in employing ABM are not clear...Those developing it need to display a better sense of how their modeling results might actually relate to those making decisions at a higher level within a thicket of political, economic and legal restraints. How might these decision makers use or be informed by modeling results? (Pp. 1).

DCDC leaders and researchers responded by forgoing the agent-based approach and opting instead to construct WaterSim. WaterSim is a regional-scale simulation model of water supply and demand for the Phoenix Metropolitan region which integrates information about climate, land use, and population growth to examine future water use scenarios.

Shifting to WaterSim was a calculated choice driven by several factors. DCDC leaders felt that the regional focus of the model was sufficiently broad-scale and long-term to begin realistically assessing water management scenarios under climatic uncertainty, a central component of DCDC's mission. WaterSim also offered a valuable means by which to study how policy community members interact with and assess boundary objects. Finally, it was hoped that

by representing the regional water system as objectively as possible DCDC could provide a politically neutral means of assessing potential water policy scenarios. When asked how DCDC managed the demands of its competing stakeholders in relation to WaterSim, one designer explained,

... with WaterSim we're not taking a side on the issue ... We simply do our best to present the information and we acknowledge what's there and what's not there. The model itself is built to be as transparent as possible. You can go into the model and you can look at the assumptions ... And so the accountability to the policy community is to say, basically, we're neutral on the policy decisions here.

DCDC modelers worked largely on their own with little input from the policy community when developing the initial version of WaterSim. In consultation with the External Advisory Council and per the original DCDC proposal, it was decided to study policy maker's perceptions and evaluation of the model from a social science perspective. It was hoped that this would allow for an enhanced understanding of decision processes among policy makers and for monitoring the progression of the model over time. The research design for the study involved organizing local policy community members into focus groups. A professional facilitator then led each group through a demonstration of WaterSim, asking their opinions about the model through a prearranged set of questions.

The study did not go as planned and resulted in some animosity by the policy community. Policy community members balked at being used as test subjects and resented what they felt to be an overly structured assessment. Rather than being able to ask the questions they felt were most relevant, they were constrained for methodological purposes to answering only questions asked by the facilitator. A DCDC PI recounted,

By overly orchestrating these scientific experiments I don't think they were able to respond to some of the scenarios they saw, [or] to fully ask all the questions they wanted to ask ... I think they went away dissatisfied. I mean ... you try to do two things at the same time, set up a scientific experiment so that you collect real social science data [and] trying to build friends and influence people. I think we did the former and missed out on the latter.

Or as stated by a city water manager,

Well, nobody was involved. No one was ever asked, 'Would a tool like this be useful to you?,' until after it was developed ... And when they were finally brought in, it was a controlled experiment where they really couldn't interact with it. I wouldn't call that engagement.

In addition to dissatisfaction with their focus group experiences, the policy community was also concerned about WaterSim for several other reasons. First, WaterSim operated at a broader geographic and longer temporal scale than was useful in daily management. Second, policy makers could not adequately interrogate the model's assumptions regarding key parameters. Third, some worried that they could come under fire if the model's predictions conflicted with their claims about local water availability. In short, the model lacked relevance, was of unknown credibility, and lacked legitimacy because policy makers were not involved in the design process (Cash et al., 2003).

The water policy community's lack of enthusiasm for WaterSim was particularly troubling since other stakeholders applauded the model. As a DCDC PI stated,

[Top level ASU administrators] loved it. The great irony and the struggle is that the general public loves it, the newspaper likes it, we bring opinion leaders from the community in, they look at it, nod, it makes sense. You bring the water managers in and they think, "I can't use this at all." ... [We received] negative feedback from the decision makers but positive feedback from NSF.

While DCDC's most salient stakeholders endorsed WaterSim, the policy community was unimpressed and agitated. The strategic management question was how to modify WaterSim to be useful to the policy community while maintaining the basic structure and foci desired by other stakeholders. DCDC leaders met this challenge using a two-pronged approach. They began by holding a second workshop. This time water managers and policy makers were encouraged question WaterSim's assumptions and capabilities, and model designers were on hand to provide answers. Doing so allowed DCDC to regain legitimacy in the eyes of the policy community and improve perceptions of the model's credibility. DCDC modelers then worked on enhancing WaterSim's salience by developing downsized modules allowing simulations for specific political jurisdictions. Since these changes perceptions of WaterSim in the policy community have improved significantly, with some cities working jointly with DCDC modelers to develop customized versions of WaterSim.

As with changes in DCDC's organizational structure and research focus, the negotiation and development of WaterSim reveals specific aspects of boundary management. In managing the development of the model DCDC leaders chose to make decisions regarding two tensions. These relate to the degree of decision latitude and the time scale on which research focuses. They managed these tensions by first focusing on maintaining their autonomy, designing WaterSim to operate at the broad spatial and long-term temporal scales of greatest interest to academic researchers. After the model gained the approval from their most salient stakeholders (NSF and the academic community), DCDC engaged with policy makers to develop customizable models of WaterSim at scales most salient to each.

#### *The (Continuing) Challenge of Achieving Interdisciplinarity*

All NSF funded DMUU centers are supposed to be organized around "interdisciplinary collaborative groups" producing "new knowledge, information, and tools related to decision making under uncertainty associated with climate change and related environmental risks." Interdisciplinary collaboration was viewed as a prerequisite for developing strategies capable of informing complex decision making under uncertainty. This perspective mirrors that of the New American University, with its focus on the need for disciplinary fusion to solve applied problems. DCDC leaders have also embraced this orientation, developing and testing several strategies for achieving disciplinary integration. However, achieving integration has proven to be one of DCDC's biggest external boundary management challenges due to pressures from the academic community vis-à-vis its traditional rewards system and related time constraints on faculty.

DCDC was originally structured around four 'knowledge areas': Climate Science, Vulnerability Analysis and Resilience Theory, Decision Science, and Science and Technology Policy Analysis. These areas were to be integrated via an assessment framework in which an interdisciplinary model of human-natural systems would be built, formal decision models constructed, and possible future climate scenarios developed. Local policy makers would then evaluate the processes by which this information was created and consider potential future water policy decisions (Original proposal, pp 3-7). It was hoped that disciplinary integration could be

achieved through such assessments. However, an NSF review conducted prior to project funding expressed some concern as to how integration would be facilitated, noting a lack of a clear means for disciplinary integration as a potential weakness in the DCDC research plan (NSF review #1, Pp. 2).

DCDC leaders took a multi-faceted approach to catalyze interdisciplinarity by first developing the Water and Climate Briefings, an ongoing series of presentations on water issues designed to build connectivity between research areas. Second, they worked to incentivize disciplinary integration by prioritizing it when funding internal projects. Third, they held regular meetings among leaders of each knowledge area to maximize communication and collaboration. Finally, DCDC leaders worked to more clearly articulate how knowledge areas related to one another and to decision tools produced by DCDC.

However, despite best efforts, achieving sustained integration remains an enduring challenge. Researchers instead tended to self-organize around common disciplinary expertise and research problems rather than spanning disciplinary boundaries.

Well, we had this very nicely compartmentalized group of teams ... With few exceptions, those teams don't exist anymore ... People have just sort of reorganized themselves in terms of interests and opportunities. (DCDC PI)

DCDC research scientists agreed that although concerted efforts at integration were being attempted, the actual degree to which it was achieved remained mild. They consistently noted two barriers to interdisciplinary collaborations. First, it was often uncertain how interdisciplinary contributions would be remunerated by home departments and discipline specific journals.

I am an interdisciplinary scientist but my faculty position is in the department of geography, so I'm evaluated by my geography colleagues as though I were a faculty member in geography. (DCDC research scientist)

Second, interdisciplinary collaborations typically take more effort and time to achieve success, resulting in less time for discipline specific projects with greater potential payoffs.

There is overhead for interaction. You have to somehow balance out the efforts you're putting in to actually doing [a] high-quality, intellectually stimulating piece of work. And on top of that, if you have to interact constantly, then that is an overhead as well ... and often the pay-offs of doing the work is critical ... You know, it's, it's a hard balancing act and all the different enterprises which we have, and the fact is that everybody is so terribly busy, incredibly busy at each point in their daily life ... (DCDC research scientist)

In both cases barriers to effective interdisciplinarity resulted from demands and pressures placed upon researchers by the academic community. At the level of the individual researcher incommensurable demands between the academic community and the boundary organization created significant role strain. Researchers responded by aligning their work with the academic rewards system, which ultimately governs their future career opportunities. This strategy, in turn, reduces the ability of the boundary organization to meet stakeholder demands. Role strain at the individual level thus creates challenges at the organizational level. Achieving integration under these conditions is an ongoing challenge. In a recent review (2007: pp 2) NSF again noted a lack of significant integration, but realized that "this is not unexpected" given the newness of the project. In response DCDC leaders developed and refined the conceptual framework of the organization to better incorporate formal and informal mechanisms for knowledge integration. It is hoped that this will promote greater interdisciplinarity.

## DISCUSSION AND WAYS FORWARD

Humanity is currently facing complex environmental problems with profound implications for our future well-being. We urgently need new organizational mechanisms for better linking scientific understanding of these problems to environmental policy and natural resource management. While boundary organizations housed in research universities offer a potentially powerful means of linking science to action, these organizations have received little attention. This study has contributed to our understanding of these organizations through an in-depth investigation of a university-based boundary organization, examining the groups which it serves, the conflicting demands they place on the organization, and how relations among these groups are managed. This section relates our findings and then uses them to illustrate our conceptual model of boundary management.

A number of well-grounded findings emerge from this analysis. First, we have demonstrated that boundary management in a university-based boundary organization is an active, dynamic process in which continuous negotiation between conflicting demands is the rule rather than the exception. Second, differences in stakeholders' relative levels of salience structure the negotiation process, shaping decisions made by organizational leaders. Third, boundary management is a two-fold process of coordinating relations among stakeholders while simultaneously adjusting the social composition, organizational structure and research focus of the organization. Fourth, rewards systems matter at both the level of the organization and the individual researcher, with divergences in these rewards systems creating the potential for nested sets of tensions and role-strains. Fifth, while some of the tensions arising from conflicting stakeholder demands can be effectively commensurated through adaptive management, the conflicting demands of some stakeholders are likely to be fundamentally incommensurable.

### *Landscapes of Tensions*

Considered in tandem, data and theory presented in this article contribute to a new conceptualization of boundary organizations and boundary management applicable to complex, dynamic institutional environments. We term this the Landscape of Tensions Model. It is represented graphically in Figure 1. It retains the strengths of the original theory of boundary organizations while achieving greater alignment with the on-the-ground reality of boundary management in complex environments. It differs from past conceptualizations of boundary organizations in several important ways. Foremost, where the original theory of boundary organizations assumes a clear distinction between the domains of 'science' and 'policy,' we follow Miller (2001: 488-495) in maintaining that university-based boundary organizations are best conceived of as working within a hybrid space where the activities of science and politics co-mingle significantly. As such, it is unrealistic to view boundary management as the act of achieving stability between science and policy. Instead, boundary management should be analyzed as a process of reconciling multiple tensions among the demands of stakeholders whose actions, desires and orientations often defy this simplistic dichotomy. The tension illustrated in Figure 1 is that between the production of applied versus basic knowledge, with knowledge production viewed as occurring along a continuum between the ideal-typical polarities of basic and applied science. Each of the other three tensions could be similarly conceptualized.

Another important distinction of our model is its explicit focus on boundary management as a dynamic process, highlighting the temporal dimension of this activity. Based on our findings we contend that boundary organizations operating in complex institutional environments are unlikely to attain permanent stability. Rather, boundary management is an ongoing process of negotiating the multiple tensions which ensue from divergent demands. Figure 1 illustrates this ongoing process in relation to DCDC's management of the tension between basic and applied research. By managing this tension differently at different times it became possible to eventually meet the needs of all four stakeholders. Where most existing research tends to treat boundary management as an act, we have shown it to be a fluid process of managing multiple sets of tensions. In Figure 1 the temporal dimension of boundary management is shown by the movement of the organization in relation to the axis labeled 'time.'

The model also uses a stakeholder perspective to explicitly consider the actual groups and organizations served by the boundary organization. Traditional boundary organization theory frames constituents abstractly as 'principals' operating in either the 'scientific' or 'policy' domains. These terms are vague and often used in ways that obscure relations among the organization and its stakeholders. For instance, the New American University is designed to foster scientific research but also to engage with and inform policy makers. Thus it is thus unclear to which domain this principal belongs and where the 'boundary' lies. By treating constituents as stakeholders with multiple interests it becomes possible to analyze differences in the demands which they place on the organization more concretely. In Figure 1 stakeholders' positions along the horizontal axis represent their demands as they relate to the ideal polarities of basic versus applied knowledge production.

Additionally, utilizing a stakeholder perspective brings the issues of conflict and competition to the foreground of boundary organization studies. Due to the focus of earlier work on achieving stability, issues of conflict went largely unconsidered. However, as is the case with boundary work in the intellectual arena (Gieryn 1999; Hilgartner 2000), organizational forms of boundary management are shaped by the relative saliency of those involved. In our study this is exemplified by the decisions of organizational leaders to shift the composition of DCDC's governance body and its research focus in response to pressure from their most salient stakeholders. By allowing for assessments of stakeholders' relative levels of salience the model is better attuned to reality, and can also be more readily connected to other perspectives emphasizing the importance of power in organizational decision making, such as resource dependency theory. In Figure 1 stakeholders' relative ability to demand salience is indicated by their stakeholder type. The response of the organization to these differential levels of salience is represented by the lateral movement of the organization across the hybrid space within the landscape of tensions.

Lastly, our model pays explicit attention to the fact that different levels within the same organization can demand different outcomes from boundary organizations and contribute to the tensions which must be managed. Cash (2001) found that boundary organizations can stabilize relations between bureaucratic strata within the same organization. The opposite phenomenon also exists. The New American University desires different things from DCDC than do academic departments. As shown here, and as confirmed by others (Boardman and Bozeman, 2007), this can cause tensions at the level of the organization and role-strain for the individual researcher, affecting DCDC's ability to perform boundary management. In Figure 1 stakeholders operating at different levels within the same organization are represented by the size of the stakeholder.

## *Enhancing the Efficacy of Boundary Organizations in Complex, Dynamic Environments*

Our study has important implications for the practice of boundary management in complex institutional environments. First, boundary management should not be viewed as an achievement, but as an ongoing process of negotiation between the organization and its stakeholders. Accomplishing stability is a tenuous operation achieved only periodically in relation to changing organizational environments, resource availabilities, and stakeholder demands. Whatever stability the boundary organization creates will likely be temporary and in relation to specific issues.

Second, boundary management is not about managing relations among abstract science and policy communities, but about meeting the demands of specific stakeholders. Boundary organizations exist at the nexus of complex, often incommensurable sets of tensions. Effective boundary management requires identifying these tensions and working to manage each given changing circumstances. To this end, boundary managers should organize focus groups with each stakeholder to examine what it desires and expects. These focus groups should be conducted at regular intervals beginning with the inception of the organization. This will allow boundary managers to better understand the tensions they must manage and the environment in which they operate. It will also increase the legitimacy of the boundary organization in the eyes of stakeholders.

Third, the existence of equivalent pressures, accountabilities and incentives among stakeholders will be rare, and may only coincide periodically. As a result, it will be necessary to manage tensions differently at different points in time. Though salience differentials shape boundary organization activities, these too are things to be managed rather than seen as deterministic forces which cannot be overcome. It is possible to meet the needs of those with less salience, but this must be accomplished at strategic times. Boundary managers will be continuously forced to make difficult choices, and there will be no way of meeting the demands of all stakeholders at all times. However, boundary management can be made more effective through strategic timing and by being explicit with stakeholders about when their demands will be addressed.

Fourth, boundary managers should develop fora in which stakeholder groups can meet with each other. This can serve to enhance stakeholders' awareness of the divergent demands placed on the boundary organization and the tensions which these engender. They may also serve to lower cultural boundaries between stakeholders and allow them to identify mutually beneficial research issues or activities, decreasing divergent pressures on the boundary organization. In these ways stakeholder communication can facilitate boundary management and develop more realistic expectations about what the boundary organization can provide.

Fifth, boundary organizations should support ongoing external assessments of their activities. Assessments are important for fostering adaptive learning, and as boundary management occurs amid changing circumstances, flexibility and adaptation are critical. Further, in knowing that the information they provide will be confidential stakeholders are likely to be more forthcoming with external reviewers. External reviewers are also better positioned to critique boundary organization leaders and powerful stakeholder groups as they have no vested interest in the organization's success or failure.

Finally, university-based boundary organizations will be more effective in universities with a high degree of goal alignment at administrative and departmental levels. Administrators should collaborate with faculty to develop a collective mission for their university. This should serve to lessen the decoupling of values and expectations at different administrative levels which

creates role strain and negatively affects the efficacy of the boundary organization. Concomitantly, boundary organizations will be more effective in universities implementing rewards systems valuing applied research, helping assuage concerns that applied research will not contribute to career advancement. Still, while individual universities can work to create environments in which policy related research is better supported, they are in many ways limited by the larger inter-university system in which they are embedded.

### *Coda*

This paper may seem to suggest that DCDC has struggled in its attempts at boundary management. This is true; however, this is in no way a critique of the center, but rather a hallmark of its leaders' creativity and perseverance. In fact, DCDC has had important impacts on both public policy and basic science. A survey conducted in tandem with this study found that twenty-four percent of DCDC affiliated policy makers cite its research in professional reports, and forty percent report that DCDC research has informed decisions made by their administrative units. The 2008 External Advisory Committee report praised the quality of the center's basic research and WaterSim for its improved analytic capability and responsiveness to policy makers' needs. NSF has also recently praised the organization, calling it "excellent" and "one of the best funding decisions NSF has made." In contrast to the quote introducing this article we close with an aphorism attributed to Abraham Lincoln which we feel better captures the essence of boundary management. "You can please some of the people all of the time, you can please all of the people some of the time, but you can't please all of the people all of the time." In attempting to be all things to all people all of the time there arises the risk of being nothing to no one. As we have shown, effective boundary management is about knowing when to be what to whom.

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## Appendix A

The potential combinations of the attributes of power, legitimacy and saliency lead to a typology of seven potential stakeholder types.

- 1) power only = *dormant stakeholder*
- 2) legitimacy only = *discretionary stakeholder*
- 3) urgency only = *demanding stakeholder*
- 4) power + legitimacy = *dominant stakeholder*
- 5) power + urgency = *dangerous stakeholder*
- 6) legitimacy + urgency = *dependant stakeholder*
- 7) power + legitimacy + urgency = *definitive stakeholder*.

Stakeholder salience is predicted to be low when only one of the stakeholder attributes are believed to exist, moderate where two are believed to exist, and high where all three are believed to be present.

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<sup>i</sup> Theoretically, policy makers could choose to completely withdraw from any interaction with DCDC. Since a boundary organization must, by definition, have at least one stakeholder from the policy community this could be seen as a form of power wielded by this stakeholder.

<sup>ii</sup> Agent-based models are computational models capable of quantifying decision making processes at the level of the individual actor and exploring the subsequent emergence of systemic properties from their interactions with each other and their environments (Janssen, 2002).