SCIENCE-POLICY RELATIONS: WHO IS INFLUENCING WHOM?

by

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(Under the Direction of Laura A. German)

ABSTRACT

This dissertation research investigated the relationship between environmental science and policy, with the aim of finding common ground for strengthening the role of scientific evidence in policy development. This project is important as humanity faces increasingly intractable environmental problems characterized by high uncertainty, complexity, and swift change (Crona and Parker 2012). How science is developed and applied to policy-making is one major factor influencing "humanity's environmental future" (Caldwell 1990). Yet, science is currently underutilized in environmental policy despite the growing call for effective scientific engagement in public policy (NSF 2002). How to effectively research and address these obstacles is a top priority in the twenty-first century.

The research followed a three-phase approach. The first phase consisted of a meta-synthesis of existing literature of boundary organizations and boundary spanning to assess formal variables shaping the effectiveness of science-policy integration. Phase two involved an in-depth ethnographic inquiry of three water policy case studies in the state of Georgia. The ethnographic phase provided a deeper look into the informal social and political factors shaping environmental policy in the state. The third phase examined whether and how science was incorporated in each water case study and which factors influenced scientific trajectory.

Results from the meta-synthesis suggest that successful science-policy linkages may be less about utilizing formal boundary organizations and spanning processes and more about fostering the *process* through which science and policy are intermingled. In addition, the focus of boundary organizations as the most effective means to span the science-policy boundary are questioned in the research. The ethnographic inquiry demonstrated how a handful of stakeholder groups structure water policy decisions in Georgia. Though formal institutions (e.g., Georgia Legislature and Georgia Department of Environmental Protection) provided a structure for interaction, the established systems of social and informal relationships within, among, and outside of various institutional capacities ultimately shaped each water policy case study in Georgia. The comparative assessment between formal and informal factors shaping the science-policy interface demonstrated the greater explanatory power of the critical policy lens, as illustrated by all that is missed through the analysis of formal features of the science-policy boundary. Future work should focus on how to address the politicization of science during science-policy integration efforts.

INDEX WORDS: Science-policy interface, Environment, Water policy, Ethnographic inquiry, Meta-synthesis, Georgia, United States

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My Ph.D. tenure began in the fall of 2011. During these first few fall months my husband, Jess, began a new career, we remodeled a 1950s fixer-upper, and I was diagnosed with the genetic disorder BRCA-1. My diagnosis was devastating for us on many levels. Academically, I began bouncing from academic advisor to academic advisor knowing that I was now considered a high-risk graduate student who would probably not make it through the program and thus, was not worth the extra time and hassle. Luckily, Dr. Laura German and I developed a friendly mentoring relationship early in 2012 during the first graduate course she taught at the University of Georgia. She worked with me early on to strategize an academic plan that I could handle while undergoing major surgeries. Due to her willingness to help me over the last six years, our professional relationship and academic success has flourished (earning several grants, awards, and fellowships!). Laura has been the steady hand helping me structure all of my academic work while also providing me with personal advice when I needed it most. Without her help, it is safe to say, my academic tenure at the University of Georgia may have been brief!

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understanding, and supportive partner for my time on earth. We have been through so much together in our young marriage from health crises to house floods to moving across the country twice now for school and work…Looking back over our almost eight years together, it seems almost unbelievable to me that we were able to handle so many difficulties, while honestly, flourishing in our personal relationship and in our professional lives. Our marriage relies on always helping each other first and foremost and I have to credit Jess with my success—he is always first to listen and provide sound academic and personal advice. He is my *raison d'être* in the beautiful world we have created together. To have such a calm and sturdy confidant has been and will always be my rock through life.

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CHAPTER 1

INTRODUCTION

Research description

Humanity faces increasingly intractable environmental problems characterized by high uncertainty, complexity, and swift change (Crona and Parker 2012). How science is developed and applied to policy-making is one major factor influencing "humanity's environmental future" (Caldwell 1990). Yet, science is currently underutilized in environmental policy despite the growing call for effective scientific engagement in public policy (NSF 2002). Current obstacles to effective scientific engagement in environmental policy include the inability to frame information in terms that resonate with policy and decision makers (Jacobs and Pulwarty 2003); insufficient efforts to "translate" scientific information in environmental policy (Ascher, Steelman, and Healy 2010); poor access to research findings (Driscoll et al. 2011); and a paucity of published literatures relevant to policy needs (Janse 2008).

Further science-policy integration difficulties include knowledge hierarchies that distance scientists from real world application (Gieryn 1995, 1999) and the tendency for social and political framings to shape both the formulation of scientific explanations of environmental problems, and the solutions proposed to reduce them (i.e. science and policy are always mutually constituted) (Forsyth 2003; Hess 1997). Additionally, a growing body of anti-science literature, or "a twisting of the findings of empirical science" (Ehrlich and Ehrlich 1996), bolsters predetermined worldviews which can support political agendas and undermine scientific credibility. This work recognizes that science and policy are inextricably interlinked and "co-

produced" (Jasanoff 2004) with politics rather than separate from it (i.e. boundary organizations do not exist in political vacuums) and that that more science does not mean better policy (Sutherland, Spiegelhalter, and Burgman 2013). Yet, how to effectively research and address these science-policy obstacles (both the instrumental and political-critical science-policy processes influencing science-policy integration) is important with imminent environmental problems of the twenty-first century.

Overall, the applied aim of this dissertation research was to find common ground for strengthening the role of scientific evidence in policy development and to provide the necessary tools for a better understanding of the complexities associated with integrating science into environmental policy. Key findings will provide boundary organizations and those individuals involved with environmental policy in the state of Georgia with a better grasp of how to effectively bridge science and policy. This dissertation will also extend more broadly, as this research will highlight effective boundary spanning processes so integration of science with environmental policy can be more successful in the future. Finally, this research will provide additional information on how knowledge and information becomes policy and which mechanisms enhance the incorporation of science into environmental policy.

Theoretically, this dissertation contributes to our understandings of the science-policy interface through distilling the relative influence of instrumental and political-informal processes and how they produce outcomes. This work ultimately questions the basic premise that boundary organizations (and instrumental science-policy processes) are the most effective means to span the science-policy boundary. In addition, this research illuminates what is gained and lost through a look at both the instrumental and political-informal science-policy factors separately so as to identify unique strengths and weaknesses of each.

A three-phase approach to this dissertation occurred: first, I conducted a meta-synthesis (Chapter 3) of existing literature of boundary organizations (organizations which bridge science and policy) and boundary spanning (processes designed to enhance the integration of science and policy) to assess formal variables shaping the effectiveness of science-policy integration. Conducting a meta-synthesis extended beyond a literature review to provide the necessary research to address significant gaps in the literature and to provide the basis for the ethnographic component of this dissertation project.

Second, I conducted in-depth, ethnographic research around three water policy case studies in the state of Georgia: (1) groundwater withdrawal regulations, (2) riparian protections, and (3) the Comprehensive Statewide Water Policy (2008). The ethnographic component of this dissertation was completed to provide a deeper look into the variables and factors which may limit or support effective environmental science-policy linkages. Chapter 4 explores the relative influence of political-informal factors in contentious environments and examines how water policy was created in Georgia and which actors and influences impacted policy trajectories.

Third, Chapter 5 draws on ethnographic data from the three case studies on water policymaking in Georgia and the formal features outlined in the meta-synthesis. I systematically evaluated the variables and factors shaping science-policy integration and boundary spanning processes within each case study. This comparative assessment of water policymaking in Georgia juxtaposes the results of the informal (ethnographic) inquiry with the formal science-policy variables identified in the meta-synthesis.

Field site

I chose the state of Georgia to conduct this research because it is an ideal environmental to study the science-policy interface: a scarcity of water resources exist despite their relative

abundance and controversies with scientific evidence are present in the political sphere. First, as a politically conservative state, policies that might be considered pro-environment have historically been a hard sell (personal communication, Dr. Gragson and Dr. Fowler). Second, science and scientific consultation is traditionally underutilized on environmental policy issues in the state. Recent examples of this occurred during the creation of the Georgia Comprehensive State-wide Water Plan (2008) and the subsequent 11 Regional Water Councils created by Governor Nathan Deal. Not a single scientist from the southeast region was asked to serve or be a consultant to the Regional Water Councils (RWCs) (300 members total), which are the guiding force over current water issues in the state as each council prepares an annual report detailing water use, management, conservation efforts, and areas for improvement for each county in Georgia.

Adding to the general lack of scientific consultation on environmental issues are the anti-science stances adopted by some Georgia politicians in the public sphere. Representative Paul Broun blasted climate change, evolution, embryology, and the big bang theory (New York Daily News, 2013) while representatives Doug Collins, Phil Gingrey, Jack Kingston, Tom Price, Lynn Westmoreland, and Johnny Isakson equally castigate scientific evidence of climate change (Sprouss, 2013). In addition, a host of special interest groups and lobbyists, scientists, non-profit organizations, and key individuals and groups are identified as influencing environmental policy-making decisions.

Finally, a water paradox, the state of Georgia presented an ideal setting to explore water policymaking efforts as it receives 50 inches of annual precipitation and is located amid 14 major river systems and seven highly productive groundwater aquifers (GAEPD, 2011; Kundell & Tetens, 1998). Yet, despite abundance water resources in Georgia, problems exist where

demands fueled by population and economic growth, as well as ongoing interstate litigation pressure Georgia's water supply (Kundell & Tetens, 1998; Campana, 2012). These issues, coupled with persistent droughts and ongoing "Tri-state Water Wars" deliberations (between Georgia, Alabama, and Florida), have brought water issues to the forefront of environmental policymaking in Georgia (Campana et al. 2012; CVIOG 2006; Seager et al. 2009). To address water issues, Georgia began to re-examine its law and policy governing water allocation to ensure that its water resources are allocated fairly and efficiently in the years to come (Fortuna, 2004). Through statewide, regional, and local planning processes, stakeholders provided input as to how water resources should be governed in Georgia. These issues provided ripe ground for investigation of environmental science-policy efforts focused on water-related issues.

Chapter Objectives

Chapter 2 provides a brief review of areas of literature concerning the science-policy interface and policy theories. I focus on how different bodies of theory define policy problems and solutions. I rely on these bodies of literature for the body of the dissertation in chapters 3, 4, and 5.

The objective of Chapter 3 is to explore science-policy linkages through a meta-synthesis of published case studies on boundary organizations and boundary spanning processes. Scholarship on science-policy linkages centers on boundary organization theory and boundary spanning processes. Yet, scholars continue to acknowledge that boundary organization and spanning research rarely engages in theory building and extended cross-case comparisons. The intent of this chapter is to better understand what features and strategies of boundary organizations and spanning processes result in policy outcomes. Overall, 39 published case studies were analyzed through a systematic grounded theory approach and 39 structured

interviews were performed with authors to validate the grounded theory results. During the grounded theory phase of research, 47 explanatory science-policy variables were identified and evaluated using aggregated and disaggregated statistics to determine correlation with science-policy outcomes. Variables associated with the scale of boundary organizations and/or boundary spanning processes, media involvement, and creating salient, legitimate, and credible information for policymakers positively correlated with science-policy outcomes. The meta-synthesis further develops the possibility that successful science-policy linkages may be less about utilizing formal boundary organizations and spanning processes and more about fostering the *process* through which science and policy are intermingled.

Chapter 4 examines the political processes at play during water policymaking in Georgia and the extent to which instrumental, political, and more critical factors are significant in influencing policy trajectories. I utilized an ethnographic approach to provide an in-depth analysis of three water policy case studies in the state of Georgia to examine political processes involved. Overall, the findings support the conception of policy through critical-based political theories rather than purely instrumental theoretical lenses, as evidence of a web of multifaceted dynamic policy processes and influences structure water policy decisions in Georgia. Although hundreds of individuals and stakeholder groups were involved in the state of Georgia in each water case study, those associated with agricultural, industrial, and governmental entities significantly influenced water policy efforts. The handful of stakeholder groups who structure water policy decisions in Georgia provide a deeply embedded power core. Though formal institutions (e.g., Georgia Legislature and Georgia Department of Environmental Quality) provided a structure for interaction, the established systems of social and informal relationships

within, among, and outside of various institutional capacities ultimately shaped each water policy case study in Georgia.

The objective of Chapter 5 is to conduct a meta-synthesis of science policy in the state of Georgia and compare these results with the extensive ethnographic inquiry of science-policy integration efforts in the state of Georgia. First, I systematically evaluated how science was incorporated into water policy efforts in Georgia concerning each water case study. Then, utilizing the meta-synthesis conceptual frameworks, I evaluated which science-policy variables were present during the case studies. Finally, I compared the results from the ethnographic inquiry to the meta-synthesis in an effort to address gaps in the science-policy literature.

Chapter 6 provides a summary of the findings from the analyses presented in chapters 3-5. I summarize the dissertation's main findings and discuss the implications for the three studies presented in the dissertation for environmental science-policy interface strategies of the future.

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CHAPTER 2

THE SCIENCE-POLICY INTERFACE: A LITERATURE REVIEW

Introduction

Expecting that policymakers should be using the "best available evidence" from research when making decisions does not recognize the formal and informal social processes at play in selecting scientific information or courses of implementation (Bracken & Oughton 2013). To understand science-policy linkages, scholarship from the natural sciences to the humanities is dominated by instrumental views on science-policy integration by boundary organizations and spanning processes. Critiques of this scholarship come from within the boundary organization literature, and from without. Those working within this tradition argue the formal processes associated with boundary organization and boundary spanning lack systematic measurements of key processes, variables, and outcomes while rarely engaging in theory building and extended cross-case comparisons (McNie 2007; Crona and Parker 2012; Hoppe et al. 2013), while largely taking for granted the fundamental tenets of this body of work. From outside of the boundary organization literature are those stressing the informal social and political forces shaping policy making, within policy decision arenas (Carley 2013); within the production of scientific knowledge itself (Forsyth 2003; Goldman 2011); and in the relationship between the two (Jasanoff 1990; Rice, Woodhouse, & Lukas 2009).

In this chapter, I review different theoretical lenses utilized to frame understandings of the science-policy interface and the policy-making process more broadly. I draw on these bodies of literature for the body of the dissertation in chapters 3, 4, and 5.

Science-policy interface

The science-policy interface is the "point at which science and policy meet and act on each other" (Janse 2008:183), "involves all decision making related to the systematic pursuit of knowledge" (Pielke 2007:37), and is the co-evolution (or co-production) of scientific and political norms within the policy process itself (Forsyth 2003; Jasanoff 2004; Hess 1997). Various forms of interactions between science and policy exist including those classically labelled as (1) a "science push," which enables the pursuit of knowledge itself to drive scientific production which can provide solutions to everyday problems (Dilling and Lemos 2011); (2) a "demand pull," which occurs when science is commissioned by a stakeholder (Dilling and Lemos 2011); and (3) a "co-production model," whereby the research agenda is shaped in an ongoing, iterative fashion between knowledge producers and users (Dilling and Lemos 2011). Pielke (2007) further outlines various roles individual scientists subscribe to with varying degrees of interactions and influence toward policy and decision making (e.g. Pure Scientist, Issue Advocate, Science Arbiter, Honest Broker).

Theoretical understandings of the science-policy interface may be characterized by two broad strands of thought. The first is an instrumentalist view that focuses on the prescribed practices (fixed sets of rules of organizational procedures and structures) utilized during science-policy interactions (Hastings, 2011). This approach views the science-policy interface as a technical challenge of structuring the boundary in ways that maximize the likelihood of policy uptake through formally established entities (e.g., boundary organizations) and procedures (e.g.,

boundary spanning processes focused on technical science-policy exchanges). The second broad view is one conceiving of both science and policy, as well as the relationship between them, as largely informal spheres in which actions (of scientists, of policy-makers) are largely driven by informal-political factors. Each body of literature thus views "the problem" in fundamentally different ways. We follow with a description of each body of thought, and how they view the science-policy problem.

Instrumental views of science-policy integration

Boundary organizations (organizations bridging science and policy) and boundary spanning (processes utilized to bridge science and policy) overwhelmingly emphasize formal[1] processes of engagement (Dilling and Lemos 2011). These instrumental processes can be traced to instrumental notions of the policy process typically associated with Lasswell's (1951) application of the social sciences to address the needs of policymakers. For Lasswell, policy science was pragmatic; the future is, to some degree, both predictable and anticipated; a problem is discovered, information is gathered and analyzed, alternatives are assessed, and policy makers render a decision that reflects a rational response to the problem at hand (Herbert 1976; Field 2007). This pragmatic approach influenced mainstream policy research for decades, which focused on how different societal factors ultimately affect specific policy creation and outcomes (e.g., crime rate, traffic congestion, employment, etc.) (Stokey and Zeckhauser 1978).

The instrumental (or means-end) conception of the policy process ultimately stems from the notion of rationality, in which determining whether a policy is rational is a matter of determining whether it efficiently and effectively accomplishes given goals (Thacher 2004).

[1] Formality is defined as pre-established organizations with prescribed practices utilized during science-policy interactions (Hastings, 2011).

From this perspective, static rational policies should be effective in managing the issues to be faced (Herbert 1976).

The science-policy literature continues to focus on instrumental features of the science-policy boundary and how they shape the uptake of science. These include: the availability and accessibility of information (Dilling and Lemos 2011; Lemos et al. 2012; Rice et al. 2009); professional training of both scientist and decision maker (Rice et al. 2009); the long-term presence of researchers with sustained interactions (CGIAR 2009; Clark 2009; Driscoll et al. 2011; Kirchoff et al. 2013), deliberate and reflexive interactions (Rice et al. 2009); high-quality and independent research (CGIAR 2009); finding the right institutional partner (CGIAR 2009); working closely with NGOs (CGIAR 2009); and working within an environment conducive to the implementation of environmental policy (CGIAR 2009) as significant formal areas that determine successful science-policy interface outcomes.

Additional instrumental factors emphasize the need for iterativity between knowledge producers and users (Dilling and Lemos 2011; Lemos et al. 2012; McNie 2007), the human and technical capacity and resources of organizations and institutions (Dilling and Lemos 2011; Lemos et al. 2012), and the customization and sensitivity of scientists to decision makers' research needs (Dilling and Lemos 2011; McNie 2007). Engaging in assessment and evaluation activities once science-policy interaction is complete (Driscoll et al. 2011), utilizing skilled practitioners to assist in boundary-spanning functions (Driscoll et al. 2011), previous positive experiences with innovation through science use and knowledge-seeking behavior by decision makers (Lemos et al. 2012), and sensitivity to the scale of the problem (McNie 2007) are further areas outlined which impact the success of science-policy integration. Finally, whether research is perceived as credible, salient, and legitimate (Cash et al. 2003) are further markers provided in

the science-policy literature for determining whether policymakers will embrace scientific information when making decisions (Clark 2009; Janse 2008; Kirchoff, Lemos, and Engle 2013; Lemos et al. 2012; McNie 2007).

Yet, the science-policy literature overwhelmingly focuses on "success" of science-policy integration corresponding with utilizing formal boundary organizations (organizations designed to enhance the integration of science and policy) to link scientific and political worlds (Lemos and Morehouse 2005; Crona and Parker 2012; Weertz and Sandmann 2010). The science-policy boundary literature discusses boundary organization theory and various characteristics of and actions taken by boundary organizations.

The theory of boundary organizations analyzes boundary organizations, boundary spanners (individuals, not organizations, spanning science-policy), and boundary spanning processes in terms of their relations with the domains of science and politics (Guston 1999). Boundary organization theory developed in a variety of science-policy contexts, including the environmental arenas related to climate (Miller 2001), health (Guston 1999), agriculture (Carr and Wilkinson 2005; Cash 2001), and water (White et al. 2008; White et al. 2010), among others. Boundary organizations are typically defined as formal organizations which create a more "neutral" space for knowledge co-production, dissemination, and brokering activities (Guston 2001; Crona and Parker 2012). These organizations frequently (a) provide accountability and responsibility to stakeholders to establish checks and balances between entities at the boundary so trust can develop (Guston 2000, 2001; Crona and Parker 2012); (b) involve the participation of principals (i.e. policymakers), agents (i.e. scientists) and professional mediators), to facilitate effective communication with the added help of professional facilitation (Braun and Guston 2003; Guston 2000); and (c) consult with stakeholders directly affected by policy choices to help

grasp “local realities” during scientific research and public participation efforts (Vogel et al. 2007:358; Bremer and Glavovic 2013:109).

Scholars working in the instrumental tradition also emphasize the use of boundary spanners (boundary spanners can also be separate from boundary organizations) to strengthen the integration of politics and science (Weertz and Sandmann 2010) as spanners are particularly important to maintaining relationships, building trust, communicating information needs and concerns, and bridging gaps between various stakeholder groups (McNie et al. 2008). These organizations further develop and utilize boundary objects (Guston 2001; White et al. 2010), or “hybrid, flexible, portable tools” (White et al. 2010:222), that sit amongst various social worlds (i.e. science, non-science, public, etc.). Boundary objects such as repositories and maps (Star and Griesemer 1989), databases (Quay 2004; Leeds-Hurwitz 2013), computer programs and modelling (see White et al. 2008, 2010) are argued to enhance the science-policy interface as they fuel collaboration and cooperation between various entities at the boundaries (White et al. 2010).

Political and critical views of science-policy integration

Criticisms of instrumental approaches to science-policy research and analysis focus on dissecting the informal-political processes inherent during science-policy integration efforts. These criticisms incorporate political and more critical (including a focus on social capital and informal hierarchy) policy lenses to understanding influences at the science-policy boundary. The political and critical critiques of boundary organization theory and boundary spanning as well as political and critical policy lenses utilized to study informal processes of the science-policy interface follow.

Recent literature critiques boundary organization theory (and boundary spanning writ large) in its assumption of a clear distinction among science, politics, and boundary spanning processes. Instead, science-policy scholars argue boundary organizations and spanners occupy a hybrid space in which science and politics co-mingle and constituents embody elements of both (Hoppe et al. 2013). Thus, organizations bridging science and policy are inextricably interlinked and "co-produced" (Jasanoff 2004) with politics rather than separate from it (i.e. boundary organizations do not exist in political vacuums).

Building on the criticisms of boundary organizations and spanning processes as interlinked with politics rather than separate from it, informal[2] social practices and norms are a growing focus of science-policy research as political factors also affect the creation and utilization of scientific knowledge (Jasanoff, 1990; Rice et al., 2009). The social dynamics occurring during the science-policy process, such as relational interactions (Miller, 2001; McNie, 2007), socio-political environments (McNie, 2007), the social and political framings shaping the formulation of scientific explanations and the solutions proposed to reduce them (Forsyth 2003; Hess 1997), and power and conflict relations (Schusler et al., 2003; Hackett and Parker, 2012) are a key focus of this scholarship. Also highlighted is the tendency to render the policymaking process as a purely technical exercise thereby masking power relations at play (McNie, 2007). Scholars working in this tradition suggest that additional research is needed to better understand the influence of science-policy factors, particularly those focused on informal and political processes, as there is a meager consideration and understanding of how they influence the science-policy interface and environmental policy (Lopez-Rodriguez 2015; Hoppe 2010).

[2] Informality is defined as inter-personal, relationship driven contact and/or espoused through networking during science-policy processes (Lemos and Morehouse, 2005; Otronen, 2003).

To incorporate more informal lenses into science-policy research and practice, science-policy scholars are integrating political approaches to understanding influences at the boundary. Literature which incorporates informal and political processes focus on the realization that actors often act for their own benefit during political processes (Tullock 1965) and that "the policy process is an ongoing struggle where the campaigns and battles wax and wane but never really stop" (Field 2007:42). Political science-policy studies further examine: a diversity of interests and groups and how these views result in some sort of compromise (Dahl 1961), how stakeholders contend for influence over public decisions through exchange relationships or interactions (Hillman and Hitt 1999), and how power dynamics ultimately bias political results in ways that serve their particular interests (Hunter 1953).

Yet, both instrumental and political policy scholars note that the focus on mere political policy theories generally fail to acknowledge formal structures (e.g., institutional, governmental, etc.) and larger, contextual factors and issues (e.g., environmental, health, economic, etc.) that may also impact policy decisions. Finally, politically-based policy theories are critiqued by instrumental policy scholars as "vague and unsystematic 'political' research loaded with implicit causality and value judgements, and not subject to exposure or dissection" (Carley 2013:7). Although political theories attempt to uncover stakeholder interests and influence, critical policy scholars have additionally noted how they do little to determine who exerts greatest influence over time as well as why and how power is wielded (Field 2007:54).

To address criticisms of both instrumental and political-informal processes impacting science-policy efforts and policy processes, critical policy theorists structure their research to incorporate the advantages of both policy approaches. In other words, critical policy theorists propose a more holistic understanding of science-policy integration efforts and policy processes

through focusing on a diversity of both instrumental-formal and political-informal dimensions and how these factors may ultimately influence policy trajectories. A critical perspective extends beyond traditional instrumental and/or political policy analyses to provide an in-depth focus on underlying influences (both rational and political) structuring policy decisions—investigating both political actors and wider interests involved in political spheres (Peck & Theodore 2010). Through a critical perspective, adherence to one policy perspective is rejected as it assumes policy making as a web of multifaceted dynamic influences, which sway with political momentum (Field 2007). In addition, rather than comparing secondary resources as detailed through media, legal, and archival material, the critical policy perspective incorporates frames of analysis which focus directly on *primary* sources; gathering firsthand information about the policy processes at play during specific policy actions (Peck & Theodore 2010). The critical perspective acknowledges policy formation is a socially constructed process, visualized as a field of adaptive connections, deeply structured by enduring power relations and shifting ideological alignments (Peck & Theodore 2010). Policy actors are not conceptualized as lone entities, but as "embodied members of epistemic, expert, and practice communities" who are sociologically complex actors, located in shifting organizational and political fields (Peck & Theodore 2010:170). This view toward policy making focuses on the "mobility and mutation" of ideas and political techniques as they transform between various jurisdictions.

A related field of scholarship informing critical policy analysis includes social capital studies which describes "relations of trust, reciprocity, and exchange; the evolution of common rules; and the role of networks" (Adger 2003:389). Social capital exerted during the policy process explicates how individuals invest in social relations, as well as how individuals access and mobilize resources to influence policymaking. Thus, the social connections (e.g., the number

of ties, the strength of tie ties, and the resources ‘‘owned’’ by those ties) and how individuals mobilize resources to gain and exert political influence (Boxman, De Graaf, & Flap 1991) is examined. A social capital lens further examines how individuals gain access to novel information or opportunities by strategically bridging ‘‘structural holes’’ in and across policy networks (Burt 2004). The related field of informal hierarchy studies highlights the patterning in social relations with additional attention paid to interpersonal relationships, actor perceptions, and power dynamics, and how these shape relations of influence between actors (Diefenbach & Sillince 2011) while contributing to social relationships of dominance and subordination in official and unofficial systems (Magee & Galinsky 2008). Applying a more critical lens to policy analysis is important as policy scholars argue social and informal processes prevail and determine much of what happens in formal democratic structures and processes (Hasanagas 2013; Lake 2009).

Incorporating a critical-political perspective to investigating the science-policy interface, science-policy scholars are focusing on the level of trust between scientists and decision makers and how trust is built and maintained (Dilling and Lemos, 2011; Janse, 2008; McNie, 2007). Critical science-policy scholars argue trust is built between scientists and policymakers when differences in background (Rice et al., 2009); the knowledge, values, and beliefs of scientists (Janse, 2008); as well as their risk tolerance and risk perception (Kirchoff, Lemos, and Engle, 2013) are managed during interactions at the boundary. In addition, the existence of a personal relationship (between those at the boundary) (Driscoll et al., 2001) further builds trust with relationship and social capital best forged through participating in informal forms of engagement (Bremer and Glavovic, 2013) including social events outside of the workplace (retreats,

fieldwork activities, luncheons, etc.) to help break down work-related barriers which may impede successful science-policy integration.

Critical science-policy scholars have begun providing recommendations for how best to span science-policy boundaries based on their research and experience with practice. Some argue scientists themselves should disseminate their research to policymakers, regulators, and regulating organizations as this builds trust between various entities at the boundary (Cutts et al. 2011). Building interpersonal trust, it is argued, increases input from decision-makers which enhances saliency, and thus, applicability of science to policy decisions (Hastings, 2011; Hoppe, 2010; Hoppe et al., 2013). Still others advocate for approaches that blur the boundaries between research and dissemination, such as promoting conditions conducive for learning through experiential, social, and institutional learning which allows for enhanced collaboration to occur and helps break down situational barriers while fostering a more collective and informed stakeholder group (Klerkx and Leeuwis, 2009; Bracken and Oughton, 2013; Zehr, 2005).

Finally, critical science-policy scholars focus on the relational dimensions of those at the boundary. This work centers on how various stakeholders develop and maintain strong social relationships to enhance social bonding and personal networking—these improved relational dimensions are argued to provide improved conditions for knowledge creation and dissemination (Holmes and Savgård, 2009). Developing enhanced social relationships are also said to occur through building social capital with the target audience through tapping into existing social capital mediums as well as the expertise available through organizations, institutes, universities, scientists, policymakers, etc. (Bielak et al., 2008; Turnhout et al., 2008). Finally, some critical science-policy scholars explore the importance of managing power differentials (e.g. conflicting

demands, positions, and resources) in order to create a more "neutral" space for collecting information and ideas from all stakeholders (Crona and Parker, 2012; Kirchoff et al., 2013).

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CHAPTER 3

ENVIRONMENTAL SCIENCE AND POLICY: A META-SYNTHESIS OF CASE STUDIES ON BOUNDARY ORGANIZATIONS AND BOUNDARY SPANNING PROCESSES[3]

[3] Jensen-Ryan, D. and German, L. Submitted to *Science and Public Policy*, 04/13/2016.

Abstract

Scholarship on science-policy linkages centers on boundary organization theory and boundary spanning processes. Yet, scholars continue to acknowledge that boundary organization and spanning research rarely engages in theory building and extended cross-case comparisons. We conducted a meta-synthesis of published qualitative articles to better understand what features and strategies of boundary organizations and spanning processes result in policy outcomes. 39 published case studies were analyzed through a systematic grounded theory approach and 39 structured interviews were performed with authors to validate the grounded theory results. Overall, 47 explanatory science-policy variables were identified and evaluated using aggregated and disaggregated statistics to determine correlation with science-policy outcomes. Variables associated with the scale of boundary organizations and/or boundary spanning processes, media involvement, and creating salient, legitimate, and credible information for policymakers positively correlated with science-policy outcomes. Our results further develop the possibility that successful science-policy linkages may be less about utilizing formal boundary organizations and spanning processes and more about fostering the *process* through which science and policy are intermingled.

Introduction

Humanity faces increasingly intractable environmental problems characterized by high uncertainty, complexity, and swift change (Crona and Parker 2012). How science is developed and applied to policy-making is one major factor influencing "humanity's environmental future" (Caldwell 1990). Yet, science is currently underutilized in environmental policy despite the growing call for effective scientific engagement in public policy (NSF 2002). Current obstacles to effective scientific engagement in environmental policy include the inability to frame information in terms that resonate with policy and decision makers (Jacobs and Pulwarty 2003); insufficient efforts to "translate" scientific information in environmental policy (Ascher, Steelman, and Healy 2010); poor access to research findings (Driscoll et al. 2011); and the tendency for social and political framings to shape both the formulation of scientific explanations of environmental problems, and the solutions proposed to reduce them (i.e. science and policy are always mutually constituted) (Forsyth 2003; Hess 1997). Further difficulties include the recognition that more science does not mean better policy (Sutherland, Spiegelhalter, and Burgman 2013); knowledge hierarchies that distance scientists from real world application (Gieryn 1995, 1999); the tendency to frame questions and methods in the absence of early policy engagement; and a paucity of published literatures relevant to policy needs (Janse 2008). Additionally, a growing body of anti-science literature, or "a twisting of the findings of empirical science" (Ehrlich and Ehrlich 1996), bolsters predetermined worldviews which can support political agendas and undermine scientific credibility. How to effectively research and address these obstacles will be a top priority in the twenty-first century.

Scholarship on science-policy linkages from the natural sciences to the humanities is dominated by boundary organization theory (Guston 2001; O'Mahony and Bechky 2008).

Boundary organizations are institutions that straddle politics and science (Guston 1999) and are identified based on the formality of the institution and their focus on the science-policy interface (Crona and Parker 2012). Classic examples of boundary organizations include the EPA, the Sea Grant Program, and the Intergovernmental Panel on Climate Change (IPCC) as outlined in Guston et al. (2000). Comparative analyses of boundary organizations and boundary work have included analysis of ozone depletion politics, knowledge systems supporting El Nino forecasts, acid rain and climate change, and policy debates around environmental education in public schools and the role of social science in the National Science Foundation (Gieryn et al. 1985, 1999; Betsill and Pielke's 1998; Buizer et al. (2010) Clark 2000a; 2000b; Zehr 2005).

Yet, a systematic analysis of science-policy case studies spanning a variety of environmental topics has yet to be completed. This research is important as scholars continue to acknowledge that boundary organization and boundary spanning research lacks systematic measurements of key processes, variables, and outcomes while rarely engaging in theory building and extended cross-case comparisons (McNie 2007; Crona and Parker 2012; Hoppe et al. 2013). This article helps address these gaps through a meta-synthesis of qualitative published case studies to evaluate the strength of the relationship between science-policy variables employed by boundary organizations and through boundary spanning processes and subsequent science-policy outcomes.

Following a literature review describing the theoretical framings of our research, we present the methodology of meta-synthesis. The results of the meta-synthesis follow the methodology with the science-policy literature framing our discussion. Finally, we provide concluding thoughts and future recommendations.

Literature Review

The Science-policy Interface: Boundary Organizations and Boundary Spanning Processes

Boundary organizations and boundary spanning processes (processes designed to enhance the integration of science and policy) link scientific and political worlds (Lemos and Morehouse 2005). The science-policy boundary literature discusses boundary organization theory and various characteristics of and actions taken by boundary organizations and boundary spanning processes.

The theory of boundary organizations analyzes boundary organizations, boundary spanners, and boundary spanning processes in terms of their relations with the domains of science and politics (Guston 1999). Boundary organization theory developed in a variety of science-policy contexts, including the environmental arenas related to climate (Miller 2001), health (Guston 1999), agriculture (Carr and Wilkinson 2005; Cash 2001), and water (White et al. 2008; White et al. 2010), among others. Boundary organizations are typically defined as formal organizations which create a more "neutral" space for knowledge co-production, dissemination, and brokering activities (Guston 2001). These organizations frequently (a) provide accountability and responsibility to stakeholders to establish checks and balances between entities at the boundary so trust can develop (Guston 2000, 2001); (b) involve the participation of principals (i.e. policymakers), agents (i.e. scientists) and professional mediators, to facilitate effective communication with the added help of professional facilitation (Braun and Guston 2003); and (c) consult with stakeholders directly affected by policy choices to help grasp "local realities" during scientific research and public participation efforts (Bremer and Glavovic 2013:109).

Boundary organizations also utilize boundary spanners (individuals, rather than organizations, which span science-policy efforts) to strengthen the integration of politics and

science (Weertz and Sandmann 2010). Scholars argue boundary spanners are particularly important to maintaining relationships, building trust, communicating information needs and concerns, and bridging gaps between various stakeholder groups (McNie et al. 2008). Boundary organizations further develop and utilize boundary objects (Star and Griesemer 1989) or "hybrid, flexible, portable tools" (White et al. 2010:222), that sit amongst various social worlds (i.e. science, non-science, public, etc.). Boundary objects such as repositories and maps (Star and Griesemer 1989), databases (Quay 2004), computer programs and modelling (see White et al. 2008, 2010) are argued to enhance the science-policy interface as they fuel collaboration and cooperation between various entities at the boundaries (White et al. 2010).

However, recent literature critiques boundary organization theory (and boundary spanning writ large) as it is problematic to assume a clear distinction among science, politics, and boundary spanning processes. Instead, boundary organizations and spanners occupy a hybrid space in which science and politics co-mingle and constituents embody elements of both (Miller 2001). As Crona and Parker (2012) highlight, the science-policy interface is a continuous process of negotiating among tensions derived from inconsistent demands placed on boundary organizations and spanners by different stakeholders. Decision-making processes and outcomes are still subjected to local politics and underlying priorities despite the best intention of boundary organizations and partnerships (Cash 2001). Thus, organizations bridging science and policy are inextricably interlinked and "co-produced" (Jasanoff 2004) with politics rather than separate from it (i.e. boundary organizations do not exist in political vacuums).

To make sense of this wide-ranging literature, we distill evidence and debates surrounding the role of specific *characteristics* of boundary organizations and spanning

processes, and specific strategies or *actions* employed at the boundary, that are deemed to be influential in shaping the success of science-policy processes.

What Characteristics of Boundary Organizations and Spanning Processes are deemed most Influential in Shaping Policy Outcomes?

Various boundary spanning processes affect the uptake of environmental science in policy. First, the kinds of academic disciplines and modes of engagement are discussed as significantly influencing the science-policy interface (Guston 2001; McNie 2007). Boundary organizations and boundary spanning processes which are interdisciplinary or cross-disciplinary in nature are said to enhance scientific relevance for policymaking (Thrift et al. 2009). Transdisciplinarity is also identified as an important feature in enhancing science-policy integration by engaging academic oriented disciplines *and* various individuals, groups, institutions, and stakeholders who may be impacted by policy decisions or able to contribute valuable insight to addressing problems not captured through disciplinary measures alone (Clapp and Mortenson 2011). Ultimately, the boundary spanning literature demonstrates how boundary organizations and spanning activities can involve various entities such as scientists, policymakers, universities, industry, consultants, think-tanks, state agencies, private companies, community organizations, representatives of indigenous groups, non-governmental organizations, funding agencies, to help influence legislative actions and implementation.

The formality (i.e., pre-established organizations with prescribed practices) of boundary organizations and boundary spanning processes are also discussed as impacting successful science-policy integration measures (Hastings 2011). There is considerable disagreement on whether formality is beneficial or harmful to achieving policy influence. Some argue that the formality of boundary organizations or boundary spanning processes better aids institutional and

policy process engagement as pre-established networks and institutional capacity are already in place to aid science-policy interaction (Bremer and Glavovic 2013). Others contend that boundary organizations and boundary spanning processes which are flexible and dynamic are significant to successful environmental science-policy linkages as it allows for multifaceted stakeholder participation as well as ideas about research to remain in flux. Thus, innovative solutions to specific problems can be addressed through best available options, instead of through a fixed team of specialists or traditional metrics applied to addressing policy issues across the board (Hastings 2011). Similarly, some maintain that ad hoc and self-organized processes are more effective, as they are organically arranged (Hahn et al. 2006; Kallis et al. 2009) around particular environmental issues and thus, are able to assemble appropriate stakeholders (both scientific and non-scientific) to accurately influence environmental policy measures (Bremer and Glavovic 2013).

Scholars seem to also disagree on whether boundary organizations and spanning processes which are operationalized through official (government) or unofficial (non-profit, non-governmental) pathways are most effective. Zehr (2005) and Tuinstra et al. (2006) argue that government-centered processes are more effective, as government involvement lends them added credibility among decision-makers. Boundary organizations or spanning processes which are driven by specific legislation, and therefore tied to specific policy aims, are also said to be more effective as policymakers have already approved the initiative in support of the interests of various stakeholders, (e.g. Resource Management Act of New Zealand highlighted by Bremer and Glavovic 2013, or the Enhanced Forest Management Pilot Projects of Innes 2003). Shaw et al. (2013) and Tomich et al. (2007), on the other hand, view science-policy efforts which are not-

for-profit as most effective as actions and research on behalf of environmental issues are seen as free from economic influence.

Sources of funding are also relevant to the discussion of the effectiveness of boundary organizations and/or boundary spanning processes (Kirchoff et al. 2013). Some argue for boundary organizations and boundary spanning which are funded by the government as this can increase perceived credibility and accountability by stakeholders (Franks 2010). Other argue that processes funded by a foundation are important as it demonstrates both private and public interest for an initiative (Clapp and Mortenson 2011). Still others suggest that processes funded by the public are most effective for demonstrating the overarching need detailed by members of society (Kueffer et al. 2014), or that processes funded by industry help by supporting more intensive and project-driven efforts (e.g. Clapp and Mortenson 2011).

Finally, issues of scale are also discussed in the literature as relevant to the discussion of the effectiveness of boundary organizations and/or boundary spanning processes. The importance of scale highlighted in science-policy literatures emphasizes how science-policy integration occurs best when operationalized through a multi-dimensional, adaptable approach which recognizes local to global scales while being open and transparent to facility dialogue and collaboration between a wide-range of different actors (Watson, 2012). For example, if environmental policy efforts target local riparian protections, scholars argue research should reflect this policy objective through focusing science on local riparian issues. Science-policy engagement exists at a multitude of scales in the literature ranging from local, state, regional, national, and international boundary organizations and spanning processes. Arguments for a more regional boundary spanning approach are stated in the literature as these efforts can pin-

point specific environmental strategies finely tuned for an area (Bremer and Glavovic 2013).

Which Strategies at the Boundary are deemed most Influential in Shaping Policy Outcomes?

Boundary organizations and spanning processes engage in various actions to attempt to influence legislative, policy change, and/or support implementation. But which of these strategies are most influential in shaping policy? Boundary organizations and boundary spanning processes which facilitate dialogue and communication, as well as coordinate entities at the boundary (science, policy, citizens, etc.), are said to influence policy as enhanced communication between entities increases the chance of finding common ground and areas for science-policy incorporation (Breuer et al. 2010). The brokering of information and the effective exchange of research directly helps environmental science become more accessible to policymakers, and thus, more easily translated into policy (Cash 2001).

Knowledge co-production further supports policy influence by allowing for the mutual investment of all entities acting at the boundary (Dilling and Lemos 2011). Co-production operates from the foundation that all knowledge is "co-produced" in science and society as "each [science and society] underwrites the other's existence" (Jasanoff 2004:17). A co-productionist model is undertaken by boundary organizations and through boundary spanning processes, whereby the research agenda is shaped in an ongoing, iterative fashion between knowledge producers and users (Dilling and Lemos 2011).

Another set of actions employed by boundary organizations and/or through spanning processes focus on relational dimensions. Boundary organizations and spanning processes which help develop and maintain strong social relationships enhance social bonding and personal networking which provides improved conditions for knowledge creation and dissemination (Holmes and Savgård 2009). Developing enhanced social relationships are said to occur through

building social capital with the target audience through current institutional networks so as to tap into existing social capital as well as the expertise available through organizations, institutes, universities, scientists, policymakers, etc. (McNie 2007). Others maintain social capital is best forged through participating in informal forms of engagement (Bremer and Glavovic 2013) with social events outside of the workplace (retreats, fieldwork activities, luncheons, etc.) to help break down work-related barriers which may impede successful science-policy integration. Finally, some authors explore the importance of managing power differentials (e.g. conflicting demands, positions, and resources) in order to create a more "neutral" space for collecting information and ideas from all stakeholders (Kirchoff et al. 2013).

Many of the strategies at the boundary focus on creating *salient, credible, and legitimate* knowledge for all stakeholders (Cash et al. 2003) as it is argued to create an inclusive, objective scientific investigation, while also reflecting the needs of stakeholders affected by decisions (Cash et al. 2001). Saliency, credibility, and legitimacy associated with science-policy integration is created through several mediums in the literature:

First, developing standards, recommendations, or plans through boundary organizations and/or boundary spanning processes is argued to enhance the effectiveness of boundary organizations and spanning processes as provide a strong *salient* starting point for future policy development as plans can easily translate into policy and/or provide evidentiary support for why or why not certain legislation should pass depending on results of a plan (Lopez-Rodriguez 2015). Boundary organizations and/or spanning processes which develop standards and recommendations further aid decision-making processes, as clearly articulated options to address issues can be easily translated into legislation (Kamelarczyk and Gamborg 2014). During the processing of developing standards, recommendations, or plans effective working groups on

various topics are also created through boundary organizations and/or boundary processes which ultimately help to influence policy decisions (Tuinstra et al. 2006).

Second, how knowledge is distributed by boundary organizations and/or processes is also identified as important to develop *legitimacy*. Some argue for disseminating research results directly to policymakers, regulators, and regulating organizations as this builds trust between various entities at the boundary and increases input from decision-makers which enhances saliency, and thus, applicability of science to policy decisions (Cutts et al. 2011; Hastings 2011). Others argue instead for distributing information to the media to help relay environmental science to the public and influence policy indirectly as this builds public knowledge and awareness of an issue regardless of its political sensitivity which can either force the hand of the government to act or create conditions conducive to science-policy interaction to put legislation into place to fix an issue (Quay 2004; Schwach et al. 2007). Still others focus instead on how knowledge is packaged, and emphasize the need to produce several types of documents for distribution to stakeholders as this increases effective translation of scientific materials (Eden 2011; Hahn et al. 2006; Bremer and Glavoic 2013).

Some argue for the need to go beyond one-way communication and one-off encounters to foster ongoing engagement with governmental bodies—which is deemed necessary for adequately tailoring the message to policy makers (e.g. governmental organizations, cooperative extension services, and local, state, and federal agencies, among others), to provide consistency in research requests, and to effectively build lasting relationships to enhance the ability for science to inform policy (Brunel et al. 2013; Buizer et al. 2010). Still others argue for approaches that blur the boundaries between research and dissemination, such as promoting conditions conducive for learning through experiential, social, and institutional learning which allows for

enhanced collaboration to occur and helps break down situational barriers while fostering a more collective and informed stakeholder group (Klerkx and Leeuwis 2009).

Third, shaping the research trajectory and executing scientific research is effective by enabling boundary organizations to bolster *credibility* by helping manage scientific uncertainty (Holmes and Savgård 2009; Hoppe 2010) when participating in research design and dissemination. Efforts to tailor research approaches is also hailed in the literature as important for the uptake of science in policy as it allows for detailed and tailored attempts to successfully influence legislative actions and implementation measures (Kallis et al. 2009). Those emphasizing the nature of the research process have also argued for scientific research conducted at specific places on specific issues and problems—coined site-specific research (Innes 2003), place-based research (Shaw et al. 2013), and "problem-oriented" research (Schut et al. 2013:95)—as this approach provides precise data, thus strengthening its credibility for use by decision makers. Other research strategies include: (a) long-term or sustained research as decision-makers are more apt to incorporate scientific data due to the capacity to provide enhanced monitoring and follow-up during implementation (Bremer and Glavovic 2013); (b) systematic evaluations throughout research design as it provides enhanced capabilities for adaptation of research and is thus perceived as more precise to address science-policy issues (Schwach et al. 2007); and (c) familiarity with the details of government structures, politics, and cultural practices (Rice et al. 2009) so research can be strategically designed and dispersed into the political arena.

Methodology

Qualitative meta-synthesis[4] (Sandelowski, Docherty, and Emden 1997; Jensen and Allen 1996; Thorne, Jensen, Kearney, Noblit, and Sandelowski 2004) is a synthesis in which the findings from qualitative studies are formally combined through grounded theory analysis. Meta-synthesis is a peer-reviewed research technique which is becoming more prolific as disciplines compare qualitative research studies and generalize qualitative knowledge (Sandelowski et al. 1997). Biomedical, health, and nursing research (e.g., Knowles et al. 2014; Ooi et al. 2016; McCarthy-Jones et al. 2012), in particular, utilizes meta-syntheses to extract key medical practices discussed in qualitative studies to further medical application and theory (Timulak and Creaner 2013). Meta-syntheses are also conducted in the fields of education (e.g., Sipe and Curlette 1997), social science (e.g., Hicks and Wood 2016), computer science (e.g., Douglas et al. 2008), social work (e.g., Aguirre and Bolton 2013), psychology (e.g., Fehr et al. 2010), linguistics (e.g., Yoder et al. 2016), among others. Qualitative meta-synthesis was utilized in this study to provide a systematic means of deriving new science-policy knowledge from findings available in existing research studies.

Meta-synthesis Phase Completion

This meta-synthesis was operationalized through the six key phases. The traditional meta-synthesis approach, conducted by Sandelowski et al. (1997) and Timulak and Creaner (2013), was utilized for our study in addition to structured first-hand interviews with authors of the published case studies. A description of each meta-synthesis phase follows:

[4] Also referred to as qualitative meta-data-analysis (Paterson, Thorne, Canam, and Jillings 2001), meta-ethnography (Noblit and Hare 1988), meta-study (Paterson et al. 2001), thematic synthesis (Thomas and Harden 2008), formal grounded theory (Kearney 1998), and meta-interpretation (Weed 2008).

Phase I: Identification of Research Question

The following research question guided this meta-synthesis: What features and strategies of boundary organizations and spanning processes result in effective policy influence and other intermediate outcomes?

Phase II: Creation of an Inclusion and Exclusion Protocol

Published case studies[5] that discussed boundary organizations, boundary spanning processes, and the science-policy interface and which address environmental policy and decision-making were identified for inclusion in the meta-synthesis. The search strategy included three elements: database searches, citation tracking, and expert contacts.[6] Overall, 6057 titles and when possible, abstracts of articles were inspected, yielding 278[7] published case studies that potentially met the meta-synthesis inclusion and exclusion protocol. Building upon Timulak and Creaner's (2013) approach toward systematically scoring potential meta-synthesis articles, each of the 278 articles was inspected and given a point value for inclusion. Table 3.1 depicts the Meta-synthesis Inclusion Protocol. Of the 278 articles analyzed utilizing the inclusion criteria, 227 were rejected from this analysis, leaving 51[8] published case studies for review.[9] Each of the 51 articles were coded for science-policy variables. While this would typically conclude the data collection phase for a meta-synthesis, information gaps that made coding of variables difficult or ambiguous were identified – requiring follow-up interviews with case study authors. As 12 authors declined participation or were unable (due to time constraints) to participate in the meta-

[5] Oxford Dictionary (2015) defined case studies as "a particular instance of something used or analyzed in order to illustrate a thesis or principle."
[6] Appendix A. Environmental Science and Policy: Meta-synthesis Search Strategy.
[7] Appendix B. Environmental Science and Policy: Articles Reviewed by Meta-synthesis Inclusion Criteria.
[8] Appendix C. Environmental Science and Policy: Search and Appraisal Process Flowchart
[9] Appendix D. Environmental Science and Policy: Published Case Studies Included in Meta-Synthesis.

synthesis, only 39 articles are included in the final analysis. Appendix E provides a detailed description of published case studies while Appendix F displays case study information in table format.

Phase III: Grounded Theory of Published Case Studies

The grounded theory approach taken in this meta-synthesis was shaped by analyzing features and strategies of boundary organizations and spanning processes present in each article, and relating these to science-policy outcomes. Features were characterized based on the structural component of the boundary organization or boundary spanning process. Strategies were defined as courses of action of boundary organizations and/or through boundary spanning processes. Other science-policy variables that did not fit into either of these categories were also identified, and subsequently categorized as factors endogenous to the scientific process. Finally, outcomes were determined based on a review of the science-policy literature as well as studies in political science, organization theory, and law and policy science. Rather than only determining whether environmental science in each case study impacted legislation and its implementation, intermediate outcomes such as increased awareness and other legal and governmental actions were included. Overall, eight science-policy outcomes were identified.

Phase IV: Construction of the Formal Conceptual Framework

To systematize the identification of features, strategies, other factors, and outcomes of the boundary spanning process, formal conceptual frameworks (Tables 3.2-3.5) were created during the course of the meta-synthesis to accommodate emergent themes and variables that surfaced from the analysis.[10] We utilized a detailed grounded theory approach by adding more codes to the preliminary conceptual framework as they emerged in the case studies, which led to the

[10] Appendix G: Environmental Science and Policy: Preliminary Meta-synthesis Conceptual Framework.

identification of 47 science-policy variables. The presence/absence of these variables was coded for in each article. Based upon the collated meta-synthesis codes from the published case studies, excel files were created using binary code (1 or 0, with 1 indicating presence of explanatory variable and 0 indicating absence).

Phase V: Interviews

This phase is an addition to the traditional method of meta-synthesis. Since it could not be assumed that every author who published their case study had objectively evaluated each of the science-policy variables analyzed, let alone using the same criteria, phone and Skype interviews were conducted with each case study author in late 2016 and early 2017. During these interviews, we asked the primary author of each environmental science-policy case study to identify which variables (Tables 3.2-3.5) were present in their case study. A "yes" or "no" was gathered from the authors as well as any additional information authors' felt needed conveyed to accurately reply to the science-policy variables and outcomes. Overall, 39 interviews were completed.

When coding differed between case study authors and our coding results, follow-up questions were asked during the interviews for clarification. Differences in reporting detail existed due to the emergence of outcomes following the publication of case studies and the time-lapse between the case studies (which started as early as 1999) and due to the inability of the case study authors to acknowledge and mention certain science-policy variables and outcomes due to the limitations of publishing in journals. Ultimately, these interviews checked the accuracy of coding and ensured each of the codes was answered objectively by the primary expert of the environmental science-policy issue at hand. This eliminated third party bias and ensured the validity of our results.

Phase VI: Results

The sixth and final stage of the meta-synthesis discusses the results and interprets the findings—drawing conclusions, and offering implications for theory, further research, and practice (Timulak 2009). In testing for the relationship between specific features, strategies, and other variables of boundary organizations and/or spanning processes (the independent variables) and policy and other outcomes (the dependent variable), independent variables were run in both disaggregated (individual variables) and aggregated (by thematic cluster) forms. For the former, Chi-square Tests (and Fisher's Exact Test[11] when necessary) were run, resulting in 376 Chi-square and Fisher's Exact Tests and 376 gamma statistics (47 variables x 8 outcomes). Logistic regressions were utilized to test aggregated variable groupings and associations between thematic clusters and outcome variables, for a total of 48 regressions (6 thematic clusters x 8 outcomes). Gamma tests were also run for each variable to determine the strength of the relationships between variables. A typical significance level (error rate) of 0.05 was used to evaluate statistical significance in this approach. Tables 3.6 and 3.7 depict the results of these tests, highlighting science-policy variables which correlated with science-policy outcomes.

Limitations of the Methodology

It is important to note the main restrictions to this research approach before discussing the results. The sample size is limited (n=39). Even though peer-reviewed meta-syntheses generally analyze 10-50 case studies (Timulak and Creaner 2013), this sample size may not reflect the diversity of published case studies on environmental science-policy issues worldwide. In addition there are difficulties in tracing the political impacts of scientific research. Difficulties may exist due to (1) the complications of tracking the impact of a particular research project

[11] The Fisher's Exact Test was appropriate to use when the expected number of observations in a cell was less than 5.

alongside the many other strands of evidence that typically inform a policy decision (Holmes and Savgård 2009); (2) the time lags of research uptake (Holmes and Savgård 2009); (3) an absence of identifying conceptual impacts, not just instrumental (Holmes and Savgård 2009); and (4) a lack of precision in research program objectives (Holmes and Savgård 2009). Thus, while research is often initiated to support policymaking, many research outcomes may not reach the policy arena and may arrive in fundamentally different ways than intended (Schut et al. 2013) – and therefore tend to be underreported. However, due to the variety of science-policy case studies analyzed and the years in which these took place, the interviews with the authors of the case studies strengthened our results as they were able to report, first-hand, whether policy and other outcomes had materialized over time.

Findings

Findings are reported according to each of the science-policy outcomes in the conceptual framework. The statistical results are first presented in summary form, followed by a discussion of findings for each of the dependent variables.

Statistical Results

Table 3.6 depicts the results of the statistical analysis for the two-way tests of the relationship between each of the boundary features and strategies and the corresponding environmental policy outcomes (Chi-square, Fisher's Exact, and Gamma). Only those statistical tests reported as significant are provided, despite the 376 tests performed. Positive gamma statistics are indicative of a greater likelihood of the associated outcome when the predictor is present; negative gamma statistics are indicative of a lower likelihood of the associated outcome when the predictor is present. Table 3.7 depicts the results for the logistic regressions which demonstrated significance, for a total of 6 regressions out of the 40 tests performed.

Outcome 1: Awareness of Policymakers

In the two-way tests, four science-policy variables were found to be correlated with increasing awareness of the scientific issue among policymakers due to boundary organization involvement or through boundary spanning processes:

1. **F10:** When the boundary organization and/or boundary spanning process was funded through an industry involved with the science-policy issue in the case study, there was less evidence that the boundary spanning effort had increased awareness of the scientific issue among policymakers.
2. **S13:** When the boundary organization and/or boundary spanning process adapted the scope of scientific research to better inform the specific environmental policy decision, there was evidence for increased awareness of the scientific issue among policy makers.
3. **S15:** When the boundary organization and/or boundary spanning process engaged in adaptive management techniques (continuous monitoring, evaluation, and adjustment of science and subsequent policy recommendations) to enhance research uptake, there was evidence for increased awareness of the scientific issue among policy makers.
4. **S17:** When the boundary organization and/or boundary spanning process delivered scientific information (i.e., presentations, reports, etc.) to policymakers during decision-making process, there was evidence for increased awareness of the scientific issue among policy makers.

In the regressions, the only grouping correlated with increased awareness of the environmental science among policymakers was saliency (S10-S16).

Outcome 2: Awareness of Public

In the two-way tests, three science-policy variables were correlated with increasing awareness of the scientific issue among the general public due to boundary organization involvement and/or boundary spanning processes:

1. **F4:** When the boundary organization and/or boundary spanning process occurred at the local (district or lower) level, there was evidence for increased awareness of the scientific issue among the general public.
2. **S9:** When the boundary organization and/or boundary spanning process actively involved mass media to build support for policy decisions among the public, there was evidence for increased awareness of the scientific issue among the general public.
3. **S21:** When research/data was delivered to the general public directly by either scientists, members of boundary organization, or policymakers, there was evidence for increased awareness of the scientific issue among the general public.

On the other hand, no logistic regressions were found to correlate with increased awareness of the scientific issue among the general public for our data set.

Outcome 3: Creation of Governmental Committee

In the two-way tests, seven science-policy variables were correlated with the creation of a governmental committee to handle the science-policy issue due to the involvement of a boundary organization and/or boundary spanning process:

1. **F7:** When the boundary organization and/or boundary spanning process occurred at the national level, there was evidence of government committees being created to handle the science-policy issue in case studies.
2. **S1:** When a boundary organization was utilized at the science-policy interface, there was evidence of government committees being created to handle the science-policy issue in case studies.
3. **S9:** When the boundary organization and/or boundary spanning process actively involved mass media to build support for policy decision among the public, there was evidence of government committees being created to handle the science-policy issue in case studies..
4. **S14**: When the boundary organization and/or boundary spanning process gathered local perspectives (i.e., community, indigenous, etc.) to aid scientists and policymakers involved in decision-making processes, there was evidence of government committees being created to handle the science-policy issue in case studies..
5. **S18:** When the boundary organization and/or boundary spanning process worked alongside scientists and policymakers to manage the scientific uncertainty associated with the environmental science utilized for case study, there was evidence of government committees being created to handle the science-policy issue in case studies..
6. **S20:** When the boundary organization and/or boundary spanning process structured and facilitated visits for policymakers to research site to enhance their understanding of the research/evidence, there was evidence of government committees being created to handle the science-policy issue in case studies..
7. **S22:** When the boundary organization and/or boundary spanning process provided traditional conflict resolution techniques (i.e., forcing, collaborating, compromising, smoothing) during interactions between scientists and policymakers, there was evidence of government committees being created to handle the science-policy issue in case studies..

For the regressions, the science-policy variables grouped under the strategies of saliency (S10-S16), legitimacy (S17-S21), and credibility were correlated with the creation of governmental committees to handle the science-policy issues associated with the case studies.

Outcomes 4 & 5: Evidence of Judicial Impact

In both two-way tests and regressions, no independent variables were found to be correlated with evidence of environmental science utilization during court proceedings or influencing court decisions.

Outcome 6: Evidence of Executive Order Impact

In the two-way tests only one science-policy variable was correlated with environmental science impacting executive orders due to the involvement of a boundary organization and/or boundary spanning process: boundary spanning occurring at the state-level. No correlations were found with any of the variable clusters in the regressions.

Outcome 7: Evidence of Legislative Impact

In the two-way tests, four science-policy variables were correlated with environmental legislative changes due to boundary organization involvement and/or boundary spanning processes:

1. **F7:** When the boundary organization and/or boundary spanning process occurred at the national level, there was evidence of the environmental science brought to the table during the boundary spanning process shaping environmental legislation.
2. **F8:** When the boundary organization and/or boundary spanning process occurred at the international level, there was evidence of the environmental science brought to the table during the boundary spanning process shaping environmental legislation.
3. **S25:** When the boundary organization and/or boundary spanning process worked to enhance transparency of the boundary spanning process, there was evidence of the environmental science brought to the table during the boundary spanning process shaping environmental legislation.
4. **Oth8:** When the science-policy interface in case studies drew on both quantitative and qualitative evidence, there was evidence that this undermined the tendency for the environmental science brought to the table during the boundary spanning process to shape environmental legislation.

For the regressions, the cluster of variables associated with saliency (S10-S16), were found to be correlated with evidence of legislative impact.

O8: Evidence of Implementation

In the two-way tests, two science-policy variables correlated with evidence of implementation of the legislative changes associated with boundary organization involvement and/or boundary spanning processes:

1. **F7:** When the boundary organization and/or boundary spanning process occurred at the national level, there was greater evidence that these processes shaped the implementation of legislation.
2. **Oth8:** When the science-policy interface in case studies drew on both quantitative and qualitative evidence, there was a lower percentage of cases with evidence of implementation.

For the regressions, only the science-policy variables grouped under strategies of saliency (S10-S16) were found to correlate with evidence of legislative impact.

Discussion

Science-policy features and strategies associated with the scale and media involvement of boundary organizations and/or boundary spanning processes and the creation of salient, legitimate, and credible information for policymakers, correlated with several science-policy outcomes for this sample. Additionally, industry funding, the use of boundary organizations, and utilizing quantitative and qualitative data analyses were additional science-policy variables which demonstrated correlation with a specific science-policy outcome. Below, we explore the possible interpretations for our findings by drawing on the wider literature.

Science-policy Features

Only science-policy features associated with funding by industry (F10) and scale (F4, F7, F8) correlated with science-policy outcomes for this sample.

Funding

When the boundary organization and/or boundary spanning process was funded through industry, there was less evidence of increased awareness of the scientific issue among

policymakers. Possible explanations for this negative correlation could be limitations placed (through possible defunding, for example) on boundary organizations and/or spanning processes funded through industry to relay scientific results to policymakers. This would not be out-of-the-ordinary as evidence exists of industry suppressing scientific evidence (e.g., climate change, *see* Dunlap and McCright 2010), particularly studies associated with environmental science (Kuehn 2004; Martin 1981). Furthermore, scholarship demonstrates that when scientific research is funded through industry efforts, faculty behavior in the aftermath of their involvement in industry/commercially funded projects changes as scientists engaged in entrepreneurial activities are more likely to deny requests from fellow academics for research results (Louis et al. 2001) and faculty members with industry support are more secretive regarding their research findings (Blumenthal et al. 1996). Thus, industry funding could suppress scientific dissemination by boundary organizations and/or through spanning processes as well as restrict research sharing vis-à-vis scientists at the boundary, impacting the ability to inform policymakers involved at the science-policy interface. More research should be conducted regarding the impacts of industry funding as well as a broader study of how various funding mediums shape science-policy outcomes as there remains considerable disagreement over the appropriate funding for shaping science-policy outcomes with scholars advocating for government (Kirchoff et al. 2013; Franks 2010), foundation (e.g. Hastings 2011; Clapp and Mortenson 2011), public (e.g. Klerkx and Leeuwis 2009; Kueffer et al. 2014), and industry funding (Clapp and Mortenson 2011) and subsequent science-policy influence.

Scale

Predictors associated with scale correlated with several science-policy outcomes including increasing public awareness of scientific issues, the creation of governmental

committees, and legislative changes and implementation. Attention to scale when integrating science and policy is well established across science-policy literatures (*see* Cash and Moser 2000; Sarkki et al. 2013). The suite of opportunities present at different scales and the factors that matter the most at those scales produce favorable policy changes with scholars noting how scientists are better able to influence the uptake of science into policy, when scientists adapt their research to the scales that match policy interests (Sarkki et al. 2013).

- *Local*

When boundary organizations and/or spanning processes were executed at the local-level it correlated with increasing the public's awareness of the environmental science-policy issue at hand. In line with our results, Bremer and Glavovic (2009, 2013) as well as Reid et al. (2006) found that boundary spanning processes which exist at the local scale led to greater awareness by the general public due to the enhanced ability to mobilize local stakeholders' participation in the science-policy interface and thus, increase their knowledge concerning the scientific issues at hand. Additional research should focus on how local boundary organizations and/or spanning process mobilize stakeholder participation and how models of participation could be applied across varying scales.

- *National*

The most frequently correlated science-policy variable associated with scale occurred at the national-level. This science-policy variable correlated with the creation of governmental committees for continued guidance over science-policy issues, and evidence of legislative changes and implementation. Hoppe et al. (2013) found in their work on the science-policy interface and climate change that boundary work is a social relationship between a provider and user of expertise with boundary organizations and spanning processes at the national-level

displaying strong instrumental roles in support of their national governments. Overall, this "nationalized" expertise provided enhanced trust and political control, or a closer link between science and national politics. Hoppe et al.'s (2013) work provides an explanation for why boundary organizations and spanning processes occurring at the national-level correlated with several science-policy outcomes in our study as relationships of trust influence science-policy cooperation as well as providing precise expertise as to how environmental science can influence policy in the political sphere in which it exists. As Hoppe et al. (2013) argued, "successful boundary arrangements are those that have adjusted to their diverse national contexts of policy issue politics and political-cultural spheres" (17). Additional research on boundary work should occur which explores national science-policy endeavors and the mechanisms through which boundary work effectively links with government initiatives at the national-level.

- *International*

When boundary organizations and/or spanning processes were executed at the international-level, it correlated with evidence that environmental science impacted legislation. The science-policy literature recognizes how research at global scales lends itself to larger policy endeavors. For example, science-policy boundary work through the Intergovernmental Panel on Climate Change impacts national legislation and international agreements (Bremer and Glavovic 2013); the Southern African Millennium Ecosystem Assessment (SafMa, Fabricus et al. 2006), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, Perrings et al. 2011), and the United Nations Environment Programme (UNEP), are further international-scale efforts which resulted in shaping national and international environmental policies. Additional research could focus on the mechanisms through which international scientific studies are disseminated and details of how they were incorporated into legislation.

Science-policy Strategies

Both for the two-way statistical analyses and logistic regressions, the strategies associated with creating salient, legitimate, and credible knowledge (Cash 2003) correlated with four of the eight science-policy outcomes. The only other two strategies which were statistically significant at influencing a specific science-policy outcome were the use boundary organizations and the mass media.

Boundary Organizations

Our results indicate utilizing a boundary organization correlated with the creation of a separate governmental committee to continue handling science-policy issues associated with the case studies. This result is not surprising as the literature argues boundary organizations provide a more "neutral" space for knowledge co-production, dissemination, and brokering activities (Guston 2001; Crona and Parker 2012). The stability associated with providing accountability and responsibility to a variety of stakeholders (Guston 2001; Crona and Parker 2012; Bremer and Glavovic 2013; Vogel et al. 2007), and professional mediation and facilitation (Braun and Guston 2003) further create ideal conditions in which a government entity can successfully forge meaningful long-term reciprocal relationships (both scientific and personal) with those occupying a stable science-policy space through a boundary organization.

In contrast to this interpretation, the positive correlation between utilizing a boundary organization and the creation of a separate governmental committee to continue handling science-policy issues may also indicate that boundary organizations (nor perhaps scientists) are not trusted by policymakers, and thus a committee is created to provide oversight to the boundary process and to handle ongoing scientific issues (*see* Roux et al. 2006). In addition,

governmental committees may be constituted to better align the scientific aspect of the policy process with special interests by "stacking" committees. As Sarewitz and Pielke (2007) argued, scientific research trajectories are often influenced by political pressure and powerful political entities who have a stake in the outcome of research results. Thus, continued influenced between boundary organizations and/or processes and governmental committees regarding scientific issues could impact research trajectory, results, and the uptake of information in policy. Further exploration into how government entities/committees influence boundary organizations and/or spanning process should occur especially with regard to deeply political issues associated with the environment.

Media

Our results indicate the direct involvement by boundary organizations and/or through a boundary spanning processes with the media correlated with two science-policy outcomes: increasing awareness of the general public and the creation of a governmental committee. Our results reflect other studies which conclude the use of mass media as an influential tool for widening public awareness of environmental issues (Schoenfeld et al. 1979; Slovic 2000). It also points to research on the science-policy-media interface which details how social relationships are built over time between scientists, policy actors, and the public through media distribution (Boycoff and Boycoff 2007). Thus, media involvement enhanced relationship building at the boundary which correlated with increasing public awareness and the creation of a governmental committee as media coverage itself served to intersect public, science, and government entities.

Even with media involvement positively correlating with two science-policy outcomes, the literature points to how environmental issues frequently attract widespread attention and yet, tend to decline from public view which ultimately lends them to remain largely unresolved

(Downs 1972). This explains why media coverage may have increased public and some governmental response, but did not correlate with impacting legislation or implementation. The lack of media influence on legislation and/or implementation is disheartening especially as Kitzinger and Reilly (1997) found that high levels of media coverage do not last long and that a lack of policy events (i.e., legislation) leads to a lack of media interest.

Yet, these findings provide evidence for scientists and those operating at the science-policy boundary to continue their efforts in disseminating scientific research via media. Peters (2012) provided a 30-year assessment of research centered on science and the media which found scientists consider visibility in the media as important; however, their communication practices are outdated (with science purposefully distancing itself from the media for issues ranging from credibility to the belief that scientific results will be mis-interpreted)—even within the younger generation of scientists. As the contentiousness between science and politics grows in the 21st century, it behooves scientists to study and transform the media-science interface to ultimately improve the likelihood of increasing awareness for the general public.

Saliency, Legitimacy, and Credibility

Strategies associated with creating salient, legitimate, and credible knowledge (Cash 2003) were found to correlate with half of the science-policy outcomes. Our results affirm the continued and deliberate focus of science-policy efforts on efforts to enhance saliency, legitimacy, and credibility as these prove fruitful in yielding successful science-policy outcomes (*see* Crona and Parker 2012; Driscoll et al. 2011; Franks 2010; Holmes and Lock 2010, among others). Our findings also further develop the possibility that successful science-policy linkages may be less about utilizing formal boundary organizations and spanning processes and more

about fostering the *process* itself as salient, legitimate, and credible for policymakers and stakeholders' interacting at the boundary.

Saliency is defined as when a boundary organization or spanning process engages in activities designed to enhance the "relevance of the assessment to the needs of decision makers" (Cash 2003:8086). Saliency was the science-policy category most correlated with science-policy outcomes as variables associated with saliency were found significant for the two-way statistical analyses and for the logistic regressions. Overall, S13 (adapted scope of research) and S15 (engaged in adaptive management) correlated with increasing awareness of the scientific issue for policymakers. S14 (gathered local perspectives) correlated with the creation of a government committee. When aggregated, the science-policy variables associated with saliency (S10-S16) correlated with *four* science-policy outcomes: increasing awareness of policymakers, creation of a government committee, the uptake of science in legislation, and subsequent implementation. These results demonstrate the importance of boundary organizations and/or spanning processes in designing research, boundary activities, etc. with decisionmaker needs at the forefront, as science-policy literature indicates. Additional science-policy research should focus on identifying additional saliency mechanisms and how these mechanisms can be incorporated into existing and future science-policy efforts.

Legitimacy was also a science-policy category which correlated with science-policy outcomes, although less so than saliency. Boundary organizations and/or spanning processes are legitimate when they engage in activities aimed to create the "perception that the production of information and technology has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of opposing views and interests" (Cash 2003:8086). Variables associated with legitimacy were found significant for the two-way

statistical analyses and for the logistic regressions. Unsurprisingly, S17 (scientific knowledge dissemination to policymakers) correlated with increasing awareness of the scientific issue for policymakers and S21 (scientific knowledge dissemination to public) correlated with increasing awareness of the scientific issue for the public. S18 (managing scientific uncertainty) and S20 (joint visits to research sites) correlated with the creation of a government committee. When aggregated, the science-policy variables associated with legitimacy (S17-S21) correlated with one science-policy outcome: the creation of a government committee. These results indicate how science-policy strategies focused on legitimacy build fruitful and meaningful relationships which can ultimately influence policy outcomes. Additional research should focus on why and how strategies associated with legitimacy build confidence in science-policy efforts and how these strategies may be incorporated into highly contentious environmental science-policy matters.

Finally, credibility was a science-policy category which correlated with science-policy outcomes, although less so than saliency and legitimacy. A boundary organization or spanning process is credible when it engages in activities to enhance and/or communicate the "scientific adequacy of the technical evidence and arguments" (Cash 2003:8086). Variables associated with credibility were found significant for the two-way statistical analyses and for the logistic regressions. S22 (conflict resolution exercised at the science-policy boundary) correlated with the creation of a government committee and S25 (enhanced transparency of the boundary spanning process itself to those at the boundary) correlated with the uptake of science in legislation. Like legitimacy, when aggregated, the science-policy variables associated with credibility (S22-27) correlated with one science-policy outcome: the creation of a government committee.

Science-policy Other

Interestingly, when the science-policy interface in case studies drew on both quantitative and qualitative evidence, there was a lower percentage of cases with evidence that the environmental science utilized during the boundary spanning process had shaped environmental legislation or implementation. There were also no positive correlations with the use of *either* qualitative or qualitative evidence. These results counter much of the literature and longstanding science-policy experiences which argue that both quantitative and qualitative modes of evidence and analysis are critical to inform decision-making processes (Jick 1979; Curry et al. 2009), to reject "epistemological hierarchy" (O'Neill 2010), and provide fruitful social and political responses (O'Neill 2010). To address this issue, additional research should explore whether and how the use of qualitative and quantitative currently influences political decision-making.

Statistical Insignificance of Variables Emphasized in the Literature

Some of the key features, roles, and strategies hailed in the literature as substantial to the uptake of science in policy were not correlated with science-policy outcomes in our sample. The co-production of knowledge (Jasanoff 2004) and creation and use of boundary objects (Star and Griesemer 1989), for example, are discussed as significant activities undertaken by boundary organizations and spanning processes (Jasanoff 2004; Rice et al. 2008; Clark 2009; Dilling and Lemos 2011; Driscoll et al. 2011; Lemos et al. 2012). A lack of correlation among co-production of knowledge and the creation and use of boundary objects with science-policy outcomes was particularly surprising, given their prevalence in the literature and their almost taken-for-granted status as key strategies of boundary organizations and spanning processes.

Prior research has also consistently identified the need for institutionalized formal boundary organizations (Cash 2001; Guston 2001; White 2011; White et al. 2010). Yet, the utilization of a boundary organization did not correlate with several science-policy outcomes in

this study including the uptake of science in legislation and subsequent implementation. This is surprising, given the reliance (both academically and practically) in science-policy contexts. However, as Hoppe et al. (2013) noted, formal boundary organizations can become vulnerable to losses in credibility and trust as organizations become entangled in politics surrounding scientific issues which can negatively impact policy results. In addition, Blades et al. (2016) found formal boundary organizations require high levels of investment and resources from all participants which can negatively impact science-policy integration efforts; a need for more short-term partnerships between scientists and policymakers is needed, they argued. Similar to Blade et al. (2016), our results question whether boundary organizations are the most effective means to span science-policy boundaries and effectiveness of formal features of boundary organizations and spanning processes. Instead, effective boundary efforts may be less about the formal organization or structure itself, but about the process through which science and policy are intermingled.

Conclusion

This study provided a systematic analysis of published environmental science-policy case studies ranging from 1999-2016, to better understand which boundary spanning processes (including those utilized by boundary organizations) result in successful science-policy outcomes; key information currently lacking in boundary spanning scholarship (*see* Vogel et al. 2007; McNie 2007; Crona and Parker 2012; Hoppe et al. 2013). While providing detailed processes and variables associated with boundary organizations and boundary spanning, this extended cross-case comparison also provides the necessary conditions to further develop the theory of science-policy linkages, and boundary organization theory specifically.

Overall, 39 published environmental science-policy case studies were analyzed through the peer-reviewed method of meta-synthesis, a systematic grounded theory approach of analysis

(Sandelowski et al. 1997 and Timulak and Creaner 2013). We updated the method of meta-synthesis to also include structured interviews which occurred with the 39 authors of the published science-policy case studies to validate our grounded theory efforts and to check the accuracy of the results of this meta-synthesis. Overall, 47 explanatory science-policy variables were coded and evaluated using the Chi-square Test (and Fisher's Exact Test when necessary) and logistic regressions to determine correlation with science-policy outcomes.

When evaluating the strength of relationships between science-policy processes and science-policy outcomes, our results indicate science-policy variables associated with scale, media involvement, and creating salient, legitimate, and credible information for policymakers correlated with several science-policy outcomes. Industry funding, the use of boundary organizations, and utilizing both quantitative and qualitative data analysis were also science-policy variables which correlated with single science-policy outcomes.

The frequent and positive correlations between science-policy strategies associated with saliency, legitimacy, and credibility and outcomes emerged at the forefront of this study. A shift in focus from development of formal/institutional boundary organizations and/or spanning efforts to the science-policy processes—especially those mechanisms which bolster saliency, legitimacy, and credibility—may be fruitful to overcome current science-policy interface obstacles. As the literature indicates, boundary arrangements include a wide variety of hybrid organizational forms that straddle and mediate the boundary between science and policy, of which formal boundary organizations are one type (Hoppe et al. 2013). The focus of boundary work as seemingly separate from a formal institution or organization may enhance its perception (and reality) of being distant from political interference, thus bolstering its potential credibility to influence science-policy efforts. By concentrating on the process itself, the alignment of different

types of knowledges from different actors (e.g., citizens, professionals, bureaucrats, experts) may be better exercised to ultimately coordinate the effective production, dissemination, and acceptability of knowledges for political decisions (Hoppe et al. 2013).

Our work provides a starting point for understanding the crucial role played by science-policy variables, but additional work is required to understand the nuances and dynamics involved within each of these processes. Academic and applied researchers should focus on exactly *how* science-policy variables result in successful science-policy integration, while investigating other explanatory variables (alone and in combination) which may also significantly influence the uptake of environmental science in policy. Finally, this work highlights the need for an updated approach toward meta-synthesis to include more qualitative approaches toward understanding the nuances involved in producing the science-policy outcomes.

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Table 3.1: Meta-synthesis Inclusion Criteria (adapted from Timulak and Creaner 2013)

Criteria	Score
1. Is there an explicit theoretical framework and/or literature review?	1
2. Are the aims and objectives clearly stated?	1
3. Is there a clear description of the context?	1
4. Is there a clear description of the sample and how it was recruited?	1
5. Is there a clear description of methods and data analysis techniques?	1
6. Are attempts made to establish the reliability or validity (credibility, trustworthiness) of data analysis?	1
7. Is the published case study peer-reviewed and from a reputable journal?	1
8. Is there inclusion of sufficient original data (such as quotes from participants) to mediate between the data and interpretation?	1
9. Is the topic focused on environmental issues at the science-policy interface?	1
10. Is there a clear description of boundary organizations and/or boundary spanning processes and outcomes?	1

Table 3.2: Formal Meta-synthesis Conceptual Framework, Features

Feature	Variables	Description
Formality	**F1: Formality**	**F1:** The BO and/or BSP occurred through a permanent formal structure utilized for bridging science and policy
Multi-disciplinary	**F2: Multi-disciplinary Organization or Expertise**	**F2:** BO and/or BSP is interdisciplinary, transdisciplinary, and/or multi-disciplinary (i.e., spanning is composed of various individuals from a variety of professional disciplines)
Legislated	**F3: Legislative mandate**	**F3:** Legislation mandated the creation or utilization of a BO and/or BSP
Scale: The scale at which BSP was carried out	**F4: Local**	**F4:** BSP occurred at the local (district or lower) level
	F5: State	**F5:** BSP occurred at state level (state-wide)
	F6: Regional	**F6:** BO BSP occurred at an interstate-state (regional) level
	F7: National	**F7:** BSP occurred at the national level
	F8: International	**F8:** BSP occurred at the international level
Funding Source: The source of funding for BO and/or BSP	**F9: Public**	**F9:** BO and/or BSP funded through taxpayer dollars (i.e., grants)
	F10: Industry	**F10:** BO and/or BSP funded through an industry involved with science-policy issue in case study
	F11: Foundation	**F11:** BO and/or BSP funded through foundations
	F12: Funding Allocating Body/Action	**F12:** BO involved in the case study operated as a funding allocating body to fund research and/or science-policy actions

Table 3.3: Formal Meta-synthesis Conceptual Framework, Strategies

Strategy	Variable	Description
Boundary Organization	S1: Utilized boundary organization	S1: A BO is utilized at the science-policy interface
Boundary Spanner	S2: Utilized boundary spanner	S2: A boundary spanner, with or without the use of a BO, is utilized at the science-policy interface
Co-production[12]	S3: Co-production of knowledge	S3: The research agenda was shaped in an ongoing, iterative fashion between scientists and policymakers
	S4: Facilitation of co-production of knowledge	S4: BO and/or BSP facilitated the co-production of knowledge between scientists and policymakers
	S5: Creation of boundary object	S5: BO and/or BSP helped scientists and policymakers co-create a boundary object
	S6: Created conditions conducive to learning	S6: BO and/or BSP utilized specialized learning techniques (experiential and/or social learning) to aid scientists and policymakers interacting at the boundary
Informal[13]	S7: Relationship and social capital building	S7: BO and/or BSP facilitated interpersonal relationships beyond knowledge content (e.g., co-production of knowledge) to build effective science-policy interactions
	S8: Built a political constituency	S8: BO and/or BSP actively networked to build informal political capital to gain support for policy issue
Media	S9: Mass media involvement	S9: BO and/or BSP actively involved mass media to build support for policy decision among the public
Saliency[14]	S10: Decision-aids developed by scientist	S10: Scientists (either working for a BO or independent from a BO or BSP) created a source of information (e.g., map, database, model, etc.) to aid decision-making
	S11: Created scientific advisory group	S11: BO and/or BSP created external scientific advisory group to aid science-policy decision making processes
	S12: Adapted research (scale)	S12: BO and/or BSP aided scientists and/or policymakers to adapt the scientific research to the scale of a specific environmental policy decision
	S13: Adapted research (scope)	S13: BO and/or BSP aided scientists and/or policymakers to adapt the scope of scientific research to better inform the specific environmental policy decision

[12] Co-production was defined as knowledge is co-produced by scientists and policymakers (Jasanoff, 2004).
[13] Informality was defined as inter-personal, relationship driven contact and/or networking during science-policy process (Lemos and Morehouse, 2005; Otronen, 2003).
[14] Saliency was defined as when a boundary organization or spanning process engaged in activities designed to enhance the "relevance of the assessment to the needs of decision makers" (Cash 2003:8086).

	S14: Systematic engagement with local knowledge and perspectives	S14: BO and/or BSP gathered local perspectives (i.e., community, indigenous, etc.) to aid scientists and policymakers involved in decision-making processes
	S15: Engaged in adaptive management	S15: BO and/or BSP engaged in adaptive management techniques (continuous monitoring, evaluation, and adjustment of science and subsequent policy recommendations) to enhance research uptake
	S16: Government involvement	S16: BO and/or BSP actively involved government entities/agencies, distinct from decisionmakers, to aid science-policy process
Legitimacy[15]	S17: Scientific knowledge dissemination	S17: BO and/or BSP delivered scientific information (i.e., presentations, reports, etc.) to policymakers during decision-making process
	S18: Managed scientific uncertainty	S18: BO and/or BSP worked alongside scientists and policymakers to manage the scientific uncertainty associated with the environmental science utilized for case study
	S19: Enhanced transparency (research)	S19: BO and/or BSP worked to enhance transparency of research methods and data
	S20: Joint visits to research sites	S20: BO and/or BSP structured and facilitated visits for policymakers to research site to enhance their understanding of the research/evidence
	S21: Dissemination of research/data to public	S21: Research/Data was delivered to the general public by either scientists, members of BO, or policymakers
Credibility[16]	S22: Conflict resolution	S22: BO and/or BSP provided traditional conflict resolution techniques (i.e., forcing, collaborating, compromising, smoothing) during interactions between scientists and policymakers
	S23: Skill development	S23: BO and/or BSP provided skill training and development for policymakers and/or scientists to enhance science-policy interaction
	S24: Systematic research evaluation	S24: BO and/or BSP systematically evaluated research utilized during spanning process to check against political biases

[15] Legitimacy was defined as when a boundary organization or spanning process engaged in activities aiming to create the "perception that the production of information and technology has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of opposing views and interests" (Cash 2003:8086).

[16] Credibility was defined as when a boundary organization or spanning process engaged in activities to enhance and/or communicate the "scientific adequacy of the technical evidence and arguments" (Cash 2003:8086).

	S25: Enhanced transparency (process)	S25: BO and/or BSP worked to enhance transparency of BSP
	S26: Systematic spanning process evaluation	S26: BO and/or BSP systematically evaluated spanning processes between scientists and policymakers to check against bias

Table 3.4: Formal Meta-synthesis Conceptual Framework, Other

Other	Variables	Description
Policy Window	**Oth1: Window of policy opportunity existed**	**Oth1:** BO and/or BSP capitalized on a window of opportunity for action to be taken on environmental issue at hand (Kingdon, 1995)
Type of Science Utilized	**Oth2: Social Science Only**	**Oth2:** Science-policy interface draws *only* on social science (i.e., political science, geography, demography, psychology, sociology, anthropology, history, linguistics)
	Oth3: Economics Only	**Oth3:** Science-policy interface draws *only* on economic science
	Oth4: Biophysical Science Only	**Oth4:** Science-policy interface draws *only* on biophysical science (i.e., biology, chemistry, engineering, computer science, mathematics, physics)
	Oth5: Mixed Evidence/methods	**Oth5:** Science-policy interface draws on multiple forms of disciplinary expertise
	Oth6: Quantitative Only	**Oth6:** Science-policy interface draws *only* on quantitative evidence (statistical, mathematical, and/or computational data techniques or models)
	Oth7: Qualitative Only	**Oth7:** Science-policy interface draws *only* on qualitative evidence (interviews, observation, and/or archival techniques)

Table 3.5: Formal Meta-synthesis Conceptual Framework, Outcomes

Outcomes:	Variables	Description
Awareness	**O1: Awareness among policymakers**	**O1:** Awareness of scientific issue among policymakers was increased due to BO involvement and/or through BSP
Awareness	**O2: Awareness among public**	**O2:** Awareness of scientific issue among the general public was increased due to BO involvement and/or through BSP
Government Committee	**O3: Creation of governmental committee**	**O3:** A special committee was created by government to handle science-policy issue in case study, due to the direct involvement of BO and/or through BSP
Judicial	**O4: Evidence of judicial impact**	**O4:** The environmental science brought to the table during the BSP was utilized during court proceedings
Judicial	**O5: Evidence of judicial impact**	**O5:** The environmental science brought to the table during the BSP influenced court decisions
Executive Order	**O6: Evidence of executive order impact**	**O6:** The environmental science brought to the table during the BSP shaped executive orders
Legislative	**O7: Evidence of legislative impact**	**O7:** The environmental science brought to the table during the BSP shaped environmental legislation
Implementation	**O8: Evidence of implementation**	**O8:** The pieces of legislation influenced by the BSP were implemented

Table 3.6: Results, Two-way Explanatory Variables and Science-Policy Outcomes

Outcome	Predictor	%Predictor = 0 with Outcome = 1	%Predictor = 1 with Outcome = 1	Gamma	Chi-square Test P-value	Fisher Exact Test P-value
O1	*F10*	100.0%	69.2%	-1.000	N/A	0.009
O1	*S13*	50.0%	94.3%	0.886	N/A	0.045
O1	*S15*	70.0%	96.6%	0.846	N/A	0.045
O1	*S17*	33.3%	94.4%	0.943	N/A	0.023
O2	*F4*	33.3%	66.7%	0.600	0.042	0.055
O2	*S9*	33.3%	66.7%	0.600	0.042	0.055
O2	*S21*	23.1%	69.2%	0.765	0.006	0.015
O3	*F7*	17.6%	59.1%	0.742	0.009	0.020
O3	*S1*	0.0%	51.6%	1.000	N/A	0.012
O3	*S9*	20.0%	54.2%	0.651	0.035	0.049
O3	*S14*	13.3%	58.3%	0.802	0.005	0.008
O3	*S18*	10.0%	51.7%	0.812	N/A	0.028
O3	*S20*	15.4%	53.8%	0.730	0.021	0.037
O3	*S22*	21.1%	60.0%	0.698	0.013	0.022
O6	*F5*	0.0%	30.0%	1.000	N/A	0.020
O7	*F7*	29.4%	68.2%	0.674	0.016	0.025
O7	*F8*	36.0%	78.6%	0.734	0.011	0.019
O7	*S25*	37.0%	83.3%	0.789	0.008	0.014
O7	*Oth8*	81.3%	30.4%	-0.817	0.002	0.003
O8	*F7*	23.5%	59.1%	0.649	0.026	0.050
O8	*Oth8*	68.8%	26.1%	-0.724	0.008	0.011

Table 3.7: Results, Logistic Regression Predictors and Science-policy Outcomes

Outcome	*Predictors*	*Likelihood Ratio* χ^2	*Df*	*P-value*
O1	*S10-S16*	15.736	7	0.028
O3	*S10-S16*	15.752	7	0.027
O3	*S17-S21*	14.615	5	0.012
O3	*S22-S27*	15.278	6	0.018
O7	*S10-S16*	14.357	7	0.045
O8	*S10-S16*	14.156	7	0.048

CHAPTER 4

THE POLICY PROCESS: A CRITICAL ASSESSMENT OF WATER POLICY MAKING IN THE STATE OF GEORGIA[17]

[17] Jensen-Ryan, D., German, L., and McDowell, R. To be submitted to *Environmental Science & Policy.*

Abstract

Attempts to address environmental problems often lead to diverse conclusions and dissension, rather than agreement. In an effort to clarify differences that occur during policy processes, scholars have advanced alternative policy theories explaining the political process. Competing theories focus on instrumental, political, and critical conceptions of policy processes. The instrumental (or means-end) conception stems from the notion of rationality while political-based policy theories seek to understand political struggles of policy processes. Critical policy theories investigate both the rational *and* the political through a focus on actors and wider interests involved in political spheres.

To advance our understanding of the political processes at play in contentious environmental arenas, we examined how water policy was made in the State of Georgia and the policy factors significant in influencing policy trajectories. Georgia presents an ideal setting to explore the science-policy interface, particularly with regard to water issues. The "Tri-state Water Wars" (between Alabama, Georgia and Florida), tensions over water use between Georgia, Tennessee and South Carolina, and increased environmental variability due to the effects of global climate change, have created tremendous and growing pressure on water resources in the state. These issues, combined with population growth in metro Atlanta, persistent droughts starting in the early 2000s, and increased demand for agricultural water use in southern Georgia have prompted dramatic reevaluations of Georgia's water management and allocation systems.

This paper utilized an ethnographic approach to provide an in-depth analysis of three water policy case studies in the state. Our findings support the conception of policy through critical-based political theories rather than purely instrumental and political theoretical lenses, as

evidence of a web of multifaceted dynamic policy processes and influences structure water policy decisions in Georgia. Although hundreds of individuals and stakeholder groups were involved in the state of Georgia in each water case study, only those associated with agricultural, industrial, and governmental entities significantly influenced water policy efforts. The handful of stakeholder groups who structure water policy decisions in Georgia provide a deeply embedded power core. Though formal institutions and roles provided a structure for interaction, established systems of social and informal relationships within, among, and outside of various institutional capacities (i.e., GAEPD, legislature) ultimately shaped each water policy case study.

INDEX WORDS: Water, Critical Policy Analysis, Georgia, United States, Social Capital, Informal Hierarchy

Introduction

The policy process is often discussed as a means to alleviate "wicked problems," particularly those focused on environmental issues (Balint, et al., 2011). "Wicked problems" exist when: (1) the extent of the problem is not known; (2) conflicting solutions exist toward alleviating the problem; and (3) the issue will never be totally solved (Bason, 2010). Attempts to address environmental issues typically result in diverse conclusions, with information and modes of policy making leading to dissension rather than agreement. These differences represent a critical part of policy research, with scholars utilizing alternative theories to explain political processes (Kahan et al., 2012). The literature is divided as to the key factors shaping policy processes. Do decision-makers carefully evaluate alternative policy solutions rationally? Are policy arenas governed more by political and informal factors embedded within existing systems? Or, do various political factors create a web of influences during decisionmaking processes?

To explore the relative influence of different policy influence in contentious environmental arenas, we employed ethnographic methods to examine how water policy was created in the State of Georgia and the extent to which various factors significantly influence policy trajectories. The state presented an ideal setting to explore environmental policymaking given the imbalance between water abundance and pervasive water shortages and conflicts. Georgia receives 50 inches of annual precipitation on average, is drained by 14 major river systems and is underlain by seven highly productive groundwater aquifers (GAEPD, 2011; Kundell and Tetens, 1998). Yet despite abundant water resources, problems exist where demands fueled by population and economic growth, intense agricultural irrigation, as well as ongoing interstate litigation pressure Georgia's water supply (Kundell and Tetens, 1998; Campana, 2012;

Mullen, 2011). These issues, coupled with persistent droughts and ongoing "Tri-state Water Wars" (between Georgia, Alabama, and Florida), have brought water issues to the forefront of environmental policymaking in the state (Campana et al. 2012; CVIOG 2006; Seager et al. 2009). To address water issues, Georgia continues to re-evaluate its law and policy governing water allocation to ensure that its water resources are allocated fairly and efficiently in the years to come (Fortuna, 2004). Three key issues have featured prominently in these debates: groundwater withdrawals, riparian buffers, and statewide water planning efforts. Through statewide, regional, and local planning processes, stakeholders provided input as to how water resources should be governed in Georgia.

Yet, divisions exists as to which stakeholders can access water planning arenas and questions remain as to how stakeholder access influences water decisionmaking efforts in the state (Kundell and Tetens, 1998; CVIOG, 2006). We focused our research on how water planning is carried out in the state and which factors and stakeholders are most influential in the process. We posed the following research question: "*How is water planning exercised in Georgia, and which contextual factors and stakeholders significantly influence panning trajectories?"* To address this question, we provide an in-depth investigation of three water policy case studies: groundwater withdrawals, riparian buffers, and statewide water planning. In particular, we focused our research efforts on key issues within the water planning arenas including groundwater moratoriums, riparian buffer variances, and the Comprehensive Statewide Water Plan (2008).

Following a literature review to describe the theoretical framings of our research and a brief history of water policy in Georgia, we present the methodology. Results highlighting the factors and stakeholders significantly involved in each water case study and general features of

the policy process in Georgia follow. Our results are further distilled and related back to key policy literature in the discussion. Finally, we provide concluding thoughts and recommendations for future actions.

Literature Review

Alternative Theories of the Policy Process

A review follows providing background of policy processes, with a particular focus on instrumental, political, and critical theories.

Instrumental Conceptions: Policy-making as a Rational, Means-End Process

Instrumental notions of the policy process are typically traced back to Lasswell's (1951) application of the social sciences to address the needs of policymakers. For Lasswell, policy decisions were pragmatic; the future is, to some degree, both predictable and anticipated; a problem is discovered, information is gathered and analyzed, alternatives are assessed, and policy makers render a decision that reflects a rational response to the problem at hand (Herbert, 1976; Field, 2007). This pragmatic or instrumental approach influenced mainstream policy research for decades, which focused on how different societal problems (e.g., crime rate, traffic congestion, employment, etc.) shape policies and policy outcomes (Stokey and Zeckhauser, 1978; Munger, 2000).

The instrumental (means-end) conception of the policy process ultimately stems from the notion of rationality, in which determining the appropriateness of a given policy is a matter of determining whether it efficiently and effectively accomplishes given goals (Thacher, 2004). From this perspective, static rational policies should be effective in managing the issues of concern (Herbert, 1976; Swanson and Bhadwel, 2009). Yet, instrumental political theories are critiqued first and foremost, for the linearity of the policy process, as scholars note the significant

back-and-forth which commonly occurs between various stages of policy action (Field, 2007). In addition, rational theories may disregard the main actors and how they influence events, while omitting an analysis of the political struggles that may take place within and between various stages of policy making (Carney, 2015). Other conceptions of the policy process have emerged to address these gaps.

Political Theories of the Policy Process

Due to the realization that actors often act for their own benefit during political processes, more politically centered policy theories emerged (Tullock, 1965). The functional political theory of policy making conceives of the process as iterative cycles, in which a series of events or activities, arranged in sequence, form feedback loops in which policies are created, implemented and then contested. This model assumes "the policy process is an ongoing struggle where the campaigns and battles wax and wane but never really stop" (Field, 2007:42). Deconstructing the functional policy cycle, the pluralist political theory examines a diversity of interests and groups and how competing interests result in some sort of compromise (Dahl, 1961). Transactive political theories build upon the pluralist model and explore how stakeholders contend for influence over public decisions (Friedmann, 1981), for example through short-term exchange relationships or interactions (Hillman and Hitt, 1999). This theory assumes political entities formulate political strategies only in response to specific, salient public policy issues (Gotz, 1993).

Although the aforementioned political theories attempt to uncover stakeholder interests and influence, other scholars have noted how they do little to determine who exerts greatest influence over time as well as why and how power is wielded (Field, 2007). Elite political theory delves into power dynamics by presupposing that small groups of well-connected people are able

to ultimately bias political results in ways that serve their particular interests (Hunter, 1953). This theory takes a longer-term view, exploring how political groups form and exert power over time (Hillman and Hitt, 1999).

Those critical of political theories note that they generally fail to acknowledge formal structures (e.g., institutional, governmental, etc.) and larger, contextual factors and issues (e.g., environmental, health, economic, etc.) that may also impact policy decisions. They are also critiqued as "vague and unsystematic 'political' research loaded with implicit causality and value judgements, and not subject to exposure or dissection" (Carley, 2013:7).

Critical Policy Theories

Critical policy theories provide an in-depth focus on underlying influences (both rational and political) structuring policy decisions—investigating both political actors and wider interests involved in political spheres (Peck and Theodore, 2010). Thus, critical policy analysis is inspired by the Lasswellian tradition (instrumental) *and* by a desire to speak truth to power (political) (Orsini and Smith, 2010).). It acknowledges policy formation is a socially constructed process, visualized as a field of adaptive connections, deeply structured by enduring power relations and shifting ideological alignments (Peck and Theodore, 2010). Policy actors are not conceptualized as lone entities, but as "embodied members of epistemic, expert, and practice communities" who are sociologically complex actors, located in shifting organizational and political fields (Peck and Theodore, 2010:170). This view toward policymaking focuses on the "mobility and mutation" of ideas and political techniques as they transform between various jurisdictions.

Employing a critical perspective, adherence to one policy perspective is rejected in favor of the view that policy making is a web of multifaceted dynamic influences, which sway with political momentum (Field, 2007). Rather than comparing secondary resources as detailed

through media, legal, and archival material, the critical policy perspective incorporates frames of analysis, which focus directly on primary sources; gathering firsthand information about the policy processes at play during specific policy actions (Peck and Theodore, 2010

Social capital theories further inform critical policy analysis includes which describes "relations of trust, reciprocity, and exchange; the evolution of common rules; and the role of networks" (Adger, 2003:389). While the notion of social capital itself is rather apolitical, its uptake by critical policy studies illustrates its crucial role within the political process. Within the policy process, social capital emerges from individuals' investment in social relations, and how these relationships are utilized to access and mobilize resources to influence policymaking. Thus, the social connections (e.g., the number of ties, the strength of the ties, and the resources ''owned'' by those ties) and how individuals mobilize resources through these connections to gain and exert political influence (Boxman et al., 1991) are examined. A social capital lens further elucidates how individuals gain access to novel information or opportunities by strategically bridging ''structural holes'' in and across policy networks (Burt, 2004). The related field of informal hierarchy studies highlights the patterning in social relations with additional attention to how interpersonal relationships, actor perceptions and power dynamics shape relations of influence between actors (Diefenbach and Sillince, 2011) while contributing to social relationships of dominance and subordination in official and unofficial systems (Magee and Galinsky, 2008). Applying a more critical lens to policy analysis is important as policy scholars argue social and informal processes prevail and determine much of what happens in formal democratic structures and processes (Hasanagas, 2013; Lake, 2009).

Water Policy in Georgia: An Overview

Established in 1848 (*Hendrick v. Cook*), Georgia water law adheres to the "reasonable use" doctrine which allows users to benefit (i.e., use) from water as it flows naturally across property. This system of water allocation, coined "regulated riparianism" (Dellapenna, 2002; Kundell and Tetens, 1998; Moore, 2004; Pendergrast, 2007), is governed by two factors: (1) reasonable use, and (2) any diversion cannot interfere with a downstream riparian's legitimate use of water (Kundell and Tetens, 1998; Dellapenna, 2002; Moore, 2004; Pendergrast, 2007). In addition, (1) "regulated riparianism" does not allow water to be withdrawn from a water source without a permit; (2) the rights to water are determined by the permitters, not the permittee; and (3) regulated riparian statutes contain elaborate enforcement provisions (e.g. civil and criminal penalties, injunctions, administrative orders, etc.) (Dellapenna, 2002; Kundell and Tetens, 1998). Both Georgia's Department of Natural Resources and the Environmental Protection Division oversee "regulated riparianism" in the state.

Department of Natural Resources [DNR] Board

DNR has statewide responsibilities for the management and conservation of Georgia's natural and cultural resources. DNR conducts their operations through six divisions: Coastal Resources Division; Environmental Protection Division; Historic Preservation Division; Law Enforcement Division; Parks, Recreation & Historic Sites Division; and the Wildlife Resources Division. Overseeing the six divisions is the Board of DNR which consists of one member from each congressional districts in the state and "five members from the state at large, one of whom must be from one of the following named counties: Chatham, Bryan, Liberty, McIntosh, Glynn, or Camden" (Constitution of the State of Georgia, Article IV, Section VI). Georgia's Constitution states that the 19 members of DNR's Board, appointed by the Governor and

confirmed by the Georgia Senate,[18] "shall be representative of all areas and functions encompassed within the Department of Natural Resources" (Constitution of the State of Georgia, Article IV, Section VI). With all but one of these individuals being a President, Vice President, or head of a highly successful industrial company or consultancy firm, current DNR Board appointees are heavily weighted toward industry. The outlier was a former lawyer for King & Spalding and is currently adjunct professor at Mercer University School of Law. The appointed DNR Board consists of 16 white males, two white females, and one non-white male.

The Board of DNR oversees the operations of each division and rulemaking for the agency. They are responsible for creating administrative rules ranging from air and water quality to hunting seasons, and provide input into issues such as budget recommendations and legislative initiatives, meeting 10 times a year to complete their work (Georgia DNR, 2017). Georgia's DNR Board plays a particularly influential role in water policy and planning issues as they oversee budget and rulemaking for the Environmental Protection Division (GAEPD), the state agency charged with managing Georgia's water.

Georgia's Environmental Protection Division [GAEPD]

GAEPD is charged with protecting Georgia's air, land, and water resources through the authority of state and federal environmental statutes (GAEPD, 2016). GAEPD administers 26 state environmental laws that regulate public and private facilities in the areas of air quality,

[18] Georgia's Board of DNR includes: Duncan Johnson, Jr. (Chairman, Johnson Motor Company), S. Aaron McWhorter (Vice Chairman, North Georgia Turf and Sports Turf, Inc.), Jeff Sinyard (Secretary, Adams Exterminators), Nancy Addison (Health Services Center), William Bagwell, Jr. (Homestead Investments, LLC), Dwight Davis (retired attorney and current adjunct professor at Mercer University Law School), Dwight Evans (Pendleton Consultant Group), Alfred Jones III (Sea Island Acquisitions), Ray Lambert, Jr. (Lambert Company), Robert Leebern, Jr. (Troutman Sanders Strategies), J. Mark Mobley Jr. (Mobley Gin Company), Thomas Phelps Jr. (Home South Communities Construction), Matthew Sawhill (Atlanta Gas and Light), Paul Shailendra (SG Property Services), Winburn Steward, Jr. (Bibb Distributing Co.), Miki Thomaston (Rayonier Advanced Materials), Philip Watt, M.D. (Southeast Asset Advisors), Philip Wilheit, Jr. (Wilheit Packaging), Delos Yancey III (State Mutual Insurance Company).

water quality, hazardous waste, water supply, solid waste, surface mining, underground storage tanks, and others. GAEPD is also responsible for administering programs under four federal laws: the Clean Air Act, the Resource Conservation and Recovery Act, the Safe Drinking Water Act and the Clean Water Act.

The Director and Deputy Director of GAEPD are appointed by Georgia's Governor and affirmed (through majority vote) by DNR's Board.[19] The Director and Deputy Director lead GAEPD in developing and enforcing rules based on Georgia (Official Code of Georgia Annotated, or OCGA) statutes. Any proposed new rules and changes to existing rules must be presented to the Board of DNR for consideration. GAEPD also issues and enforces all state permits in these areas and has full delegation for federal environmental permits except Section 404 (wetland) permits. Finally, the GAEPD, under Chapter 391-3-7, is also able to certify Local Issuing Authorities (LIAs) (391-3-7.09) for a city or county which demonstrates compliance with the provisions in O.C.G.A. 12-7-8(a) (Title 12: Conservation and Natural Resources, Chapter 7: Erosion and Sedimentation Control) (e.g., qualified inspection personnel). Any county or municipality which is certified pursuant to these rules and regulations and O.C.G.A. 12-7-8(a) can operate as a LIA, and thus the enforcing authority for O.C.G.A.12-7-8(a).

Though "regulated riparianism" governs water use in Georgia, with DNR and GAEPD overseeing water issues and regulations, glaring omissions in regulation have led to extensive water concerns in the state, particularly regarding groundwater, surface water, and statewide water planning efforts. For example, at various points in Georgia's history, laws regulating groundwater use have not adequately protected groundwater supply or users; thus, groundwater moratoriums have been issued by GAEPD to restrict groundwater use in areas and aquifers most

[19] In May of 2017, Richard Dunn is Georgia's Director of GAEPD and Lauren Curry is Georgia's Deputy Director of GAEPD.

threatened by over-use. In addition, a lack of uniformity due to vagueness in statewide surface riparian law exists which create contentious debates regarding riparian issues throughout the state. The "Tri-state Water Wars," tensions over water use between Tennessee and South Carolina, and increased environmental variability due to the effects of global climate change, have also created tremendous and growing pressure on statewide water resources (Fortuna, 2010). These issues, combined with population growth in metro Atlanta, persistent droughts in the early 2000s, and increased demand for agricultural water use in southern Georgia, have prompted dramatic reevaluations of Georgia's statewide water management and allocation systems (Fortuna, 2010). Policy debates surrounding water in the state have centered on three key policy issues: regulation of groundwater withdrawals, riparian variances, and statewide water management. We provide a brief introduction to each of these policy processes below.

Regulation of Groundwater Withdrawals

Landowners in Georgia were historically granted absolute ownership of all groundwater under their property (Fortuna, 2014). However, given the common pool nature of the resource, absolute ownership led to over-exploitation and created a situation where it was to the landowner's advantage to withdraw as much water as possible (Dellapenna, 2002). In reaction to groundwater over-exploitation, the Georgia Assembly enacted two statutes to better manage groundwater in Georgia: The Groundwater Use Act of 1972 and a 1977 amendment to the Water Quality Protection Act of 1964. These statutes, in their amended form, remain in effect today and require any water user who withdraws more than 100,000 gallons of water per day on a monthly average to first obtain a permit from GAEPD.

Despite these statutes, substantial concerns over groundwater use in Georgia remain, primarily due to agricultural water use (Kundell and Tetens, 1998). To help address these

concerns legislation was enacted in 1988 to establish a permit mechanism for agricultural water uses. The law directed GAEPD to issue permits for irrigation water uses in excess of 100,000 gallons per day that initiated prior to July 1, 1988, and established a procedure for issuing agricultural water-use permits from 1988 onward (Kundell and Tetens, 1998). Between 1988 and 1992, more than 15,000 farm-use permits were issued for those applicants who had been irrigating prior to July 1, 1988. The rate of permit application, review, and issuance slowed significantly until the announcement of a likely permit moratorium in the lower Flint River Basin (discussed below) in October 1999 caused a sharp increase in application submission (Couch and McDowell, 2006, p. 39-40). Currently, there are more than 20,000 farm-use water permits in Georgia, the vast majority of which are in southern Georgia (CVIOG, 2006).

Unlike other water use permits in the state, farm-use water permits have no reporting requirements, no expiration, and may be transferred or assigned to subsequent owners of lands that are the subjects of such permits (Kundell and Tetens, 1998). Farm-use permits may not be cancelled or withdrawn after initial use has commenced (Kundell and Tetens, 1998). They are not issued based on actual intended or measured water use; rather, they are issued based on an irrigation system's proposed maximum rated pump capacity (Kundell and Tetens, 1998). Permittees are therefore allowed to use far more water than they actually do (O.C.G.A. § 12-5-31(k)(3)(m) & (n)).

Increased inter-state tensions over salt water intrusion on Hilton Head Island, South Carolina (CVIOG 2006; Kundell and Tetens 1998), persistent and more frequent droughts in Georgia (Campana 2012), and heightened demand for agricultural water in southern Georgia (Fortuna 2010), have led to growing concerns of how to effectively regulate groundwater withdrawals. Concerns over groundwater use in southern Georgia led to the inclusion of

groundwater moratoriums in our study. Though we briefly explore the history of groundwater regulations in Georgia, our research focuses on groundwater moratoriums; in particular, the 2012 moratorium issued by GAEPD Director Judson H. ("Jud") Turner, with the support of Governor Nathan Deal.

Surface Water Riparian Protections

Georgia riparian protection is mandated by several state laws: the Metropolitan River Protection Act of 1973, the Erosion and Sedimentation Act of 1975, the Georgia Planning Act of 1989, the Mountain and River Corridor Protection Act of 2010, and. All require that local governments with riparian areas in its jurisdiction develop plans and ordinances consistent with the laws and with minimum standards issued by the GAEPD. Guiding riparian protection, first and foremost, is the Georgia Erosion and Sedimentation Act (O.C.G.A. 12-7) and its subsequent amendments that require that primary and secondary trout streams maintain an undisturbed riparian buffer of 50 feet and all other streams maintain a minimum buffer of 25 feet. [20] The Metropolitan River Protection Act (O.C.G.A. 12-5-440-457) applies to all metropolitan areas with a population of more than 1,000,000 which have a major stream that provides more than 40% of the public water supply. No land-disturbing activities may occur in the 35 foot riparian buffer along the main stem of the Chattahoochee River and along all tributaries within 2,000 feet of the river (O.C.G.A. 12-5-440-457).

A lack of uniformity in riparian law leads to local governments independently creating riparian regulations, which creates contentious debates regarding riparian issues throughout the state (Wenger and Fowler, 2000). At the center of these debates are riparian buffer width, aquatic habitat protection, water quantity and quality, issues surrounding the definition of wrested

[20] Georgia Code of Law (O.C.G.A. 12-7-3(2)) describes stream buffers as measured horizontally from the point where vegetation has been wrested by "normal stream flow" or "wave action."

vegetation and applications for riparian variances (exemptions from current riparian buffer laws). Around 220 variance applications are received annually by GAEPD[21] (Georgia Soil and Water Conservation Commission, 2016) with past research determining variances are granted more than 85% of the time (Champagne and Boden, 2003). Due to the identification of variances as the key issue regarding riparian protections in Georgia, our research focused on the history, policy process, and major stakeholders involved with variances as they emerged in legislation (originally entitled "Minimal Requirements" in 1977) through the present day.

Comprehensive Statewide Water Plan

The Comprehensive Statewide Water Plan (SWP) provides the basis for the reevaluation of Georgia's statewide water planning efforts (SWP, 2008). The SWP focused on three interconnected water issues: (1) water conservation, (2) water quantity, and (3) water quality (SWP, 2008). To help address these issues, the SWP provided a framework to measure water resources, forecast how much water supply would be needed to support future growth, and identify regional solutions to address any gaps that emerged between water supply and future demand (Georgia Comprehensive State-wide Water Plan 2008). Due to Georgia's recent efforts at statewide water planning, our final case study focuses on the Georgia Comprehensive Statewide Water Plan (SWP) of 2008 detailing how state water planning arose and the major stakeholders involved in the process.

Methodology

Case Study Selection

[21] GAEPD has 60 days to provide written comment to variance applicants or issue a variance. The public in Georgia has 30 days to provide written comments on proposed buffer variances (Georgia Soil and Water Conservation Commission, 2016).

Given the extent and complexity of water issues in the state of Georgia, and the need to focus on a few of these issues to effectively analyze political processes and wider influences on decision-making, three water case studies were chosen for our ethnographic inquiry. The primary criterion for case study selection was case diversity, so as to maximize contrast in key variables hypothesized to significantly shape findings. These included:

1. Cases that concluded favorably and unfavorably with respect to safeguarding key environmental qualities or processes (as determined by water stakeholders in Georgia);
2. Cases that are already resolved and those that remain unresolved despite concerted efforts to address them; and
3. Cases with varying degrees of contentiousness.

This process led to the prioritization of three case studies: groundwater use, riparian protection along surface water bodies, and statewide water planning. A summary of the three case studies is provided in Table 4.1.

Data Collection

Due to the multi-sited nature of this research (Marcus, 1995; Pollard, 2004), the difficulty of understanding policy processes exclusively through formal documentation, and the need for "thick description" (Geertz, 1973) of case studies, we utilized qualitative, ethnographic methods to gather data. Methods included semi-structured interviews and focus groups (Spradley, 1979), document review (Scott, 2006), media analysis (Gould, 2004), and a questionnaire (Dillman, 2000). Research and data collection occurred over a 9-month period between August 2015 and May 2016.

Interviews and Focus Groups

Overall, we conducted 81 individual interviews and three focus groups with a total of 12 participants. We utilized a semi-structured interview process (Bernard, 2011) and conducted interviews with a representative cross-section of policymakers, scientists, consultants, government agency employees, environmental group advocates, and other local stakeholders. While individual interviews covered all case studies, the three focus groups focused on the Statewide Water Planning process—with one group also focusing on groundwater moratoriums. Figure 4.1 provides information on the people interviewed for this research. Overall, 37% represented environmental consultants, 31% represented scientists, 18% represented industry affiliates, 8% represented representatives of environmental groups, 6% represented policymakers. A standard semi-structured interview protocol was customized for each respondent (i.e., policymaker, scientist, NGO employee, etc.). Each interview focused on themes associated with the chronology of the case study (with an emphasis on major events), the information utilized to inform decision-making within each case study, policy outcomes, and political influences. All interviews took place in line with accepted Institutional Review Board informed consent procedures and were transcribed verbatim from audio-recording.

Document Review

We also reviewed archival materials to understand the circumstances and discourses surrounding each water policy case study and to understand the historical context in which each case study occurred (Harrison, 2001). Guiding questions for the document review (Appendix H) were adapted from Scott (2006) with a focus on basic questions of political involvement and more in-depth theoretical questions. Private (e.g., email, memos, letters) and official public documents were also reviewed (e.g., reports, press releases, regulations, archives). Private and

official documents needed for the study that were inaccessible during research or from interview subjects were retrieved through the Georgia Open Records Act (2012).[22]

Media Analysis

We also conducted a media analysis as media (1) drives policy discourse (Hammond, 2004), (2) filters the opinions of policy actors (Andsager, 2000; Boykoff, 2008), (3) creates the "frame" of reference for policy (Wanta and Ghanem, 2007), while (4) enabling the identification of prominent environmental discourses that structure the behavior of actors and enables and constrains policy action (Hajer, 1995). Over the period of data collection, media from news inquiries, magazines, radio programs, television clips, and governmental, nongovernmental, and non-profit news releases was gathered and analyzed. Appendix I describes how media was analyzed.

Questionnaire

The members (~200) of the 11 Regional Water Council (RWCs) were targeted for the distribution of our questionnaire. Each member is knowledgeable about groundwater, surface water, and statewide water planning as the councils provide an annual report detailing water use, management, conservation efforts, and areas for improvement for each county in Georgia. While individual interviews would have been preferred, time and funding limited this possibility. Thus, we distributed a questionnaire to each member of the (RWCs) (Appendix J); 21 were returned. These questionnaires, distributed in spring 2016 (after individual interviews were completed), were analyzed to decipher how the RWCs influenced water decisionmaking processes in the

[22] The Georgia Open Records Act details how all documents, papers, letters, maps, books, tapes, photographs, computer based or generated information, or similar material prepared and maintained or received in the course of the operation of a public office or agency are public records (§ 50-18-1). Furthermore, public records also include these items when they are received or maintained by a private person or entity on behalf of a public office or agency and that are not otherwise subject to protection from disclosure (§ 50-18-70(a)(2)).

state. Although the overall response rate was low (10.5%), qualitative analyses of the questionnaires were performed.

Analysis

Content Analysis and Grounded Theory

We analyzed all interview, focus group, questionnaire, and observational data using ethnographic content analysis (Bernard, 2011), an iterative method designed to uncover meaningful concepts and verify relationships among them (Altheide, 1996). We also utilized grounded theory coding methodology (Glaser and Strauss, 1967; Strauss and Corbin, 1990) to examine interview transcripts for emerging themes and place them into categories and sub-categories that formed the basis of empirical and theoretical arguments. Both analytical approaches were facilitated by the use of the qualitative analysis program Atlas.ti.

Results

A few key stakeholder groups were found to be at the center of water policy influence in the state. These include: Agriculture, Metro Atlanta Chamber (MAC), Gubernatorial and Legislative Nodes, the Water Council, the Board of Georgia's Department of Natural Resources (DNR), Georgia's Environmental Protection Division (GAEPD), and Industry. However, the strategies and themes associated with how these stakeholders predominantly emerged in each case study varied.

Overall, the groundwater moratorium case study revealed a deep history of laxity concerning groundwater restrictions in Georgia until overuse generates expeditious moratoriums on withdrawals—a reactive stance toward groundwater regulation in the state. From practicel, political and legal stnadpoints, Georgia's position can be summarized as follows: agricultural water use in the state should be subject to no limitations, regardless of the long-term

consequences for the Flint River Basin (Figure 4.2) (Supreme Court Decision, Special Master Lancaster, No. 142, 2017). Shaping Georgia's position toward groundwater moratoriums are powerful stakeholders groups (agricultural industry, legislators, and GAEPD) which structure whether, when, and how groundwater regulation occurs.

The results of the riparian variance case study indicated the GAPED (particularly the directors), face gubernatorial, legislative, industrial, and environmental group pressures with regard to variances. However, industrial pressures, and the tactics (i.e., lobbying and legislative connections, membership on committees, etc.) they employ offset stricter environmental recommendations, especially as variances become more legalistically-determined, and less influenced by scientific evidence.

Finally, the most significant theme our interview subjects highlighted with respect to the SWP case study was whether planning and implementation would occur at the watershed level or at the level of the county or region. A multitude of actors and stakeholders contributed to this debate; however, SWP execution occurred at the county-level with the creation of Regional Water Councils throughout the state. The process in which state water planning ideas were submitted, legislation was written, and final decisions regarding the level at which state water planning would occur ultimately flowed between and through entities representing agricultural, industrial, and legislative interests. A detailed description of the stakeholder categories involved in each case study as well as the themes associated with how stakeholders' exerted influence follows.

A (Purposefully) Forgotten Story: Georgia's Groundwater Regulation

As groundwater use studies signaled increasingly severe conjunctive impacts to surface waters in southwestern Georgia caused by agricultural water use, pre-emptive action was taken

through the issuance of a groundwater moratorium in 2012 prohibiting any new or expanded withdrawals of groundwater from the Floridan Aquifer[23] in parts of southwestern Georgia or surface water withdrawals in most of the lower of Flint River Basin (GAEPD Memo, 2012). This moratorium was issued almost exactly six years after a previous moratorium, issued in 1999 for the same area, with the same conditions, and for the same reason, was lifted (Couch and McDowell, 2006, p. 23).

Those interview subjects not associated with GAEPD suggest the 2012 moratorium was issued because the GAEPD over-allocated groundwater permits in the southern part of the state, thereby increasing the effects of drought (March 4, 2016 interview with environmental consultant). Little is known about the inner workings of the groundwater moratorium, as current employees of GAEPD declined to be interviewed about this topic and there is scant public or private documentation discussing this specific moratorium. Six individuals who retired from or left GAEPD were interviewed for this research. It is also important to note that during the time of this research, Special Master Ralph Lancaster, Jr., was appointed by the United States' Supreme Court to handle the 2013 lawsuit Florida filed against Georgia claiming that metropolitan Atlanta residents and southwest Georgia farmers harmed downstream aquatic species through water overuse.[24] Our interview subjects (and subsequent court documents) indicated several current employees of GAEPD were deposed for this court case, which suggests why they were unable and/or reluctant to participate in our research.

[23] The Floridan Aquifer is a natural water storage structure of limestone and dolomite which stretches under southern Alabama, southeastern Georgia, southern South Carolina, and all of Florida, spanning 100,000 square miles. It supports almost 10 million people as their primary source of water (both drinking and for irrigation purposes) and is one of the most productive aquifers in the world (USGS, 2016).

[24] Special Master, Ralph Lancaster, Jr., urged the Supreme Court on February 14, 2017, to reject strict new water consumption limits on Georgia. After hearing five weeks of testimony on the Florida/Georgia water lawsuit Special Master Lancaster found Florida had failed to show a consumption cap was needed in Georgia regarding water use. This finding is not final, as the Supreme Court could reject his recommendation; however, this was viewed as a victory in the long-running legal dispute (Tri-state Water Wars) between southeastern states.

Individuals who we were able to interview and who have worked on groundwater issues for decades in the state suggested that the combination of the worst drought in recent history during the 2010s and hydrologic data from the United States Geological Survey (USGS) revealed that a moratorium would improve conditions in southwest Georgia. According to one interview subject, "current levels of groundwater pumping would suck the Flint River dry" (March 4, 2016 interview with environmental consultant). In other words, this moratorium could prevent the lower Flint River and its tributaries from being drawn down excessively. This led to decisive action by GAEPD and the 2012 moratorium was issued seemingly overnight, with little transparency to the public, and to the surprise (not *that* it was issued, but *how* it was issued) of those who had worked on groundwater issues for decades (January 29, 2016 interview with a scientist). This was in stark contrast to the 1999-2006 moratorium, which was formally announced more than one month before it actually took effect, but more than six months after it had been publicly suggested (McDowell, 2005; Couch and McDowell, 2006 p. 40).

Historical Agricultural Dominance and Groundwater Withdrawals in 2012

Our results indicated this moratorium was issued, in part, due to agricultural water use. Groundwater from the Floridan aquifer in southwest Georgia supplies about 70% of the water used for irrigation. A combination of groundwater from other aquifers and surface water from the Flint River and its tributaries is used to irrigate the other 30% of farmland (Spurgeon and Mullen, 2005). Mounting scientific evidence has demonstrated that agricultural irrigation significantly impacts water flow in the Flint River and its tributaries, and groundwater reserves in the Floridan aquifer (Torak and McDowell, 1996; Jones and Torak, 2005; Spurgeon and Mullen, 2005). However, as one interview subject stated, "The farmers could take as much water out of the rivers and streams as they want to. No limits, no permits, no reporting. In drought

years, they would and still do pump the tributary streams to the Flint River dry" (December 11, 2015 interview with an environmental consultant). Indeed, streamflow data from USGS indicate that the Flint River and many of its tributaries do achieve low water levels faster and earlier in the year than they did before irrigation became common, and Spring Creek in the southwestern-most part of the basin now commonly goes dry (Couch and McDowell, 2006).

In spite of the vast amount of water used by farmers for irrigation, our results confirmed there is little to no publicly available data on the amount of water used for irrigation and/or agricultural purposes in the state of Georgia:

> "The Lower Flint has really been the focus of the irrigation problems. It was apparent that they probably over allocated the groundwater and surface water in the southern part of the state. But one of the things when the bills were passed, the Groundwater Use Act was passed and then the surface water amendments in '77, they exempted agriculture from the requirements of the law, one of which was to report your usage. So you really didn't have good data on the amount of water that was being used for irrigation purposes or agricultural purposes in general. Here EPD [GAEPD] was charged with allocating the water without knowing how much they had to allocate. It's like your checkbook… You can write checks, but you don't know how much money is in the checking account" (March 18, 2016 interview with a scientist).

Yet, good faith efforts have been made to set up an agricultural metering system in southern Georgia which would track agricultural water use. Though one interview subject discussed how authorizing agricultural metering was a drawn out and difficult political battle in the state, a widespread educational campaign (conducted by GAEPD) occurred in southern Georgia, which centered on the advantages of metering agricultural water usage. Based on the results of this

educational campaign, former State Representative Richard Royal (from Camilla, in the middle of the farm communities of the lower Flint River Basin) and former State Representative Bob Hanner (from Parrot, also in an agricultural area)—both highly trusted individuals in the agricultural community, were able to introduce legislation and have enough political capital to pass the Agricultural Water Use Measurement Program (HB 579) in the 2003 Legislative Session (March 1, 2016 interview with a legislator). According to our interview subjects, Royal and Hanner were able to garner political support for metering from farmers on the basis that they needed "hard data to combat lawsuits" (March 1, 2016 interview with a legislator). Implementing an agricultural irrigation metering program ultimately helped to bolster the claim that Georgia was acting as "good environmental stewards" while providing hard data on how much water was actually being used for agricultural purposes, rather than information which was subject to "other state interpretation" (i.e., Florida) (March 1, 2016 interview with a legislator). While metering is now in effect in Georgia, the data produced by meters remains publicly unavailable:[25] "the farmers, their water withdrawals, were not metered and they didn't want them metered…[Later on,] they put in meters, but they keep all the data private. Still, farmers are the only source who can access this data (December 15, interview with an environmental consultant)."

In spite of years of previous statutory reforms, permit moratoriums, we are only able to surmise why the 2012 groundwater moratorium was issued so abruptly and how it eventually came to fruition, those working in this area surmised *why* it occurred: to prevent the Flint River from being drawn down and facing additional effects of drought, to protect existing agricultural

[25] Georgia's agricultural metering data is collected and/or reported to the Soil and Water Conservation Commission, which reports it to GAEPD. The data is exempt from GORA requests, as it is considered to be proprietary.

groundwater permit holders, and to deflect legal challenges related to the "Tri-state Water Wars" from Florida or Alabama.

Georgia Riparian Zones: A Patchwork of Protection

Our results indicated riparian protections enshrined in Georgia state laws do not provide a uniform system of protection. Various federal and state agencies encourage the protection of stream buffers through best management practices (BMPs) on agricultural and forestry land, which may also be of greater width than those required by state law. This leads to an abundance of requirements, and some local governments find themselves with a patchwork of protected stream corridors of varying width and extent, a situation frustrating to property owners and officials (Wenger and Fowler, 2000). As mentioned, the heart of piecemeal riparian protection in Georgia rests on the issue of variances, or authorization given by the GAEPD allowing the disturbance of riparian areas within 25 feet of streambanks (or within 50 feet of trout streams).

How riparian protections in Georgia resulted in such of a lack of uniformity and ineffective riparian protection is a story that begins with former Governor Roy Barnes, then State Senator on the Senate Natural Resources Committee. Barnes reportedly introduced "at the last minute" an amendment to a bill dealing with the Erosion and Sedimentation Act which would establish a 25 foot buffer for streams and 50 foot buffer for trout streams (March 4, 2016 interview with an environmental consultant). According to an environmental consultant with decades of experience working on Georgia water issues, the business development community "erupted," heavily voicing their concerns that this would greatly damage business interests in Georgia. With two days left in this legislative session, Senator Barnes apparently stated, "'Well, we'll just have a variance from the EPD [GAEPD]', which was meant to appease the business community…There was not *10 seconds* of thought put into variances or the language in

there…not 10 seconds and it became law" (March 4, 2016 interview with an environmental consultant).

Leonard Ledbetter, then Director of the GAEPD (1965-1990), upon hearing of the passed amendment "screamed bloody murder" and stated, "the EPD [GAEPD] *cannot* manage a variance program statewide" (March 4, 2016 interview with an environmental consultant). Frequent calls were made to the GAEPD to issue variances and Ledbetter reportedly continued to stand his ground on the issue; meanwhile, "the pressure in the teakettle was building up" for the GAEPD to issue variances (March 4, 2016 interview with an environmental consultant). Ledbetter left the GAEPD as a result, and Joe Tanner stepped into his shoes as the Director of GAEPD. Tanner, an Atlanta native with a business degree from the University of Georgia, and equipped with deeply embedded knowledge of how to navigate the intricacies of local and state government (credited with procuring more than 400 pieces of major legislation in Georgia), took a different approach. Tanner began issuing variances, reportedly with "zero thought" into how the variance process should be structured and issued (March 4, 2016 interview with an environmental consultant).

According to our interview subjects, actors within GAEPD at this time were greatly concerned over whether and how to determine buffers as this would affect issuing variances. In other words, how to measure buffers "horizontally from the point where vegetation has been wrested by normal stream flow or wave action" (O.C.G.A. 12-7-3(2)) would ultimately determine whether variances were needed. If an activity would disturb riparian areas within 25 feet of streambanks (or within 50 feet of trout streams) then a variance would be required. Yet, how to determine where to measure variances remains a contentious issue in the state, as our interview subjects indicated. One environmental consultant relayed this frustration with GAEPD

when variances began being issued, "The process to get into a variance…If it was absolute, like Mr. Ledbetter wanted it, there'd be nothing to research. There'd be nothing to do. The question is when and where has EPD allowed people to encroach upon this buffer and how does that process work, where does it go? Where does the buffer apply? What is wrested vegetation? Is it a ditch? No. Is it a curb? No. Is it an intermittent stream? Well, maybe. Is it an ephemeral? Maybe" (March 4, 2016 interview with an environmental consultant). Due to the lack of criteria governing the variance process, before 2000, Champagne and Boden (2003) found that 85% of all variance requests in Georgia were granted after Ledbetter left the GAEPD. The lack of criteria governing when to issue variances also led to the formation of two important Statewide Buffer Committees which would create and handle variance rules.

Statewide Buffer Committees: Creation of Rules Governing Variances

Buffer variances remained the chief issue after Tanner left the GAEPD to start Joe Tanner & Associates (an enterprise which provides expertise to clients in handling governmental regulations and business developments—clients include Georgia Power, Metro Atlanta Chamber of Commerce, MNGWPD, various county governments, etc.). Harold Reheis, an environmental engineer, took up the issue when he began his tenure (1991-2003) as Director of the GAEPD. In 2000, Reheis created a Statewide Buffer Committee[26] to develop riparian variance policy. This committee was meant to promote a more scientific and balanced approach toward issuing variances in Georgia and was tasked with producing a "draft rule identifying the criteria to be

[26] Members of the first Statewide Buffer Committee included Dr. Rhett Jackson (Chair, University of Georgia, Warnell, School of Forestry and Natural Resources), Jimmy Alexander, (Attorney), Kyle Burrell, (U.S. Forest Service Fisheries Biologist), Rich Edinger, (Atlanta, City Engineer), Glynn Groszman (Sierra Club), Russ England (Fisheries, DNR), Simmons Watts (GAEPD), Seth Wenger (University of Georgia, River Basin Center), and Richard Lowrance (Ecologist, USDA).

utilized in considering applications for variances from the 25' state water buffer provisions" (EPD Memo, 2004).

Heavy deliberation occurred during variance committee meetings, and following the presentation of recommendations to GAEPD and the Georgia DNR Board:

> It was drafted [by GAEPD] based on a discussion. They would come back and we [GAEPD] would get to review it and edit it and…fight over it…That's where we had multiple meetings over a period of months. We would come together. We'd talk about this. They'd go back, edit, come again, edit, edit…ultimately it would be up to EPD. Because if you look at how EPD works…there's a Board of Directors that ultimately approves things. They would take it to that Board… the Georgia DNR Board. (March 21, interview with a Georgia representative)

In addition to pressure from DNR to change the variance requirements, developers throughout Georgia also reportedly complained to the legislature about the strict variance requirements produced by the first Statewide Buffer Committee. As recalled by a scientist in Georgia, "I actually served on two separate statewide buffer committees to review variances. We had one – off the top of my head I think it was like 1998, 1999 – which made it a lot stricter. Then, the developers complained to the Legislature, 'Now it's too hard.' So, there was another one that was set up in the early 2000s [2004] under Carol Couch when she was head of EPD. That one tried to relax it a little bit and trying to find a happier medium (interview on January 5, 2016). The members active on the Riparian Variance Committees also experienced a shift between the first and second iteration, as the second committee held fewer scientists and more city and industrial representatives (GAPED Memos, 2000 & 2004).[27]

[27] The Second Buffer Variance Committee membership included: Dough Baughman (CH2M-Hill Consultants), Laura Beall (Council for Quality Growth), Alice Champagne (Upper Chattahoochee River Keeper), Commissioner

The first round of recommendations of the Statewide Buffer Committees made it through EPD and were presented to the DNR Board, even though the recommendations made the process of receiving a variance more strict. However, these approved variance procedures from the 2000 Statewide Buffer Committee were amended in 2004, under the direction of then GAEPD Director, Carol Couch (Ph.D. ecologist, 2003-2009).

Our results, as well as work provided by Champagne and Boden (2003), indicate that variances are granted by GAEPD the majority of the time. One scientist who has worked on water issues for decades in Georgia agrees with this assessment and wonders why variance regulations exist if they are likely granted:

> "They took me out to a site and showed me the riparian buffer. Then, we looked at information on variances… there were 100' buffer requirements, but 99% of variance requests were granted. It was crazy. It made me angry. It made me realize…the importance of enforcement. Because I mean I was shocked at how willing EPD was to grant variances…It was a very eye-opening experience learning that it's great to have a policy, but if you're going to grant variances, then why bother having that policy? Then, it's just sort of like it makes it look good, but in truth it's not effective" (interview on February 16, 2016).

GAEPD's former director, Jud Turner (an attorney closely involved in tri-state water negotiations in the 2011-2016 period), also grappled with stream buffer variance issues. Georgia's Court of Appeals, on a 4-3 margin, reversed two separate decisions by superior courts

Steve Gooch, Michael Hussey (Fred Williams Homes), Dr. Rhett Jackson (University of Georgia), John Peterson (Glynn County Community Developer), Jay Puckhaber (Duke Reality Corporation), Butch Register (Register & Associates), Jan Sammons (GAEPD), Jim Scarborough (Deputy Director, Dept. of Public Utilities, Gwinnett), Greg Teague (City of Marietta), Joe Tichy (Northeast Georgia Regional Development Center), and David Waller (Georgia Wildlife Federation).

concerning variances issued for two stream projects by ruling that 25-foot buffers apply to *all state water*, not just those "…where vegetation has been wrested by normal flow or wave action" (OCGA 12-7-6(b)(15)(A)) (GAEPD, 2014). Additional ecological areas would be protected under this ruling, including freshwater wetlands, coastal wetlands and marshes, beaches, grassed swales, waters without clear banks, wrested vegetation, etc. (GAEPD, 2014). In contrast to this ruling, Turner released a 2014 memorandum reaffirming Georgia's more relaxed variance criteria on applying for and granting stream buffer variances, mandating that prior variance criteria be upheld by GAEPD: "EPD [GAEPD] will continue to make buffered state water determinations under existing protocols and recommends that the Local Issuing Authorities do the same" (GAEPD, 2014). Turner's memorandum maintaining existing GAEPD policy is creating additional confusion in the state, according to one interview subject:

> It's really frustrating from an educational point of view…You would think as a specialist, I would be able to tell somebody, 'This requires a buffer. This does not require a buffer.' But after having some of the people I told you say, 'I don't think this requires a buffer,' get fined for it, now all I can do is say, 'You're going to have to talk to a lawyer because I can't figure this out. I can't tell you what does require a buffer and doesn't require a buffer.' (February 2, 2016 interview with a scientist)

As a specialist concerning variances and buffers for decades, this scientist now tells clients to consult with lawyers rather than environmental experts on whether buffer variances are needed, as their scientific expertise has been rendered inferior to legal interpretations of riparian protections in Georgia.

Georgia Comprehensive Statewide Water Plan (SWP) (2008): A Protracted History

According to GAEPD, the opportunity to comprehensively address Georgia's water management with a statewide water plan began in 2001 when the Georgia General Assembly created the Joint Comprehensive Water Plan Study Committee and the Joint Study Committee (GAEPD, 2007). However, our data revealed a more nuanced process associated with the development of the SWP, a long-term initiative that steadily grew as political momentum mounted due to ongoing tensions associated with the "Tri-state Water Wars," agricultural and Metro Atlanta water usage, and intense periods of drought throughout the beginning of the 21st century.

To some extent, Georgia has engaged in statewide water planning for decades; indeed, the formal comprehensive SWP of 2008 took time and political effort to forge. The first cohesive SWPs emerged as early as the late 1980s, with a "rather limited, narrow water plan" (March 4, 2016 interview with environmental consultant) to address significant water issues faced in the state. Occurring after the drought of 1986, this early Water Plan was adopted in 1988 which passed the "7Q10, low flow" approach.[28]

Building on early water plans and conservation efforts in Georgia, Atlanta took the initiative to create their own water planning district, the Metropolitan North Georgia Water Planning District, in 2001. The water policy window to generate more statewide water policy intensified in the early 2000s as tensions with Alabama and Florida flared due to an intensive drought in Georgia which heightened disagreement (both inter- and intrastate) over the "very serious use of agricultural water" (December 11, 2015 interview with environmental consultant). This was a hot button issue, as EPD had issued more than 20,000 agricultural water use permits

[28] 7Q10, low flow approach is determined by the lowest average flows that occur for a consecutive 7-day period at the recurrence intervals of 10 years (USEPA, 1997).

by then, and there was no publicly available information on agricultural water usage (December 11, 2015 interview with an environmental consultant). During this time, Research Atlanta, a non-profit organization formed in 1971 to study public policy issues surrounding the Atlanta area, requested Dr. James Kundell, a scientist from the Carl Vinson Institute of Government at the University of Georgia to complete "a policy monograph on water" (March 18, 2016 interview with a scientist). By that time, Kundell has served as a trusted and influential environmental advisor to the General Assembly for many years. Terry DeMeo-King, an associate at the Vinson Institute who was working alongside Dr. Kundell at this time, built upon an early report they published together in 1998 entitled "Whose Water Is it Anyway?," and decided to complete a study on state water planning. Thus, they were contracted by Research Atlanta to complete a study on how other states were approaching water management (February 16, 2016 interview with a scientist). Funded by Georgia Power and Home Depot, DeMeo-King interviewed water policy heads in all 50 states and found four or five states that had looked at both water quality and quantity statewide (February 16, 2016 interview with a scientist). Nearly half of the states had reportedly said they wanted to do comprehensive water management planning, so this was identified as a clear trend in water management nationally. The state of Kansas rose to the top of the study, as they developed a state water policy document which delegated the authority to regional councils to develop water plans which then informed state water planning efforts (February 16, 2016 interview with a scientist). This nation-wide consultation process culminated in the publication in 2000 by Dr. Kundell and DeMeo-King, "Comprehensive State Water Management Plan: A Framework for Managing Georgia's Water Resources," which recommended the state of Georgia "produce a state plan that was primarily a policy

document…and have regional plans that looked more at the resource [water]" (February 16, 2016 interview with a scientist).

This report, together with the heightened water tensions in the state in the early 2000s, created a "buzz about a state water plan," and funds from the legislature were approved for the GAEPD to create a Joint Comprehensive Water Plan Study Committee and to begin studying more broadly what should be included in the SWP (December 11, 2015, interview with an environmental consultant). Stemming from his experience with water issues in the state, Dr. Kundell was given this task and he and his small team (which included a representative from the industry powerhouse Georgia Power) (February 16, interview with a scientist), traveled throughout the state of Georgia holding "workshops" where individuals were given "sticky notes and colored pieces of paper" to write down and submit ideas for issues that should be included in the state water-planning process (December 11, 2015, interview with an environmental consultant). According to our interview subjects, these recommendations were taken to a private meeting in Albany, Georgia, where Dr. Kundell, then Director of GAEPD, Harold Reheis, then Assistant Director of the GAEPD, David Word, Chairman of the Georgia House Natural Resources Committee, Rep. Bob Hanner, Rep. Richard Royal, Chairman of the Georgia House Agriculture Committee, Georgia State Rep. Tom McCall, and Gary Black, currently Commissioner of the Georgia Department of Agriculture but then Executive Director of the Georgia Agribusiness Council, discussed the recommendations. As reported by a participant in our study:

> "You get sort of where we're going here. Those three representatives who were farmers, Harold, and Jim [Dr. Kundell], and then Gary Black, who is now a Commissioner of Agriculture, met down in Merry Acres [a motel in Albany, Georgia.] Dr. Kundell, in his

> usual total competency self, brought all the suggestions, he had them categorized and organized, from everybody of all of these meetings on pieces of paper. The three legislators went through them, discussed them, put them in this stack. Put them in this garbage can. Put them over here. Changed them. Put it all together. Discussed it for a whole day around the table…When they finished, they said, '…write all this up and write us a bill.' That's the way things usually happened."

This meeting structured the first SWP bill of the 2003-2004 legislative session, which authorized the development of the planning document of the state water plan and the creation of the Water Council—a council to be created from Gubernatorial appointments to oversee the comprehensive statewide water planning process. However, the SWP of 2003 also had additional provisions for agricultural permits (October 27, 2015 interview with a scientist)—which "under the current law, and it's still the case, the Director of EPD [GAEPD] cannot deny a farmer a permit" (December 11, 2015 interview with an environmental consultant). This initial version of the SWP bill was defeated, which our interviewees argued was caused by the additional agricultural provisioning (October 27, 2015 interview with a scientist, April 7, 2016 interview with a legislator).

In 2004, the legislature successively passed the Comprehensive Statewide Water Management Planning Act as Representative Bob Hanner, then chairman of the House Natural Resources Committee, agreed to drop the agricultural provisions (April 7, 2016 interview with a legislator). The 2004 Act formally created the Water Council and provided funding for the planning process, which was driven by GAEPD and concluded in 2007. Early Water Council meetings with agency heads in Georgia supported a "deliberate, transparent, and public" state water planning process to take place over a three-year timeframe (October 27, 2015 interview

with a scientist), rather than a process completed within an agency [i.e., GAEPD] and then rolled out. Governor Perdue accepted the proposed 2004-07 time frame, even though "the Governor was wanting to move faster" (October 27, 2015 interview with a scientist). A budget of $30 million in total was reportedly used over the three years to support the development of the 2008 Comprehensive Statewide Water Plan (October 27, 2015 interview with a scientist). The budget for the SWP was a total of 31.2 million for the three years (GAEPD, 2011, Water Summit Presentation).

Statewide Water Planning Execution: The watershed- vs. county-level debate

The most significant issue our interview subjects highlighted during the 2004-2007 water planning process was how to create a statewide system in Georgia which would take into account the particularities unique to each region. This created the fundamental debate in Georgia between water stakeholders as to whether the Statewide Water Planning system would occur at the watershed level or a county level. This led to the issue of how to "create *de novo* entities in advisory processes when none existed," especially as "existing regional governmental bodies wanted to lay claim to be the central organization that actually did this [water planning], in terms of each region" (October 27, 2015 interview with a scientist).

On one side of this debate were key players that argued state water planning had to effectively "deal with the rural constituency" through establishing regionally-based water councils which would control water planning efforts in Georgia (October 27, 2015 interview with a scientist). The establishment of Regional Water Councils would ultimately support the regulatory system stemming from home rule, a deeply rooted American political practice that manifests due to the tension between local governments and the state (Sentell, 1998). Home rule counteracts the doctrine of legislative supremacy, in which local governments are upwardly

accountable to the state, dependent upon the state legislature for any powers possessed or exercised (Sentell, 1998). Local governments began infusing state constitutions, including Georgia's 1965 Constitution, with home rule provisions (Sentell, 1998) to grant local governments with specific legal powers. As those interviewed reported in this study, home rule had to be taken into account when operationalizing *how* statewide water planning would realistically occur—leading to it ultimately being formulated at the more county-level, instead of at the watershed-level.

> "The parameters of how we proceeded [with water planning] had to take into account the manner in which particularly rural power and rural power constituencies operate. Up until, I think, maybe the late 60s, Georgia's governor was elected not on popular vote, but by essentially a set of delegates from each county. The local power brokers, the sheriff, the mayor, the county commissioner, they were the guys who called the shots and who became governor. Because there are a lot more rural counties than there are urban counties, how you deal with the rural constituency became extremely important…there's a deep legacy of old-style views about that out there" (October 27, 2015 interview with a scientist).

The already established Metropolitan North Georgia Water Planning District (MNGWPD), which includes Atlanta and the surrounding 15 counties, also argued for the Regional Water Council approach toward the statewide water planning process (October 27, 2015 interview with a scientist). If the watershed approach toward managing Georgia's water was implemented, rather than the use of Regional Water Councils, this would defuse power from the MNGWPD which could have led to the dissolution of this statutory body. As one of our key interview subjects relayed, the dissolution of the MNGWPD would never happen as there was

"too much power" concentrated in the already established Atlanta Metropolitan Water Council (October 27, 2015 interview with a scientist).

On the other side of this debate were the Scientific and Engineering Advisory Panel (SEAP), a group of scientists asked by GAEPD to serve as an advisory panel to the state water planning process in Georgia, and environmental groups in Georgia which advocated for a watershed, or more "natural boundary" approach, toward managing Georgia's water (October 26, 2015 interview with a scientist). Our interview subjects reported that the power of rural constituencies and the already established MNGWPD outweighed SEAP and environmental group recommendations (October 26, 2015 interview with a scientist). They also reported that due to the more stringent scientific stance taken by members of SEAP, the scientists involved in SEAP were asked to no longer serve as advisors to the state water planning effort. In an effort to stop water planning efforts from occurring through Regional Water Councils, our interview subjects reported that environmental groups "resorted to their lobbying tactics to try and kill it" (December 11, 2015 interview with an environmental consultant) and were reportedly lobbying by telling individuals from southern Georgia that the comprehensive SWP allowed Atlanta to steal more rural agricultural water sources. While these efforts did not ultimately work to disband Regional Water Councils from materializing in the 2008 SWP, they were said to have contributed to an ongoing "myth" in Georgia of metro Atlanta "stealing" southern Georgia's agricultural water (December 15, 2015 interview with an environmental consultant).

After much back-and-forth in the 2004-2007 period about the structure of the state water planning system, the Regional Water Council approach was adopted in 2008. Thus, the RWCs were created to engage in water planning efforts with the GAEPD to conduct the water resource assessment work (December 11, 2015 interview with an environmental consultant). Members of

the RWCs are appointed by the Governor, Lieutenant Governor, and the Speaker of the Georgia House of Representatives and are to be, "diverse and broadly representative of local governments, water users, and other water-related interests in each planning region" (DNR, 2008). Membership was also to depend on the existing water-related organizations and institutions in each region as well as the characteristics of regional water resources, water uses, and regional economies. In addition, each council was to be "broadly representative to include agriculture, forestry, industry, commerce, local governments, water utilities, regional development centers, tourism, recreation and the environment" (DNR, 2008).

As reported by our interview subjects, only a handful of scientists or members of environmental groups serve on the councils (300 members total when all members are appointed), with most of the members associated with industry, government, or agricultural enterprises. As several of our interview subjects also relayed, in 2016, the "success" of the 2008 SWP remains debatable, as it does little to ensure regional water plans are actually implemented—especially as the Regional Water Councils (RWCs) lack funding to implement recommendations outlined in the regional water plans created by each region.

Discussion

Critical Policy Model: Predominant Stakeholders, Influences & Insight

In examining how water policy is made in Georgia and which contextual factors and stakeholders significantly influence policy trajectories, our qualitative analyses indicated that water policy occurred through a web of multifaceted dynamic influences, which sway with the political momentum (Peck & Theodore, 2010; Field, 2007). Water policy case studies in the state of Georgia exemplify a critical policy process in which rational, political, and more critical factors influence policymaking with the relationships between actors within, among, and

outside of various formal institutional capacities ultimately providing the greatest influence for each water policy case study in Georgia. The critical policy perspective allows a focus on *primary sources* (i.e., individuals and their actions), instead of secondary media and archival analyses. This in-depth approach toward policy analysis enabled a deeper understanding of the politics associated with each water case than is typically afforded to traditional political analyses. Through the critical policy prospective our study identified whether and how stakeholders were able to exert power through not only economic (rational and formal) means but also through embedded political and informal tactics not typically associated with political policy analyses—those centered on social capital and informal hierarchies.

The strength of political actors and coalitions and wider interests involved in water decisionmaking efforts in Georgia, and the role of certain contextual factors, were both found to be influential in shaping outcomes. The predominant stakeholder groups at the center of the web of influences were found to include: Agriculture, Metro Atlanta Chamber (MAC), Gubernatorial and Legislative Nodes, the Water Council, the Board of Georgia's Department of Natural Resources (DNR), Georgia's Environmental Protection Division (GAEPD), and Industry. Figure 4.3 displays the influential stakeholders involved in water policy efforts and their interactions. As depicted, GAPED is not connected, like the other stakeholders, through prominent political pipelines; however, our research participants did indicate GAPED is not free from political sway when making political decisions regarding water policy, even though the state agency and their mission of environmental protection is presumed as such.

Table 4.2 provides a brief description of how the predominant stakeholders involved in the three water case studies exerted influence. A broader discussion follows Table 4.2 linking key policy literatures to water policy efforts in Georgia.

Agriculture

The pervasive inclusion of agricultural interests in water policy efforts in Georgia enhanced their powerful collective voice which, as the qualitative and archival data indicated, allowed for their interests to prevail over those not present or omitted from the water policy table in the state (Lake, 2009) while also bolstering their significant involvement with the evolution of water interests—key processes through which social capital is exerted and maintained (Adger, 2003). One interview subject illuminated just how important agriculture is concerning water policy efforts in the state of Georgia: "The politics for water in Georgia ever since the 70s has been dominated by the agriculture influence in Georgia. That's why it took us so long to bring agriculture into the permitting program. That's why we brought them in so slow, the politics there. The agriculture interests certainly were ones that we needed to address in the politics. Not Democrat, Republican, but agriculture (December 11, interview with an environmental consultant)."

A deep, historically powerful presence in the state, agriculture reconstitutes itself as a critical node of power not only through economic means, but also through the history of home rule (Carley, 2013). Home rule delegates municipalities and counties the autonomy to act with respect to their own affairs and without the need for specific legislative authorization (Handbook for Georgia Mayors, 2016). Several interview subjects noted how home rule and agricultural interests mutually reinforce one another to act as a limitation on the state's power to enact laws regarding matters falling within home rule jurisdiction (i.e., riparian protection, groundwater use, water conservation measures), even when these matters concern statewide policy (i.e., SWP).

In accordance with other policy studies, our work provides evidence of how prevailing social establishments, like agricultural interests in Georgia, continue to structure political norms

and relations of trust (Peck and Theodore, 2010)—predominant strategies of how informal hierarchies are maintained in political systems. Most significantly, agricultural interests impact water policy in Georgia through the entrenched social capital channels, which have historically built relations of trust, reciprocity, and exchange (Adger, 2003). Throughout each water case study, pre-existing agricultural relationships impacted how stakeholder groups mobilized resources to influence policymaking through membership on decisionmaking councils (e.g., Statewide Water Council and RWCs), other formal democratic structures (e.g., Legislature), and more informal political processes in Georgia. Thus, individuals active in agricultural circles in Georgia were represented on the Statewide Water Council, and are currently represented on the Regional Water Councils and in Georgia's legislature.

Metro Atlanta Chamber (MAC)

Our results indicate MAC exerts influence with elected officials and those serving in key positions of authority in Georgia [e.g., Water Council]. MAC clearly benefits from social capital through reciprocity and two-way influence and power sharing in Georgia (Diefenback and Sillince, 2011; Hollander and Offerman, 1990). The systematized access to decision makers in Georgia affirms MAC as dependable and trustworthy—fundamental characteristics of how social capital and informal hierarchy are best developed and channeled (Hollander and Offerman, 1990; (Boxman et al., 1991). As interview subjects reported, key members of MAC were at the center of the SWP and their presence is ongoing with regard to riparian protections. Demonstrating commanding social capital, MAC expertly negotiates social connections (Boxman et al., 1991) while strategically leveraging formal loopholes (e.g., MAC representing members at Water Council meetings even though MAC did not have a formal place on the council) through informal social relationships (Burt, 2004). MAC's infusion through rational *and* political means

during water policy efforts in Georgia provides a direct example of how social and informal processes prevail and determine much of what happens in formal democratic structures (Hasanagas, 2013; Lake, 2009) as they were able to circumvent and infiltrate key decisionmaking bodies (e.g., Water Council, legislature) to ultimately inform water policymaking efforts.

Gubernatorial Influence and Georgia Environmental Protection Division

The political clout afforded to the Governor determines much of what prevails both formally (e.g., appointing agency heads and the DNR Board) and informally (e.g., creating, appointing, and structuring *ad hoc* committees and councils) with regard to water policy in Georgia. Governors Perdue and Deal demonstrated tangible influence during each water case study through appointing and influencing the directors of GAEPD, Water Council members, Regional Water Council members, and the Department of Natural Resources Board. With Gubernatorial power at the helm, formal and informal social control (i.e., informal hierarchy) is exercised to align and/or shift stakeholders ideologically to reflect Gubernatorial positions (Peck and Theodore, 2010). As one interview subject noted, "Carol [Dr. Carol Couch, then head of the EPD] did because she's an appointee…She works for the governor and the DNR Board. The governor picks her. Within her technical expertise, they're going to follow what the Governor says… That's just the political [environment]" (January 6, interview with a consultant).

Of particular significance, gubernatorial constraints greatly influence GAEPD actions. In each of our water case studies, gubernatorial administrations exerted influence by structuring how rules, regulations, and moratoriums would be written and by whom, while helping to structure various *ad hoc* water committees and councils. A reflection of gubernatorial hierarchy—individuals in Georgia are positioned through administrations in unequal relations to

each other in both formal and informal structures creating a stratified system of social positions concerning water policy efforts (Diefenbach and Sillince, 2011). In placing individuals to serve as members in collective "epistemic, practice communities," gubernatorial forces influence water policy from a top-down or trickle-down approach, even while on the outside it seems a multitude of stakeholders, backgrounds, and opinions may be involved in water policy efforts (Peck & Theodore, 2010:170).

Legislators

Several interview subjects noted the power of certain legislators in ultimately structuring water policy issues in Georgia. One key political consultant in Georgia reported on the importance of legislative approval as they were fundamental in achieving the passage of the SWP:

> The other two people that had the most power would have been the senator and the representative, so [State Senator] Ross Tolleson and [State Representative] Lynn Smith, because they ultimately were the ones that had to ensure that work product could cross the street to the gold dome and pass it [Georgia Statewide Water Plan]. You had to make sure they were brought in on everything in the plan in order to go sell it across the street. (January 6, interview with a consultant)

Another key consultant involved with the SWP noted the calculated approach taken to have those in power positions in Georgia (e.g., Tolleson and Smith) relay recommendations of the Water Council, as this would enhance the SWP's credibility:

> "The benefits of the Council, the Statutory Council and the way it was put together, is that it was a unique body in that it wasn't just an executive function, executive branch. It was a joint legislative executive function. The chairs of the Natural Resource Committees

sat on the Council. When somebody speak [spoke] for the Council…it was often one of the elected officials. Part of this is how do you…When do you make a decision? How do you communicate? Who is the best messenger? Where does that credibility lie?"

Choosing Senator Ross Tolleson and Representative Lynn Smith as the figureheads to advocate for the SWP demonstrated expert social and informal control on behalf of the Water Council and the Governor who appointed them, as these leaders in the state of Georgia exuded characteristics of individuals who gain and maintain high positions of power in formal and informal hierarchies (Diefenbach & Sillince, 2011). Our contact with and secondary research of key legislators involved in each water case study (archival and ethnographic) revealed their (1) charisma and ability to perform (Lake, 2009), (2) expert non-verbal behavior (Hall et al., 2005), and (3) general "Big Man" or "Big Woman" representations (Hollander & Offerman, 1990), demonstrating an ability to master informal means to control water policy efforts in the state. During our interview with Senator Ross Tolleson[29] he still eloquently championed the SWP, relaying how he was able to get the SWP passed at the Legislature:

"Chairing the Natural Resource and Environment Committee, I had to make sure that we could get it through the committee and to the Senate floor and pass it on the Senate floor. But it really wasn't that bad because people understood the danger of not. We pretty much passed it through the committee and then to the Senate floor and moved it right on. I'd talk to them about reality. Talk to them about the water, the lack of water. If we don't do anything, we're going to get even in worse shape. Then, the Federal Courts are going to come in and run your water policy and you're going to be in big trouble. It was a great process."

[29] Senator Tolleson agreed that his interview was public and any information obtained could be directly displayed in this research.

Statewide Water Council

Our results indicated that the structure, process, and membership of the Water Council reinforced political dominance for an elite few, which ultimately shaped the content of the SWP. These individuals were appointed through gubernatorial processes with only 14 members selected for high-level water policy creation (members represented industrial, governmental, and agricultural entities). Those elevated in this hierarchical setting ultimately received more political attention and were thus allowed more control over group decisions and processes (Anderson et al., 2001). The trust and relationships built during Water Council meetings ultimately translated into potent political capital, while other voices were omitted from the process (e.g., scientists and environmental groups).

Department of Natural Resources Board and Industry

As Table 4.2 indicated, Georgia's DNR Board and industry efforts heavily influenced each water policy case study. The industrial makeup of DNR (all but one member represents an industry in Georgia) led several research participants to report how they believe industry and developers hold substantial power over political decisions in the state: "I think that the construction industry and the developers have a great deal of power in influencing the policy decisions in this state" (February 16, interview with a scientist). When asked why industry holds power in Georgia, those interviewed frequently discussed economic issues: "Money… And it's a business. Georgia… prides itself on being a business-friendly state. It's about promoting the economy as far as I understand. Then, as far as industry, I would say they have money and influence over politicians" (February 16, interview with an environmental consultant).

How industry and DNR are able to influence water decisionmaking is substantial in Georgia. As one key interview subject reported, EPD is subject to political bias from DNR as

well from diverse groups of actors in Georgia, especially since they are political appointees of the Governor and may not want to contradict the political arena in which they serve:

> Some of them were key players because that was their job. I mentioned the EPD folks. They were at the middle of this because… Well, it's a little more complicated than this, but you get the Board of Directors of the DNR and EPD that are political appointees who are subject to influence by different interest groups. They can… Over time, they're able to exert influence on the level of enforcement. Not directly, of course, but there's that subtle… No agency is completely independent and just follows the rules. (November 5, 2015 interview with a scientist)

Overall, the critical policy perspective provided insights into the organizations and individuals at the center of the web of influences regarding the three water case studies. Extending beyond instrumental and political analyses, the critical perspective provided a deeper understanding of which stakeholders control water decisionmaking efforts in the state and how they exert the political means to control through embedded social ties and informal efforts.

Conclusions and Recommendations

Attempts to address environmental issues typically result in different conclusions with information and modes of policy making leading to dissension, rather than agreement. As contentious environmental debates dominate American politics, and as those hoping to aid environmental policy with sound scientific evidence find themselves up against political roadblocks, a deeper understanding of the environmental policy process itself is needed to equip scientists and other stakeholders with an embedded knowledge of how political systems function and how to access contentious environmental arenas. Our work contributes to the body of work

on political theory and environmental policy analysis through providing an in-depth analysis of the processes at play during water policy efforts in the state of Georgia.

Georgia was an ideal setting to explore wider dynamics surrounding water policy as drought, the "Tri-state Water Wars," and increased water demand from population and industrial growth have brought water issues to the forefront of environmental policymaking (Campana et al. 2012; CVIOG 2006; Seager et al. 2009). We utilized a detailed ethnographic approach to explain how water policy is made in the state and which factors and stakeholders significantly influenced policy trajectory. Three water case studies were chosen (focused on broad water efforts concerning groundwater, surface water, and statewide water planning) to provide a nuanced and more holistic analysis of the factors and stakeholders significantly influencing water policy.

Overall, our findings support the conception of policy through critical policy theories rather than purely instrumental and political lenses, as evidence of a web of multifaceted dynamic policy processes and influence structure water policy decisions in Georgia. Through a broader critical policy lens, our analysis identified stakeholders who ultimately influenced each case study, and explored key moments of stakeholder influence. Our results indicated that although hundreds of individuals and stakeholder groups were involved in the state of Georgia with regard to the three water policy case studies, the following groups exerted the most influence in decisionmaking processes: Agriculture, Metro Atlanta Chamber, Gubernatorial and Legislative Nodes, the Water Council, the Board of Georgia's Department of Natural Resources (DNR), Georgia's Environmental Protection Division (EPD), and Industrial Nodes.

The handful of stakeholder groups who structure water policy decisions in Georgia provide a deeply embedded power foundation; with decisions guided by social capital,

established relationships of trust, and existing power relations (see Maloney, Smith, and Stoker, 2000; McNie, 2007; Hasanagas, 2013). The vast difference in "task participation" (Fisek and Ofshe, 1970) between those granted participation in core water policy spheres in Georgia and those who remain on the periphery dictate water decisionmaking efforts; who speaks to whom, and sustained inclusive interactions significantly sway the ability to exert influence in water policy arenas (*see* Bales et al., 1951).

Further research should critically assess:

(1) Whether and how stakeholders on the periphery of policy spheres (i.e., environmental groups, scientists, etc.) may be able to effectively access and establish political networks in conservative and contentious environmental arenas (forthcoming Jensen-Ryan and German, 2017);

(2) Long-term implications of powerful social and informal political spheres and how these impact environmental policy efforts in Georgia and nationwide;

(3) Whether and how entrenched political establishments can be subverted to influence environmental policymaking in politically divided arenas.

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Table 4.1. List and Description of Georgia Water Case Studies

Case Study	**Resolved or Unresolved**	**Success or Failure**	**Contentious or Non-contentious**
i. Regulation of Groundwater Withdrawals	Resolved	Mixed	Non-contentious
ii. Riparian Protections	Resolved	Success	Highly Contentious
iii. Comprehensive Statewide Water Plan (2008)	Unresolved	N/A	Contentious

Table 4.2. Water Policymaking in Georgia: Stakeholder and Factors of Influence

Key Stakeholder	Processes of Influence
Agriculture	a. Legislative representation b. Statewide Water Council representation c. Regional Water Councils representation d. Legacy of home rule
Metro Atlanta Chamber (MAC)	a. Direct link to legislative representation b. Water Council representation ("Georgia Water Alliance") c. Riparian Buffer Committees d. RWC representation
Gubernatorial	a. Appoints and Influences Director of EPD b. "" Water Council Members c. ""RWCs' Members d. "" DNR Board
Legislative	a. Membership on the Water Council b. Structured and approved SWP c. Chaired House and Senate Natural Resource and Environment Committees d. Championed SWP
The Water Council	a. Structured and approved SWP b. Members appointed by Governor (heavy industrial, agricultural, and MAC representation)
DNR	a. Members appointed by Governor b. Structured information presented to RWCs c. Supervises EPD work (with SWP, riparian buffers, groundwater protections)
EPD	a. Director appointed by Governor b. Writes regulations, memoranda, and moratoriums c. Helps structure committees and councils (RWC, Riparian Variance Committees)
Industry	a. Representation in legislature b. "" on Water Council c. "" on RWCs

Figure 4.1. Interview Subjects by Affiliation

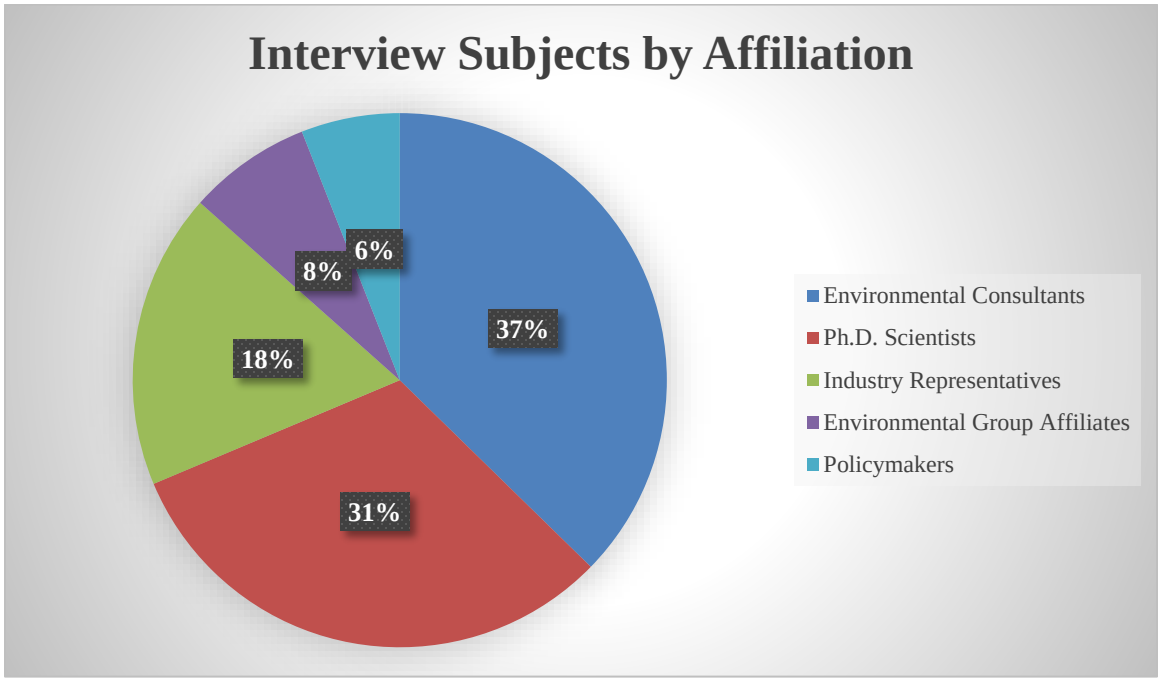


Figure 4.2 Georgia Flint River Basin, courtesy of Chattahoochee River Park.

Figure 4.3 Georgia Water Policy, Influential Stakeholders

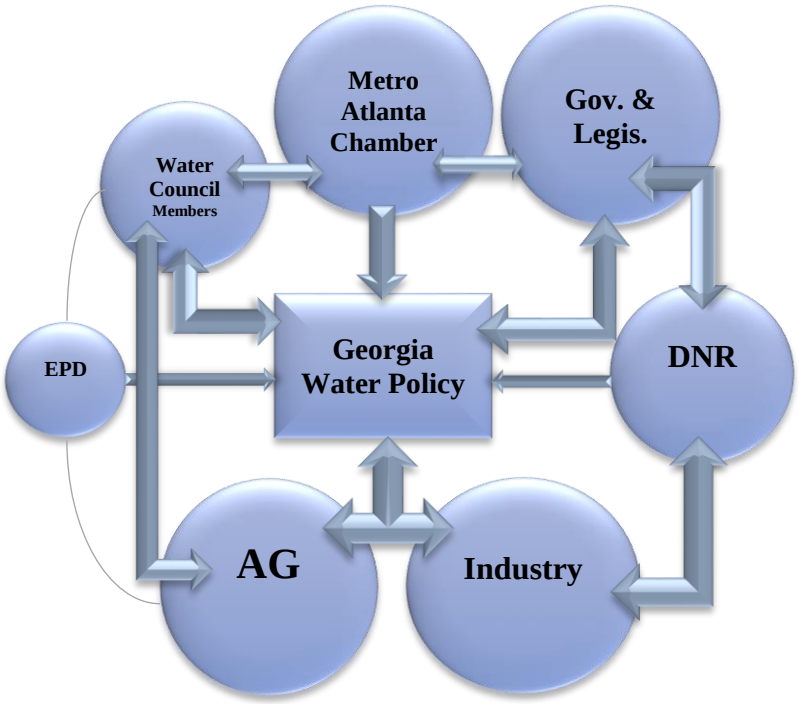
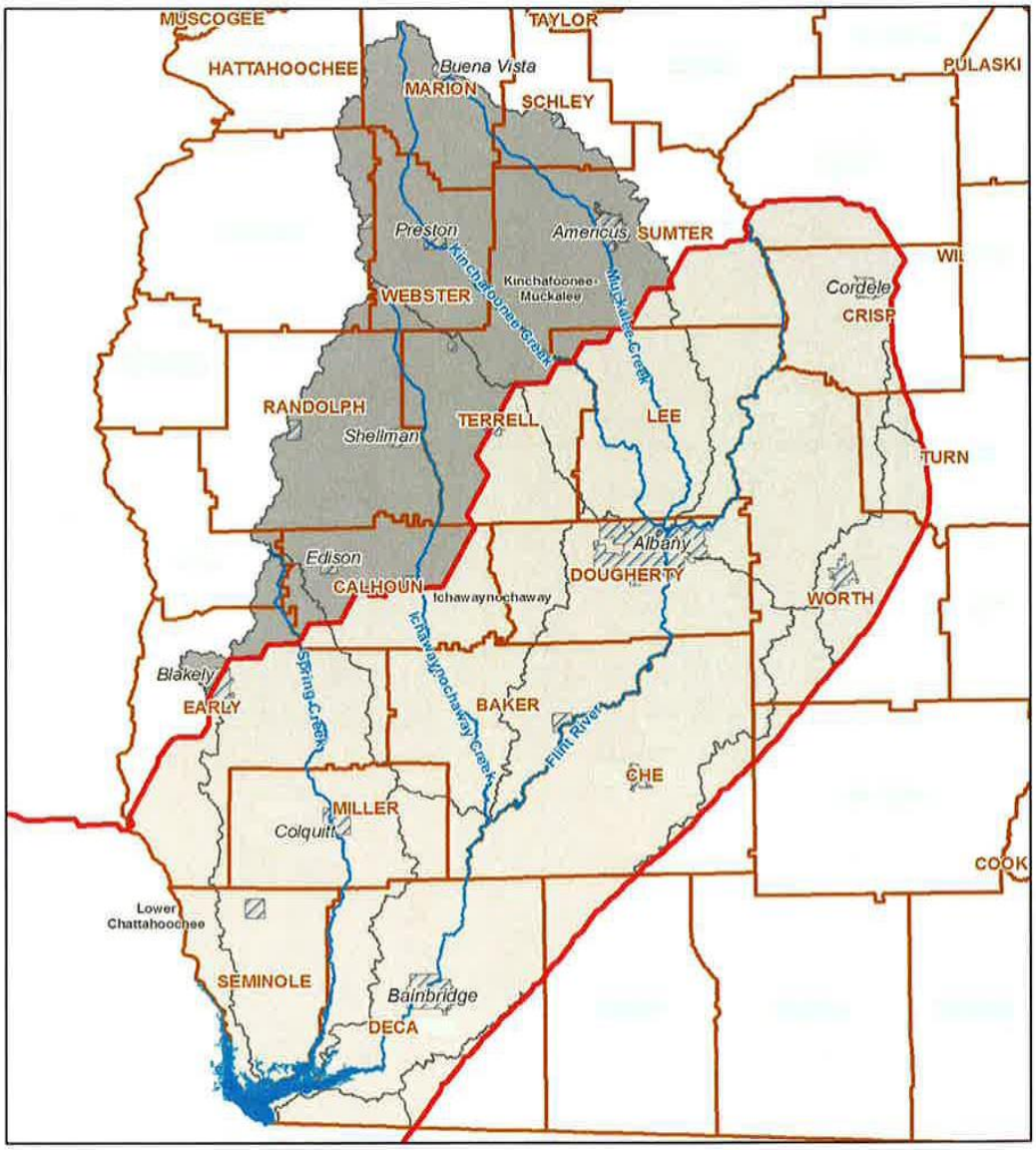


Figure 4.4: Suspension of Consideration of Agricultural Withdrawal Permits in Portions of the Lower Flint and Chattahoochee River Basins Based on County, GAEPD, 2012.



CHAPTER 5

THE ENVIRONMENTAL SCIENCE-POLICY INTERFACE: A COMPARATIVE ASSESSMENT OF WATER POLICYMAKING IN THE STATE OF GEORGIA[30]

[30] Jensen-Ryan, D. To be submitted to *Environmental Science & Policy.*

Abstract

As environmental science and politics collide at an ever growing rate in the twenty-first century, uncovering how science may influence policymakers and subsequent policy action is critical. Scholarship on science-policy linkages from the natural sciences to the humanities is dominated by instrumental views of science-policy integration by boundary organizations and spanning processes. While critical policy studies highlight more informal and political processes influencing the uptake of science. A systematic comparison of case studies utilizing both instrumental and political lenses is currently lacking in the literature.

Our research provides a holistic and systematic approach to understanding the science-policy interface through a comparative assessment of formal-instrumental *and* informal-political factors shaping science-policy integration. We examined whether and how formal-instrumental and informal-political factors influence the science-policy interface in Georgia and whether advantages exist to including an extensive analysis of informal-political science-policy factors. Three water policy case studies were chosen (focused on broad water efforts concerning groundwater, surface water, and statewide water planning) for comparison to provide a nuanced and more holistic analysis of the science-policy factors significantly influencing water policy in the state.

Our results support the advantages of conducting a deeper level of science-policy analysis through an ethnographic approach as the analysis of formal-instrumental features and strategies of boundary organizations and spanning processes provided little detail surrounding water policymaking efforts in Georgia. The ethnographic approach utilized to uncover informal social and political processes at play provided evidence of the politicization of science during knowledge generation and dissemination to stakeholders for water decisionmaking efforts.

Overall, informal-political theories provide greater explanatory power in understanding the various problems associated with the uptake of science discussed in the science-policy literatures. Explicating fine-tuned details of science-policy linkages within wider political contexts through in-depth ethnographic inquiry illuminated areas for future research; addressing the politicization of science during science-policy integration efforts and strategies for future scientific contribution to environmental policymaking efforts.

INDEX WORDS: Water, Boundary Organization and Spanning Processes, Instrumental Policy Process, Political, Environmental, Ethnographic, Politicization of Science

Introduction

Expecting that policymakers should be using the "best available evidence" from research when making decisions does not recognize the formal and informal social processes at play in selecting scientific information or courses of implementation (Bracken & Oughton, 2013). Boundary organizations (organizations bridging science and policy) and boundary spanning (processes utilized to bridge science and policy) overwhelmingly utilize formal[31] processes of engagement. Factors such as the availability and accessibility of information of those at the boundary (Dilling and Lemos, 2011) and professional training of both scientists and decisionmakers (Rice, Woodhouse, & Lukas, 2009) are but a few of the formal processes identified in the literature as impacting successful science-policy linkages. Though there is a tendency to render the policymaking process as a purely technical exercise thereby masking power relations at play (McNie, 2007), various studies have demonstrated how informal[32] social practices and norms can also affect the creation and utilization of scientific knowledge (Jasanoff, 1990; Rice et al., 2009). The social and political dynamics occurring during the policy process, such as relational interactions (Miller, 2001; McNie, 2007), socio-political environments (McNie, 2007), power and conflict relations (Schusler et al., 2003; Hackett and Parker, 2012) and knowledge creation itself (Jasanoff, 1990) further influence the science-policy interface. Yet, additional research is needed to better understand the influence of science-policy factors, particularly those focused on informal and political processes and the relationship between instrumental and political

[31] Formality is defined as prescribed practices (fixed sets of rules of organizational procedures and structures) utilized during science-policy interactions (Hastings, 2011).
[32] Informality is defined as inter-personal, relationship driven contact and/or espoused through networking during science-policy processes (Lemos and Morehouse, 2005; Otronen, 2003).

dimensions in shaping the science-policy interface and environmental policy (Lopez-Rodriguez, 2015; Hoppe, 2010).

Our work examined whether and how formal-instrumental and informal-political factors influence the science-policy interface in Georgia and whether advantages exist to including an extensive analysis of informal science-policy factors. Our comparison is focused on three water policy case studies in Georgia: (1) regulation of groundwater withdrawals, (2) riparian protections, and (3) the Comprehensive Statewide Water Plan (2008). We utilized formal science-policy variable frameworks established in a science-policy meta-synthesis (systematic assessment of published case studies) conducted by Jensen-Ryan and German (2017, in press) to distinguish formal-instrumental factors present in each water case study. The extensive ethnographic inquiry investigated informal-political factors which shaped the generation and use of science information during science-policy integration efforts. The role of science (whether and how it was utilized and which factors influenced its trajectory) is the integral thread connecting both studies. We asked the following research questions: *(1) What is the role of science in water policy in Georgia? (2) What is lost and gained through a focus on formal instrumental factors of boundary spanning processes, and through a focus on the informal political dynamics through which policies are formulated?*

Through juxtaposing the results of formal and informal science-policy factors, we hope to make novel contributions to theory on the science-policy interface and inform efforts by scientists to shape environmental policy. This work is based on the understanding that pre-established relationships of trust, existing power relations, and vocal industry lobbies are particularly influential in political systems (McNie, 2007, 2008; Hasanagas, 2013). In addition, ethnography is particularly suited to uncover political complexities that linear designs cannot

easily capture (Huby et al., 2011) which may ultimately provide deeper explanation of weak correlations identified in the wider literature as determined through the meta-synthesis.

A literature review follows that describes the theoretical framings chosen for our research as well as a brief history of water policy in Georgia to contextualize our work. We then discuss our methodology followed by the results of our inquiry. The results begin with an analysis of the formal-instrumental features of water science-policy integration efforts in Georgia. The ethnographic analysis of informal-political factors follows with a focus on understanding the role of science in water policymaking efforts and the informal social and political factors which influenced scientific trajectory in the state. A discussion follows the results which draws on science-policy literatures and compares the formal and informal processes which ultimately influenced science-policy linkages in the state of Georgia. Finally, we provide concluding thoughts and future recommendations.

Literature Review: The Science-policy Interface

The science-policy interface is the "point at which science and policy meet and act on each other" (Janse, 2008:183), "involves all decision making related to the systematic pursuit of knowledge" (Pielke, 2007:37), and is the co-production of scientific and political norms within the policy process itself (Forsyth, 2003; Jasanoff, 2004; Hess, 1997). Various forms of interactions between science and policy exist including those classically labelled as (1) a "science push," which enables the pursuit of knowledge itself to drive scientific production which can provide solutions to everyday problems (Dilling and Lemos, 2011); (2) a "demand pull," which occurs when science is commissioned by a stakeholder (Dilling and Lemos, 2011); and (3) a "co-production model," whereby the research agenda is shaped in an ongoing, iterative fashion between knowledge producers and users (Dilling and Lemos, 2011). Pielke (2007)

further outlines various roles individual scientists subscribe to with varying degrees of interactions and influence toward policy and decision making (e.g. Pure Scientist, Issue Advocate, Science Arbiter, Honest Broker).

Though various models and approaches have been developed to enhance science-policy integration efforts, substantial problems exist including: mutual incomprehension between scientists and decision makers (Clark, 2009), inflexibility of both scientists and decision makers with regard to research and how it should influence policy (Clark, 2009; Dilling and Lemos, 2011; Holling, 1995), poor access to research findings (Driscoll, Lambert, and Weathers, 2011), a lack of constructive engagement between scientists and decision makers (Driscoll et al., 2011), a piecemeal approach toward policy (Holling, 1995), the lack of understanding of the policy process by scientists (Janse, 2008; Lemos et al., 2012), difficulties associated with scientific "uncertainty" (Kirchoff et al.,2013; McNie, 2007), poor timing (Kirchoff et al., 2013), and challenges incorporating scientific information into policy (Kirchoff et al., 2013), among others.

In an effort to address currently science-policy integration obstacles, scholars have investigated which factors successfully result in science-policy integration. These factors can be grouped according to their focus on boundary organization theory and more instrumental perspectives on the boundary spanning processes, and those associated with more political and critical informal perspectives of science-policy integration.

Formal-instrumental Science-policy Processes of Boundary Organizations and Spanning Processes

Utilizing boundary organizations are typically associated as a formal factor which enhances science-policy integration efforts (Guston, 2000). Boundary organizations are defined as formal organizations which create a more "neutral" space for knowledge co-production,

dissemination, and brokering activities (Guston, 2001; Crona and Parker, 2012). These organizations frequently (a) provide accountability and responsibility to stakeholders to establish checks and balances between entities at the boundary so trust can develop (Guston, 2000, 2001; Crona and Parker, 2012); (b) involve the participation of principals (i.e. policymakers), agents (i.e. scientists) and professional mediators), to facilitate effective communication with the added help of professional facilitation (Braun and Guston, 2003; Guston, 2000); and (c) consult with stakeholders directly affected by policy choices to help grasp "local realities" during scientific research and public participation efforts (Vogel et al., 2007:358; Bremer and Glavovic, 2013:109).

Formal-instrumental factors additionally include institutional and organization setting and culture (Lemos, Kirchoff, and Ramprasad, 2012); the availability and accessibility of information (Dilling and Lemos, 2011; Lemos et al., 2012) and professional training of both scientist and decisionmakers (Rice et al., 2009). Scholars also outline the long-term presence of researchers with sustained interactions (Kirchoff et al., 2013), deliberate and reflexive interactions (Rice et al., 2009), high-quality and independent research (CGIAR, 2009), finding the right institutional partner (CGIAR, 2009), working closely with NGOs (CGIAR, 2009), and working within an environment conducive to the implementation of environmental policy (CGIAR, 2009) as significant formal factors that determine successful science-policy interface outcomes. Success of science-policy integration is also said to rest on the level of iterativity between knowledge producers and users (McNie, 2007), the human and technical capacity and resources of organizations and institutions (Dilling and Lemos, 2011), the customization and sensitivity of scientists to decision makers' research needs (McNie, 2007). Engaging in assessment and evaluation activities once science-policy interaction is complete (Driscoll et al., 2011), utilizing

skilled practitioners to assist in boundary-spanning functions (Driscoll et al., 2011), previous positive experiences with innovation through science use and knowledge-seeking behavior by decision makers (Lemos et al., 2012), and sensitivity to the scale of the problem (McNie, 2007) are further formal areas outlined which impact the success of science-policy integration. Finally, whether research is perceived as credible, salient, and legitimate (Cash et al., 2003) are further markers provided in the science-policy literature for determining whether policymakers will embrace scientific information when making decisions (Janse, 2008).

Finally, formal science-policy factors also focus on solutions to science-policy interface problems. Formal solutions include supporting organized and coordinated transdisciplinary research (Hirsch Hadorn et al., 2006; Jahn, 2012; Wiek, 2009), promoting the co-production of knowledge (Jasanoff, 2004), creating and maintaining boundary organizations (Kirchoff et al., 2013), and creating boundary objects for dual scientific and policy purposes (Clark, 2009). Encouraging the use of adaptive management when creating policies (Holling, 1995; Janse, 2008); improving the embedded capacity of organizations (e.g., human resources, technical capacity, and leadership) (Dilling and Lemos, 2011); increasing the use of "information brokers," or an intermediary between users and scientists, who is fluent in both science and policy (Dilling and Lemos, 2011); enhancing the use of "knowledge networks," or, groups comprised of policy makers, scientists, government agencies, and NGOs that communicate with one another and share information across areas of practice (Dilling and Lemos, 2011); and involving stakeholders, scientists, and decision makers from the start in helping generate priorities for research are further solutions to science-policy interface challenges (Dilling and Lemos, 2011). Finally, changing how "success" is viewed in academia (e.g. success not based exclusively on tenure, retention, and promotion but also on outcomes such as stable relationships

with stakeholders, accessibility of knowledge, and specific social outcomes) (Dilling and Lemos, 2011; McNie, 2007), improving communication between scientists and decision makers (Driscoll et al., 2011), and focusing on "action science" (e.g. science shops, community based initiatives, participatory action research, civic science) (NSF, 2011) are further formal techniques which have proven to or have been proposed to promote successful science-policy integration in the future.

Political Science-policy Processes Associated with Science-policy Integration

There is less consideration and understanding of how informal social and political factors influence the science-policy interface and environmental policy (McNie, 2007) and how political and informal processes impact science-policy integration (Hoppe, 2010; Hoppe et al., 2013). Informal factors which influence the science-policy interface have been found to include the level of trust between scientists and decision makers and how trust is built and maintained (Dilling and Lemos, 2011; Janse, 2008; McNie, 2007). Trust is built between scientists and policymakers when differences in background (Rice et al., 2009); the knowledge, values, and beliefs of scientists (Janse, 2008); as well as their risk tolerance and risk perception (Kirchoff, Lemos, and Engle, 2013) is managed during interactions at the boundary. The existence of a personal relationship (between those at the boundary) (Driscoll et al., 2001) further builds trust with relationship and social capital best forged through participating in informal forms of engagement (Bremer and Glavovic, 2013) including social events outside of the workplace (retreats, fieldwork activities, luncheons, etc.) to help break down work-related barriers which may impede successful science-policy integration.

To continue informal relationship building, scholars argue scientists themselves, rather than through other mediums, should disseminate their research to policymakers, regulators, and

regulating organizations as this builds trust between various entities at the boundary and increases input from decision-makers which enhances saliency, and thus, applicability of science to policy decisions (Cutts et al., 2011; Hastings, 2011; Hoppe, 2010; Hoppe et al., 2013). Others argue for approaches that blur the boundaries between research and dissemination, such as promoting conditions conducive for learning through experiential, social, and institutional learning which allows for enhanced collaboration to occur and helps break down situational barriers while fostering a more collective and informed stakeholder group (Klerkx and Leeuwis, 2009; Bracken and Oughton, 2013; Zehr, 2005).

A final set of informal science-policy focus on relational dimensions. Those at the boundary which help develop and maintain strong social relationships enhance social bonding and personal networking which provides improved conditions for knowledge creation and dissemination (Holmes and Savgård, 2009). Developing enhanced social relationships are said to occur through building social capital with the target audience through tapping into existing social capital mediums as well as the expertise available through organizations, institutes, universities, scientists, policymakers, etc. (Bielak et al., 2008; Turnhout et al., 2008). Finally, some authors explore the importance of managing power differentials (e.g. conflicting demands, positions, and resources) in order to create a more "neutral" space for collecting information and ideas from all stakeholders (Crona and Parker, 2012; Kirchoff et al., 2013).

Environmental Science-policy Interface in Georgia

The State of Georgia presented an ideal setting to explore the science-policy interface. First, as a politically conservative state, policies that might be considered pro-environment have historically been a hard sell. Second, science and scientific consultation is traditionally underutilized on environmental policy issues in the state. Recent examples of this occurred

during the creation of the Georgia Comprehensive State-wide Water Plan (2008) and the subsequent 11 Regional Water Councils created by Governor Nathan Deal. Not a single scientist from the southeast region was asked to serve or be a consultant to the Regional Water Councils (RWCs) (300 members total), which are the guiding force over current water issues in the state as each council prepares an annual report detailing water use, management, conservation efforts, and areas for improvement for each county in Georgia.

Adding to the general lack of scientific consultation on environmental issues are the anti-science stances adopted by some Georgia politicians in the public sphere. Representative Paul Broun blasted climate change, evolution, embryology, and the big bang theory (New York Daily News, 2013) while representatives Doug Collins, Phil Gingrey, Jack Kingston, Tom Price, Lynn Westmoreland, and Johnny Isakson equally castigate scientific evidence of climate change (Sprouss, 2013). In addition, a host of special interest groups and lobbyists, scientists, non-profit organizations, and key individuals and groups are identified as influencing environmental policy-making decisions.

Finally, a water paradox, the state of Georgia presented an ideal setting to explore water policymaking efforts as it receives 50 inches of annual precipitation and is located amid 14 major river systems and seven highly productive groundwater aquifers (GAEPD, 2011; Kundell & Tetens, 1998). Yet, despite abundance water resources in Georgia, problems exist where demands fueled by population and economic growth, as well as ongoing interstate litigation pressure Georgia's water supply (Kundell & Tetens, 1998; Campana, 2012). These issues, coupled with persistent droughts and ongoing "Tri-state Water Wars" deliberations (between Georgia, Alabama, and Florida), have brought water issues to the forefront of environmental policymaking in Georgia (Campana et al., 2012; CVIOG, 2006; Seager et al., 2009). To address

water issues, Georgia began to re-examine its law and policy governing water allocation to ensure that its water resources are allocated fairly and efficiently in the years to come (Fortuna, 2004), especially regarding groundwater, surface water, and statewide water planning efforts (*see* Jensen-Ryan and German, forthcoming).

Regulation of Groundwater Withdrawals

How to regulate groundwater withdrawals in Georgia remains the key issue regarding groundwater use and protection in the state. At various points in Georgia's history, the Groundwater Use Act of 1972 and a 1977 amendment to the Water Quality Protection Act of 1964 have not provided enough restrictions to groundwater use; thus, groundwater moratoriums have been issued by GAEPG to restrict groundwater use.

Georgia Riparian Protections

Georgia riparian protection is mandated by several laws: the Erosion and Sedimentation Act, the Georgia Planning Act, the Mountain and River Corridor Protection Act, and the Metropolitan River Protection Act. However, a lack of uniformity due to vagueness in statewide riparian law and local governments who independently create riparian regulations create contentious debates regarding riparian issues throughout the state. At the center of these debates are riparian variances, or the ability to apply and receive an exemption (or variance) from having to adhere to current riparian protections (primary and secondary trout streams maintain an undisturbed riparian buffer of 50 feet and all other streams maintain a minimum buffer of 25 feet). The issue of riparian variances in Georgia prompts contentious debates over riparian buffer width, aquatic habitat protection, water quantity and quality, as well as issues of wrested vegetation for a multitude of stakeholders in the state.

Georgia Comprehensive Statewide Water Plan (SWP)

The SWP focused on three interconnected water issues: (1) water conservation, (2) water quantity, and (3) water quality (Georgia Comprehensive State-wide Water Plan 2008). To help address these three water issues, the SWP provided a framework to measure water resources, to forecast how much water supply would be needed to support future growth, and to identify regional water solutions (Georgia Comprehensive State-wide Water Plan 2008). Through statewide, regional, and local planning processes, stakeholders provided input as to how water resources should be governed in Georgia. These issues provided ripe ground for investigation of environmental science-policy efforts, particularly those focus on water-related issues, for our work.

Methodology

For this paper, we compared three Georgia water case studies through the instrumental and political science-policy approaches outlined in the literature review—with a particular focus on the science-policy factors in both veins of literature as significant. A brief description of the case studies, as well as an explanation of the methodologies for elucidating formal and informal aspects of the policy process follows.

Case-Study Selection

Though "regulated riparianism[33]" governs water in Georgia; glaring omissions in regulation have led to vast water concerns in the state. Thus, three water case studies were chosen to provide a nuanced and more holistic analysis of science-policy factors. Further case-study inclusion criteria were employed:

[33] Kundell and Tetens (1998) describe regulated riparianism" as governed by two factors: (1) reasonable use, and (2) the diversion cannot interfere with a downstream riparian's legitimate use of water.

1. Cases that concluded favorably and unfavorably with respect to safeguarding key environmental qualities or processes (as determined by water stakeholders in Georgia);
2. Cases that are already resolved and those that remain unresolved despite concerted efforts to address them; and
3. Cases with varying degrees of contentiousness.

This process led to the prioritization of the three case studies highlighted in Table 5.1.

Analysis of Formal Features and Strategies of Science-policy Interface

The formal meta-synthesis conceptual frameworks identified (in-prep Jensen-Ryan and German, 2017) in earlier science-policy research were utilized to analyze the three water case studies in Georgia. These formal conceptual frameworks were created and applied to analyzing a host of published science-policy case studies (39) after an extensive review of the science-policy literature. Our intent with this work was to contribute to boundary organization and boundary spanning research as scholars focused on the instrumental approach argue science-policy research lacks systematic measurements of key processes, variables, and outcomes while rarely engaging in theory building and extended cross-case comparisons (McNie 2007; Crona and Parker 2012). We utilized these same frameworks to analyze and identify instrumental science-policy factors present and/or absent with regard to each water case study and to analyze what the presence/absence of variables may mean. 47 formal explanatory variables were systematically identified in the science-policy literature and utilized for the purposes of a formal science-policy meta-synthesis (in prep, Jensen-Ryan and German, 2017). Utilizing the 47 formal explanatory variables, we identified which of the science-policy variables were present during each of the water case studies in Georgia. The presence/absence of scientific variables were coded with a 1 or 0, with 1 indicating presence of explanatory variable and 0 indicating absence. Tables 5.2-5.5

depict the results of the presence/absence of each 47 formal science-policy variables and the results section discuss the results.

Ethnographic Analysis of Informal Factors Shaping the Science-Policy Process

Ethnographic methods were utilized to explore the more informal dimensions of the science-policy process. Research and data collection occurred over a 9-month period between August 2015 and May 2016 in the state of Georgia. Ethnographic methods utilized included semi-structured interviews and focus groups (Spradley, 1979), document review (Scott, 2006), media analysis (Gould, 2004), and the distribution of a questionnaire (Dillman, 2000). Overall, we conducted 81 individual interviews and three focus groups with a total of 12 participants. Each of the three focus groups focused on the Georgia Comprehensive Statewide Water Plan with one group also focusing on groundwater moratoriums in Georgia. We utilized a semi-structured interview process (Bernard, 2011) and conducted interviews with a representative cross-section of policymakers, scientists, consultants, government agency employees, environmental group advocates, and other local stakeholders. Figure 4.1 provides information on the actors interviewed for this research. Overall, 37% of our interviewees represented environmental consultants, 31% represented scientists, 18% represented industry affiliates, 8% represented affiliates of environmental groups, 6% represented policymakers. Each interview focused on themes associated with the chronology of the case study (with an emphasis on major events), the science utilized during each case study, policy outcomes, and political influences. All interviews took place in line with accepted Institutional Review Board informed consent procedures and were transcribed verbatim from audio-recording.

We also reviewed archival materials to deconstruct each water policy case study and to understand the historical context in which each case study occurred (Harrison, 2001). Guiding

questions for the document review were adapted from Scott (2006) with a focus on basic questions of political involvement and more in-depth theoretical questions. Private (e.g., email, memos, letters), and more official public documents were also reviewed (e.g., reports, press releases, regulations, archives). Private and official documents needed for completion of study that were inaccessible during research or from interview subjects were retrieved through the Georgia Open Records Act (2012).[34]

A media analysis was further conducted as media (1) drives policy discourse (Hammond, 2004), (2) filters the opinions of policy actors (Andsager, 2000; Boykoff, 2008), (3) creates the "frame" of reference for policy (Wanta & Ghanem, 2007), while (4) enabling the identification of prominent environmental discourses that structure the behavior of actors and enable and constrain policy action (Hajer, 1995). Over the period of data collection, media from news inquiries, magazines, radio programs, television clips, and governmental, nongovernmental, and non-profit news releases was gathered and analyzed.

Since time and funding impacted the ability to interview all individuals involved with each water case study, we also distributed a questionnaire to each member (~200) of the SWP's Regional Water Councils (RWCs); 21 were returned. These questionnaires were distributed in spring 2016 (after individual interviews were completed) and were analyzed to decipher how the RWCs influenced water decisionmaking processes in the state. Although the overall response rate was low (10.5%), they were considered sufficient in number to be analyzed.

[34] The Georgia Open Records Act details how all documents, papers, letters, maps, books, tapes, photographs, computer based or generated information, or similar material prepared and maintained or received in the course of the operation of a public office or agency are public records (§ 50-18-1). Furthermore, public records also include these items when they are received or maintained by a private person or entity on behalf of a public office or agency and that are not otherwise subject to protection from disclosure (§ 50-18-70(a)(2)).

We analyzed all interview, focus group, questionnaire, and observational data using ethnographic content analysis (Bernard, 2011), an iterative method designed to uncover meaningful concepts and verify relationships among them (Altheide, 1996). We also utilized grounded theory coding methodology (Glaser & Strauss, 1967; Strauss & Corbin, 1990) to examine interview transcripts for emerging themes and place them into categories and sub-categories that formed the basis of empirical and theoretical arguments. Both analytical approaches were facilitated by the use of the qualitative analysis program Atlas.ti.

Comparative Assessment of Formal and Informal Science-Policy Processes

A comparison between the formal and informal science-policy processes present during each water case study was done qualitatively. We juxtaposed the factors present in both the formal and informal studies to decipher whether unique insights were generated by each perspective, and whether one is more powerful than the other in explaining outcomes of the science-policy process.

Results

Formal Factors in the Science-policy Process

The science-policy variables and outcomes present in each case study are summarized in Tables 5.2-5.5. Table 5.2 shows formal features of the science-policy process found to be present in our water case studies. Features were characterized based on the structural component of the boundary organization or boundary spanning process. Here, we observe the formality (F1) associated with each of the water case studies as the science-policy processes was executed through the formal boundary organization, GAEPD. GAEPD's efforts for each case study were focused at local (F4) and state-levels (F5) which were ultimately funded through public (governmental) sources. The SWP exhibited additional features as the structure of this process

was open to several organizations/stakeholders (F2) and the science-policy process was legislatively mandated (F3).

Table 5.3 shows strategies, defined as courses of action of boundary organizations and/or through boundary spanning processes. Here we see all three case studies utilized a boundary organization (S1), GAEPD, as well as boundary spanners (S2) within the GAEPD to execute science-policy linkages. Facilitated by GAEPD, stakeholders at the boundary utilized co-production of knowledge and analysis (S3, S4). Several of the strategies categorized under saliency were also present in this work (S10-S16). Decision-aids were developed by scientists and the research itself was situated toward the scope and scale of the water issue at hand (S10, S12, S13); stakeholders engaged in adaptive management and involved governmental entities during science-policy interactions (S15, S16). Consistent across our work, the SWP utilized additional science-policy strategies to span the boundary including informal approaches and dissemination of information to media (S7, S8, S9). Strategies associated with credibility were also observed during the SWP process as GAEPD engaged in conflict resolution and skill development between those at the boundary while also engaging in a public and transparent science-policy process (S22, S23, S25).

Table 5.4 shows other science-policy factors, defined as variables that did not fit into either of these categories were also identified, and subsequently categorized as factors endogenous to the scientific process. Here we see the SWP as the only case study to take advantage of a policy window (Oth1), while each of the case studies were found to utilize mixed evidence and methods (biophysical and economic, *not* social) and utilized qualitative analyses (Oth5, Oth6).

Table 5.5 depicts science-policy outcomes which were determined based on a review of the science-policy literature as well as studies in political science, organization theory, and law and policy science. Rather than only determining whether environmental science in each case study impacted legislation and its implementation, intermediate outcomes such as increased awareness and other legal and governmental actions were also included.

When analyzing each water case study few science-policy outcomes resulted. No outcomes were present with riparian protections with two outcomes evident in the groundwater case study (O7, O8). The groundwater water case study was the only case study to exhibit evidence that environmental science brought to the table during the science-policy interface shaped policy (O7) (i.e., the moratorium) *and* implementation (O8). Three outcomes were evident in the SWP case study: increased awareness of science among policymakers (O1), increased awareness of science among the public (O2), and evidence that science impacted legislation (O7). The outcomes associated with increasing awareness (both for policymakers and publicly) was mostly due to the efforts of Dr. Carol Couch, according to several of our research subjects. Then head of the GAEPD, Dr. Couch structured the SWP as a commitment to engaging stakeholders which had previously never been convened (e.g., Water Council), through creating a lengthy public process for understanding and commenting, and through implementing water planning at the regional level through the creation of the Regional Water Councils (RWCs) (300 members). Due to these efforts, the SWP exhibited several science-policy outcomes as awareness of scientific issues was increased for policymakers and decisionmakers on the RWCs and as the general public increased their knowledge of water issues in Georgia due to widespread dissemination efforts. Yet, only Outcome 7 (evidence of the uptake of science in legislation/policy) was found in more than one water case study.

Overall, the formal science-policy variables which emerged as significant center on the actions taken by the Georgia Environmental Protection Division (GAEPD), the chief boundary organization involved in each water case study in Georgia and the boundary spanners associated with GAEPD. Their actions, based on the formal-instrumental analysis, depict GAEPD as successful in brokering the boundary with regard to the GW and SWP case studies, especially as there is evidence of implementation in the GW case study. The formal conceptual framework analysis also reflects GAEPD's facilitation of co-production resulted in the scientific dissemination and utilization of research by those at the boundary. In addition, the added features and strategies completed by GAEPD during the SWP seem unwarranted as there is only evidence of legislative impact (O7); whereas, the GW case study (with far fewer features and strategies present) resulted in legislative impact (O7) *and* implementation (O8). Thus, additional efforts taken by GAEPD during the SWP which focused on including additional stakeholders in boundary spanning processes, engaging in informal political tactics, disseminating information to the media, and incorporating characteristics of credibility did not seem to positively influence implementation of the SWP.

Informal Dimensions of the Science-Policy Process

This section explores what the ethnographic evidence reveals about the influence of informal factors in shaping the science-policy interface and the role of science for each water case study.

Regulation of Groundwater Withdrawals

How to regulate groundwater withdrawals in Georgia remains the key issue regarding groundwater use and protection in the state. At various points in Georgia's history, the Groundwater Use Act of 1972 and a 1977 amendment to the Water Quality Protection Act of

1964 have not provided enough restrictions to groundwater use; thus, groundwater moratoriums have been issued by GAEPG to restrict groundwater use. Our research focuses on whether and how science was involved in the 2012 groundwater moratorium issued by GAEPD director Jud Turner, with the support of Governor Nathan Deal.

GAEPD and DNR were and are currently in charge of writing scientific contracts regarding groundwater modeling in Georgia. During the Sound Science Initiative, supported during Governor Perdue's (2003-2011) administration, scientists from the United States Geological Society (USGS) and GAEPD were hired to "come up with an assessment of what the groundwater resource was doing on the coast [of Georgia]" (October 26, 2015 interview with a scientist). No scientists outside of USGS or GAEPD were formally hired to contribute during the Sound Science Initiative; however, our interview subjects reported that the USGS did contact scientists from the University of Georgia (UGA) to consult on the impacts of groundwater pumping and which scientific tests should be administered to determine groundwater effects. As reported, scientists from UGA told USGS to perform the "long duration test," and "geochemistry tests," and look at "regional patterns using computer modeling" (October 26, 2015 interview with a scientist). When each of these were suggested to the USGS, our results indicated the USGS could not utilize these groundwater tests or modeling because it was "specifically prohibited" in their contract (October 26, 2015 interview with a scientist). According to four interviewees, these tests were not performed as they may show damaging effects of agricultural water usage on the Flint River and Floridan Aquifer which would harm agricultural interests in Georgia.

Recent results concerning groundwater modeling and forecasting also support evidence that GAEPD and DNR contracts prohibited scientists from performing groundwater modeling

and forecasting, which would be more scientifically appropriate, in the opinion of scientists interviewed for this work. Discussed in detail below in the SWP section, our findings indicated great difficulty in scientists being able to produce agricultural modeling forecasts which spanned 50 years: "Looking at what we currently used in agriculture, as well as making estimates of what we're going to use 50 years from now, which was *pretty absurd*, but we did the best we could" (February 2, 2016 interview with a scientist). Of importance, these scientists were also contracted with DNR to *not* look into effects of climate change for the 50-year agricultural assessments, even if it was in their scientific opinion that climate change could significantly impact Georgia's agricultural water use in the future (February 16, 2016 interview with a scientist). Due to the inability to look into effects of climate change, our interview subjects indicated the scientific credibility of their work may have been further negatively impacted. The results of our work indicate governmental power superseded scientific credibility in this particular situation as scientists providing work for the state of Georgia are unable to incorporate the potential effects of climate change in their work, let alone discuss (both verbally and written) climate change in research.

How the current research conducted by both the USGS and GAEPD regarding groundwater is ultimately interpreted by GAEPD remains obscure as current GAEPD employees declined to be interviewed for our research. It is also important to note that during the time of this research, Special Master, Ralph Lancaster, Jr., was appointed by the United States' Supreme Court to handle the 2013 lawsuit Florida filed against Georgia claiming that metropolitan Atlanta residents and southwest Georgia farmers harmed downstream aquatic species through water overuse.[35] Our interview subjects indicated several current employees of GAEPD were deposed

[35] Special Master, Ralph Lancaster, Jr., urged the Supreme Court on February 14, 2017, to reject strict new water consumption limits on Georgia. After hearing five weeks of testimony on the Florida/Georgia water lawsuit Special

for this court case which suggests why they were unable and/or reluctant to participate in our research. However, six individuals who retired from or left GAEPD were interviewed for this research.

Those interviewed discussed how the data accrued during groundwater modeling and forecasts in Georgia is "sent back and forth between USGS and EPD to develop models" (March 14, focus group with scientists). As reported, "They [GAEPD] get that technical information…they take that data and then, again, they do a lot of things with the data… They give it [back] to us. We do a lot of manipulation and then compile reports, which then go back to the state [GAEPD]. Then they use some of that data, but they've also generated their own data." To clarify how USGS data is interpreted by GAEPD several interview subjects noted how it was difficult for them to say which and how much GAEPD actually used data (March 14, focus group with scientists). Here, the co-production of knowledge (Jasanoff, 2004) may not have been beneficial as the USGS ultimately pulled out of these groundwater modeling contracts as they were viewed as being controlled by, in the words of our interview subject, "politics and not science" (March 14, focus group with scientists).

Overall, our results indicate the science utilized for the regulation of groundwater withdrawals in the state of Georgia may be problematic. GAEPD and DNR played a heavy hand in writing scientific contracts, which ultimately constrained scientific freedom to perform appropriate groundwater forecast and modelling tests. Current groundwater forecasting and modelling is also constrained by contract to not look into the effects of climate change. These constraints led several scientists to express concern over the accuracy of groundwater forecasting

Master Lancaster found Florida had failed to show a consumption cap was needed in Georgia regarding water use. This finding is not final, as the Supreme Court could reject his recommendation; however, this was viewed as a victory in the long-running legal dispute (Tri-state Water Wars) between southeastern states.

and modelling utilized to structure groundwater regulation in the state (e.g., groundwater moratoriums, SWP, and importantly, the Regional Water Plans). Finally, our results indicate that how GAEPD interprets their and USGS groundwater data is veiled. Those actively generating data for GAEPD expressed a lack of knowledge concerning how data was interpreted and utilized for regulation purposes.

Riparian Protections

The Erosion and Sedimentation Act, the Georgia Planning Act, the Mountain and River Corridor Protection Act, and the Metropolitan River Protection Act regulate riparian protections in Georgia. All require that affected local governments develop plans and ordinances consistent with the laws and with minimum standards issued by GAEPD. The Georgia Erosion and Sedimentation Act of 1975 (O.C.G.A. 12-7) and its subsequent amendments that require that primary and secondary trout streams maintain an undisturbed riparian buffer of 50 feet and all other streams maintain a minimum buffer of 25 feet. However, a lack of uniformity due to vagueness in statewide riparian law and local governments who independently create riparian regulations create contentious debates regarding riparian issues throughout the state.

Our results indicate that science and scientists have played a role in shaping riparian statutes; however, the science behind riparian protections in Georgia is enveloped in social, economic, and political dynamics. One environmental consultant who has worked on riparian issues for decades described the particularly contentious history of buffers in Georgia and political pressure influences riparian decisions:

> "Yeah, helping figure out how to keep protection on the buffers while developers were down there trying to whittle away the buffer laws…There was a lot of fighting over these kinds of things because basically if you look back, the buffer law had been whittled away

over the years. 100' trout stream is now 50. Trying to whittle it down again. It was all very contentious, trying not to weaken the law, which as you can see, has been weakened over the years. Science or not, it's political pressure."

Trying to promote a more scientific and balanced approach toward the issuance of variances, GAEPD convened Statewide Buffer Committees (January 5, 2016 interview with a scientist) to discuss riparian variances and buffers in the state. These committees were meant to promote a more scientific and balanced approach toward issuing variances in Georgia and were tasked with producing a "draft rule identifying the criteria to be utilized in considering applications for variances from the 25' state water buffer provisions" (GAEPD Memo, 2004). The nine member committee included several scientists, who wrote variance rules and regulations which made it "a lot stricter" for developers to apply and receive a variance (January 5, 2016 interview with a scientist).

After pushback from industry, the approved variance procedures from the first Statewide Buffer Committee (2000) were amended with the second Statewide Buffer Committee in 2004. These became more "relaxed" due to developers' complaints to the Legislature, according to those interviewed (January 5, 2016 interview with a scientist). Of interest, the member composition on the second committee also experienced a shift, as the second committee held less scientists and more city and industrial representatives (GAEPD Memos, 2000 & 2004).

Overall, several scientists in Georgia reported that the past and current variance protocols are "not scientifically grounded" due to "a lot of arbitrariness" (February 4, 2016 interview with a scientist). One interview subject argued that EPD and "wildlife folks" in Georgia did not have the same objectives when it came to riparian protection: "I think EPD in general was not

particularly helpful…It was fairly clear to me that their objectives weren't necessarily the same as the wildlife folks in Georgia" (February 4, 2016 interview with a scientist).

Overall, GAEPD played a significant role in shaping riparian protections, particularly with regard to the key issue of riparian variances. Though two Statewide Buffer Committees (2000, 2004) hosted scientists and discussed scientific data regarding riparian protections, current variance regulations remain muddled in the state as variances shifted more toward the interests of developers.

Comprehensive Statewide Water Plan (SWP) (2008)

The SWP (2008) was ultimately an overview document which provided statewide water policy statutes. The SWP statutes outlined how Regional Water Councils (RWCs) would transition into providing Regional Water Plans to the state to determine how state water planning would be administered. The SWP also served as the impetus for scientific data gathering to provide information for RWCs to create their Regional Water Plans. As one interview subject noted, "In the statewide plan there wasn't science. There was more science that went into the district plans after that" (March 4, interview with an environmental consultant). Two areas, in particular, were meant to provide significant scientific data/results/inputs to the RWCs: water resource assessments and forecasts (both water use and population-based). These areas are discussed in detail to demonstrate whether and how science was incorporated into statewide water planning efforts. A discussion of how scientific materials related to water resource assessments and forecasts were delivered to the RWCs, to allow for the creation of Regional Water Plans, follows.

- *The Politics of Water Resource Assessments and Forecasts*

According to the 2008 SWP, water resource assessments were to be conducted after the passage of the SWP to determine surface water availability, groundwater availability, and assimilative capacity of surface water resources. These assessments included the creation of hydrologic models, ongoing monitoring, and the compilation and management of water data. The purpose of these assessments was to provide each RWC with sound scientific information for their construction their first Regional Water Plans, to be released in 2011.

Our findings indicate that Georgia's Environmental Protection Division (GAEPD) was in charge of pulling together information for the RWCs. GAEPD first looked to the United States Geological Society (USGS) to provide data for the RWCs (December 15, 2015 interview with an environmental consultant). Several interviewees reported that the water data compiled by USGS was not a major factor included in the subsequent Regional Water Plans:

> "One of the recommendations that came out of the water plan was to do more water monitoring, more stream gauging, and groundwater level measurement, and water quality data. The USGS contract with EPD [GAEPD] ended up being expanded to do more of that. Anyway, they were involved, but USGS is a very data driven organization and the water plan work was not so data intensive. They were involved, but I don't want it to seem like there was a ton of data analysis because that's not really true." (December 15, 2015 interview with an environmental consultant)

Second, the GAEPD appointed a Scientific and Engineering Advisory Panel (SEAP) to provide GAEPD advice on water resource assessments. Ten scientists from around Georgia and throughout the United States were invited to serve on SEAP. SEAP's main objective was to provide GAEPD with advice on in-stream flow requirements or flow regimes for surface water assessments (November 9, 2015 interview with a scientist). They recommended GAEPD follow

the "percentage of flow approach," rather than the traditional 7Q10 approach[36], to meet in-stream flow requirements (November 9, 2015 interview with a scientist). However, the percentage of flow approach was not adopted for use in the SWP or subsequent Regional Water Plans; instead, 7Q10 remains the approach taken by the state of Georgia. One past member of SEAP inferred that their recommendation was not what GAEPD or the state of Georgia wanted to hear (November 9, 2015 interview with a scientist). Another past member indicated that they believed SEAP existed to "rubber stamp" GAEPD's recommendations and once members of SEAP conflicted with GAEPD's in-stream flow recommendation for statewide water planning efforts, they were disbanded after "one in-person meeting and handful conference calls" (October 26, 2015 interview with a scientist): "SEAP just disappeared…they [GAEPD] just stopped calling us. I wrote a letter saying I was on SEAP and the next I got a letter back officially [from GAEPD] declaring that SEAP was no longer in existence" (October 26, 2015 interview with a scientist).

Yet, another key interview subject argued SEAP was never intended to actually provide scientific expertise to statewide water planning efforts. Instead, SEAP was a technical body created with the intent of giving academic experts who wanted to have some role "a place to go" which, according to a key interview subject, "should not be confused with the body that decided on technical information" (Interview with an environmental consultant). This same subject relayed that members of SEAP were not the technical body providing scientific information for water resource assessments or other statewide water planning efforts because they, unlike environmental consultants and the GAEPD, have no credibility with the Georgia Legislature.

[36] 7Q10, low flow approach is determined by the lowest average flows that occur for a consecutive 7-day period at the recurrence intervals of 10 years (USEPA, 1997).

Our informal inquiry also revealed those few non-GAEPD scientists who were involved with SEAP during the SWP process are experiencing political fallout from their efforts to provide scientific input on environmental issues in Georgia. One of the non-GAEPD scientists involved in our study stated: "There are people on campus [UGA] that sat down to figure out who were good advisors to the state [Georgia] and a bunch of us got black-listed, saying no, we're not allowed to talk to the state.. a UGA professor involved broke into tears when they told me and a number of other faculty were specifically excluded by UGA [University of Georgia] administration in providing input to the state [Georgia]." Thus, the UGA administration has been advised by higher-up governmental officials to restrict scientific influence of UGA faculty to the state. Of concern, some interview subjects are also reporting that GAEPD is now encouraging other scientists in the state to submit their manuscripts for review to make sure their findings do not contradict with the state of Georgia's: "They told us that whenever you publish anything, make sure we send it to EPD [GAEPD] first to make sure it's in the state's interest, that your publications don't go against the state's." This finding counters typical instrumental views of the science-policy interface which focus on how science *informs* policy. Yet, our results offer additional evidence (in line with Hoppe, 2013; Goldman, 2011; Goldman and Turner, 2011; Forsyth, 2003; Hess, 1997) of how politics can ultimately shape and constrain scientific knowledge generation and utilization at the science-policy interface.

Water forecasting was also a fundamental component of the SWP and a central debate of the RWCs. Regional forecasts of water and wastewater demands were to be developed for the Regional Water Councils. These spanned ten, 20, 30, 40, and 50-year forecasts and included agricultural, domestic and commercial, energy, and industrial water use sectors. Information for

domestic and commercial, energy, and industrial water use sectors was provided through water municipalities and through industrial monitoring to GAEPD.

Due to the lack of information in Georgia regarding agricultural water use, GAEPD contracted the College of Environment and Environmental Sciences (Agriculture) at the University of Georgia and Albany State University of Georgia (Georgia Water Planning and Policy Center) to work together and conduct agricultural water forecasting for the SWP and the subsequent Regional Water Plans (February 2, 2016 interview with a scientist; Marshall, 2010). The goal of this work was to ultimately support "policymakers with information, advisement, and analyses to facilitate the completion of the new plan [SWP] for Georgia" (United States Department of Agriculture, USDA, 2008). Our findings indicated a great difficulty in scientists being able to produce agricultural forecasts which spanned 50 years and to produce these when they were contracted with DNR to *not* look into effects of climate change for the 50-year agricultural assessments (even if it was in their scientific opinion that climate change could significantly impact Georgia's agricultural water use in the future).

Our research also indicated that the groundwater data provided to those producing the agricultural forecasts may have had its shortcomings as the USGS withdrew their involvement on the project because they did not agree with the technical approach taken by GAEPD and felt their work was being more directed by politics, than by science. As one environmental consultant relayed, "There was a conflict between USGS and GAEPD over some aspects of some groundwater modeling that had been going on. We basically withdrew from that particular project because we did not agree with the technical approach that GAEPD wanted us to take. Because we didn't feel… We felt like it was not being directed by the science. It was being directed more by the politics" (March 23, focus group with scientists).

Finally, population forecasts also played a key role in the 2008 SWP and subsequent Regional Water Plans. Population projections are contracted to the Carl Vinson Institute of Government (CVIOG) at the University of Georgia for completion, with the original data (numbers) provided from the Office of Planning and Budget (OPB) (February 29, 2016 interview with an environmental consultant). When the first round of population projections were released in the state in 2009 they were met with "howls and cries of outrage… We ran up against a lot of vested interests of a wide array" (March 7, 2016 interview with a scientist). As this participant reported: "When these were first being developed, there was a huge uproar on population estimates because nobody wants to hear their county's shrinking and every place doesn't always grow. But if you say you're not growing, then you're feeling like your piece of the pie may be smaller" (March 7, 2016 interview with a scientist). The reaction to the population forecasts rippled statewide: "The Governor's office hearing from lobbying firms for the engineering companies, hearing from the power company, hearing from Georgia-Pacific, hearing from the regional councils of government on how horrible these projections are. That grabbed the Governor's attention" (March 7, 2016 interview with a scientist).

The RWCs also collectively wrote to Governor Perdue asking for the forecasts to be set aside and Georgia Power, a powerful stakeholder in the state of Georgia, further criticized the projections (March 7, 2016 interview with a scientist). Georgia Power's concerns became important enough that scientists working on the population projections at the CVIOG were asked to incorporate the "high-growth scenario" from "a private econometrics firm" working for Georgia Power (March 7, 2016 interview with a scientist) to protect industry growth and water consumption levels for more rural areas.

Part of the backlash for the original population projects also stemmed from the allowance of the Metro Atlanta Water District to conduct and utilize their own population projections, which would ultimately inform the Metro Atlanta Regional Water Plan and water allocation for Metro Atlanta (rather than the population projections completed by the CVIOG and OPB utilized by all RWCS in Georgia, besides Atlanta). These projections, as reported by our research participant were "way too high as far as what population growth was going to be;" yet, "it fell on deaf ears" and the population projections completed by the Water Resources Group for the Atlanta Water Council were the projection utilized for Atlanta's Regional Water Plan (March 7, interview with a scientist).

- *The Role of Science in Regional Water Council Decisions (RWCs)*

RWCs were created in the 2008 SWP to allow for regional water planning which would promote the sustainable use of Georgia's waters. From 2008-2011 information was delivered to each of the 11 RWCs in Georgia, to aid their water decision-making processes for the completing of their Regional Water Plans. Ultimately, our findings suggest that GAEPD and DNR played and continues to play a significant role in determining what information is collected, who collects information, and how this information is presented to the RWCs.

First, when scientists presented information (a rare occurrence) to the RWCs, these presentations were based on information from DNR and the "agenda was dictated by DNR" (March 7, interview with a scientist). Even if scientists presented the information at RWC meetings, the power points and information were developed by DNR and the "regional contractors" (i.e., environmental consultants hired to aid RWCs included Ch2mHill, Black & Veatch, JJ&G, and CDM) and then, in our interview subject's opinion, "spoon-fed to them" [RWCs' members] (March 7, interview with a scientist).

Second, GAEPD is in charge of hiring consulting firms to work with RWCs[37] and the consultant groups provide the vast amount of information provided to the RWCs. These consultant groups aided the RWCs with writing the 2011 Regional Water Plans and are currently in the process of working with the RWCs to submit an updated Regional Water Plan (supposed to have been due in March, 2017; Regional Water Plans have yet to emerge). However, the current systematic use of consulting firms by the GAEPD and Regional Water Councils has some scientists in Georgia concerned about the efficacy of the work of consultants, as "the availability and ease of use of models has definitely led to misapplication" (March 14, focus group with scientists) and when scientists have reviewed consultants work it is inaccurate: "we've seen a lot of that work and we've seen it done as many times incorrectly as we have correctly. (March 14, focus group with scientists)

However, the respondents of the RWCs questionnaire did mention a handful of scientists involved in also disseminating information to members. Respondent mentioned presentations from University of Georgia faculty, GAEPD employees, and the Georgia Water Planning & Policy Center. Yet, as our results indicate, the science that was presented (by both scientists and consultants) may not have been effectively communicated. Respondents wrote in their questionnaires that "future estimates on population and needs seem like Voodoo math and are really only scientific wild ass guesses"; and "Yes we received scientific info but many times sample size cause me to question conclusions." Another member felt that Regional Water Council members had been "railroaded" through the RWC process and that ultimately, the recommendations in their Regional Water Plan fell on deaf ears at the state level because the

[37] GAEPD hired CH2M Hill to work with Coosa–North Georgia. Black & Veatch worked with the Middle Chattahoochee, the Upper Flint, and the Lower Flint–Ochlockonee. JJ&G (Jordan, Jones, & Goulding), worked with Middle Ocmulgee, Upper Oconee, and Upper Savannah-Ogeechee. CDM worked with Suwannee-Satilla, Altamaha, and Coastal for the 2011 Regional Water Plans (December 15, interview with an environmental consultant).

Councils have “no power, no funds, and no voice”. Thus, many provided concluding remarks on their questionnaire about how their Regional Water Plans have become grey literature and stagnant since 2011.

To summarize, during the process of the SWP, resources assessments and forecasts (agricultural and population) were the main areas where science served a purpose. Key interview subjects suggested, however, that data analysis was not a huge part of the resource assessments, and past scientists on the Scientific Engineering Advisory Panel (SEAP) argued their recommendations for a “percentage flow approach” for the SWP were not considered. Our research on agricultural forecasting for the SWP also yielded scientific inconsistencies as key interview subjects discussed the difficulty of supplying 50-year models for water use especially when they were prohibited from including research which detailed future impacts of climate change. Evidence that the USGS withdrew from conducting research because they considered it “political” also raises red flags.

The population forecasts of the SWP could also be argued to reflect more political influence than scientific, as the original projections released were quickly rejected for “high-growth” models prepared by scientists with the help of Georgia Power. Finally, our research of the Regional Water Councils (RWCs) detailed how GAEPD and DNR played a heavy hand in how the resource assessment and forecasting science could be distributed to members of the councils and how this impacted their ability to construct their Regional Water Plans.

Discussion

Formal-Instrumental and Informal-Political Dimensions of Science-policy Processes in Georgia

In the analyses of formal and informal dimensions of the science-policy process, the Georgia Environmental Protection Division (GAEPD) emerged as the overarching boundary

organization at the center of science-policy activity in each water case study. Both results also indicated GAEPD ultimately structured scientific studies (focused on economics and biophysical sciences) and their dissemination to policymakers. In addition, results of the analysis of both informal and formal factors indicated there was little transparency concerning how scientific research was conducted as well as a lack of systematic evaluation of research (formal variables S19 and S24). Both results also indicated the boundary spanning process itself lacked transparency (S25) and a systematic evaluation of the boundary spanning process (S26).

With the formal results, it could be argued that GAEPD's actions ultimately demonstrate the effectiveness of utilizing a boundary organization during science-policy integration efforts and that the systematic evaluation of both research and corresponding boundary spanning processes were superfluous to successfully linking science and policy for the groundwater and SWP case studies. Yet, this juncture in the formal analysis pinpoints why in-depth systematic informal evaluations should occur at the science-policy interface. The extensive informal analysis ultimately expanded the formal analysis to understand *why* certain formal science-policy variables were not present during case studies. The results of the informal science-policy analysis ultimately provide a nuanced understanding of GAEPD's science-policy linkages in Georgia. The additional informal analysis demonstrated how the boundary spanning process was politically motivated, with larger entities (industry, agriculture, urban, and governmental) ultimately dictating scientific knowledge creation and utilization in the state. Thus, the informal analysis was far more useful in revealing how water policy is made in practice, including the generation of scientific evidence itself and the politicized process through which information was disseminated.

The informal analysis demonstrates how science was politicized and ultimately controlled by political powers in Georgia. The influence of political agendas concerning water policy efforts in Georgia is widespread as members of the Regional Water Councils likewise touched on the political stronghold of the state regarding science-policy linkages in their questionnaires: "The process is improving, but politics and larger stakeholders influence funding and research" (Respondent A, 2016); "there is still too much focus on the growth of Atlanta and accommodating their needs at the expense of other regions in the state. These are the politics of OPB and EPD" (Respondent I, 2016); and, finally, "Still a bit too political, but that will continue until the 'water wars' are resolved" (Respondent N, 2016).

In addition, the informal results uncovered the political filtering of *how science took form* (how it was created and who created it). Overall, the GAEPD, formally controlled (through hiring of environmental consultants, contracts, in-house and external (i.e., USGS) scientific studies, and dissemination of information to decisionmakers) the role of science with regard to each water case study. Though the formal-instrumental science-policy literature heralds co-production of knowledge (Jasanoff, 2004) as inherently beneficial, our results point to co-production as a further tactic in controlling the science ultimately incorporated into policy in the state of Georgia. Our ethnographic work further revealed (Jensen-Ryan and German, 2017, forthcoming), how GAEPD controls the role of science is ultimately dictated by those individuals and stakeholder groups associated with agricultural, industry, and governmental entities in Georgia. Though GAEPD is the formal structure providing the medium through which science and science-policy linkages occur in the state, the established systems of social and informal relationships within, among, and outside of various institutional capacities ultimately shaped the trajectory of each water policy case study. Thus, our results indicate GAEPD is

beholden to powerful agricultural, industry, and governmental entities in the state, especially since most who are positioned in high-level environmental policy roles (Director of the GAEPD, DNR Board, and RWCs) are political appointees of the Governor; contradicting a sweeping gubernatorial agenda would result in political ruin for an individual appointed to serve.

The informal results further indicated the politicization of science in Georgia as government officials are now appointing legal experts as top leaders in environmental decision-making in the state. As a scientist in Georgia stated, "I do think that one of the things that has changed in Georgia is that EPD used to be run by engineers who had scientists as staff…I feel like the EPD has become an agency that's largely driven by legal concerns as opposed to environmental concerns. I'm not sure when we decided that it would be good to have lawyers in charge of environmental policy, but I don't think it was the right decision."

The informal science-policy results ultimately build on previous work which highlights politicized science-policy environments (*see* Lemos et al., 2012; Pielke, 2007) and the importance of divulging the political orientation of boundary organizations, boundary spanning processes, and boundary spanners (Hoppe, Wesselink, and Cairns, 2013). Through our detailed ethnographic analysis, the historical political "positionality" of GAEPD was analyzed (Kirchoff, Lemos, Engle, 2013) and critiqued. In line with Hoppe's (2010) work on how "policy politics" and "political-cultural spheres" shape boundary organizations and boundary spanning processes, our results indicated more powerful political entities in the state ultimately shaped water science-policy efforts. The informal results, then, provide a deeply embedded knowledge of political networks which shape science-policy decisions in Georgia and the boundary organization at the center of all environmental matters in the state (Dilling and Lemos, 2013).

Conclusion and Recommendations

As environmental science and politics collide at an ever growing rate in the twenty-first century, uncovering how sound science may influence policymakers and subsequent policy action is critical. Our research provides a more holistic and systematic approach to understanding how formal-instrumental and informal-political factors influence the science-policy interface through a comparative assessment of studies focused on the environmental science and policy linkages. We examined whether and how formal and informal factors influence the science-policy interface in Georgia and whether advantages exist to including an extensive analysis of informal science-policy factors. To address our research questions we focused on three water policy case studies in Georgia: (1) regulation of groundwater withdrawals, (2) riparian protections, and (3) the Comprehensive Statewide Water Plan (2008). We utilized formal science-policy variable frameworks established in a science-policy meta-synthesis (systematic assessment of published case studies) to distinguish formal factors present in each water case study. The extensive ethnographic inquiry investigated informal political factors present during science-policy integration efforts.

Our ethnographic investigation provided a deeper level of analysis than the investigation of the formal features of the policy process. The ethnographic analysis revealed how science itself was politicized in Georgia before it was dispersed through stakeholders (both scientific and non-scientific) to engage in science-policy efforts and policymaking decisions. Without the in-depth study of what constituted science in each case study and the informal science-policy factors shaping its influence in the state, it may have seemed, superficially, that science was utilized in each water case study. It may have also seemed that a boundary organization (GAEPD) distanced from both science and politics was effectively bridging the two worlds, as

science-policy influence was found to be present in two of the three water case studies. Yet, as the results indicated, GAEPD is but an instrument of larger political entities in Georgia who structure and politicize science at boundary.

Our informal results further queried the assumption from the literature advancing more instrumental views of the policy process that co-production of knowledge (Jasanoff, 2004) is inherently beneficial; instead, our results indicate co-production in Georgia was utilized as a tactic to police science. Through filtering data between science-policy entities, data was ultimately swayed to politically align with larger prevailing interests (e.g., agriculture, industry, and governmental). In addition, our work raises issues with how instrumental perspectives view the directionality of the science-policy relationship. Contrary to the assumption that science shapes policy, our work further contributes to evidence of the opposite—politics shaping, and ultimately constraining, scientific generation and utilization.

The ethnographic results also uniquely contribute to a deeper, though admittedly darker, understanding of the various problems associated with the uptake of science discussed in the science-policy literatures. Our work provides a better understanding of *why* a lack of constructive engagement between scientists and decisionmakers may exist (*see* Driscoll et al., 2011): the purposeful separation and exclusion of scientists from engaging in political spheres and the tepid attempts of scientists to immerse themselves in messy policy spheres. It also provides a better understanding for *why* challenges of incorporating sound scientific information into policy exist (*see* Kirchoff et al., 2013): governmental contracts prohibit scientific experts from including evaluations which may contradict with current cultural-political spheres (e.g., the inclusion of certain groundwater tests and information regarding climate change in Georgia). Our results provide further explanation for *why* poor access to research findings may exist (*see* Driscoll et

al., 2011): powerful political entities (like Georgia's DNR) dictate research agendas and their dissemination, which can lead to poor access to research findings *and* strategically positioned research findings which support political agendas. In other words, poor access to research findings exist due to strategic scientific studies subjectively distributed for political consideration.

Finally, our work is significant as it provides further evidence of the loss of clarity over what constitutes scientific evidence along with the discursive production of scientific 'facts' (*see* Ehrlich and Ehrlich, 1996). It provides a clear example of the politics of scientific construction and practice (*see* Forsyth, 2003; Hess, 1997) and evidence of how science and politics are inextricably interlinked and "co-produced" (Jasanoff, 2004a) (i.e., science and policy do not exist in political vacuums). Our work demonstrates how politics can influence science in its production, application, and circulation—ultimately demonstrating "the politics of knowledge" as it exists in the state of Georgia (*see* Goldman, 2011; Goldman and Turner, 2011). Future research should continue to discuss the politicization of science (including a focus on boundary organizations and more instrumental science-policy integration efforts) and to highlight cases where scientific manipulation occurs. Perhaps only through uncovering practices which politicize science, can scientists and others create strategies to better separate science and politics in the future. Additional research should:

(1) Build on our ethnographic analysis to develop criteria to critically analyze political orientations of boundary organizations and boundary spanning processes, and how political agendas influence science-policy integration efforts (*see* Hoppe 2010; 2013);

(2) Develop criteria to more strategically analyze broad political biases present at science-policy interfaces and during the co-production of knowledge, and how these impact science-policy linkages;

(3) Further develop the history of the politicization of science, to determine whether and how scientific endeavors have transcended political spheres, especially as science in the 21st century faces sharp scrutiny;

(4) Continue scholarship which develops how perceptions and measurements of academic "success" can be altered to include effective science-policy collaboration; and

(5) Pilot new models of academic engagement in policy spheres, with the aim of balancing the accuracy of social and environmental evidence informing policy with the dynamics of highly politicized policy spheres as "insiders" or as critics of the policy process.

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Table 5.1. List and Description of Georgia Water Policy Case Studies

Case Study	**Resolved or Unresolved**	**Success or Failure**	**Contentious or Non-contentious**
i. Regulation of Groundwater Withdrawals	Resolved	Mixed	Non-contentious
ii. Riparian Protections	Resolved	Success	Highly Contentious
iii. Comprehensive Statewide Water Plan (2008)	Unresolved	N/A	Contentious

Table 5.2: Formal Science-policy Features, Georgia Water Policy Case Studies, Results

Feature	Variables	GW	RIP	SWP
Formality	F1: Formality	**1**	**1**	**1**
Multi-disciplinary	F2: Multi-disciplinary Organization or Expertise	**0**	**0**	**1**
Legislated	F3: Legislative mandate	**0**	**0**	**1**
Scale: The scale at which BSP was carried out	F4: Local	**1**	**1**	**1**
	F5: State	**1**	**1**	**1**
	F6: Regional	**0**	**0**	**0**
	F7: National	**0**	**0**	**0**
	F8: International	**0**	**0**	**0**
Funding Source: The source of funding for BO and/or BSP	F9: Public	**1**	**1**	**1**
	F10: Industry	**0**	**0**	**0**
	F11: Foundation	**0**	**0**	**0**
	F12: Funding Allocating Body/Action	**0**	**0**	**1**

Table 5.3: Formal Science-policy Strategies, Georgia Water Policy Case Studies, Results

Strategy	Variable	GW	RIP	SWP
Boundary Organization	S1: Utilized boundary organization	**1**	**1**	**1**
Boundary Spanner	S2: Utilized boundary spanner	**1**	**1**	**1**
Co-production[38]	S3: Co-production of knowledge	**1**	**1**	**1**
	S4: Facilitation of co-production of knowledge	**1**	**1**	**1**
	S5: Creation of boundary object	**0**	**0**	**0**
	S6: Created conditions conducive to learning	**0**	**0**	**1**
Informal[39]	S7: Relationship and social capital building	**0**	**0**	**1**
	S8: Built a political constituency	**0**	**0**	**1**
Media	S9: Mass media involvement	**0**	**0**	**1**
Saliency[40]	S10: Decision-aids developed by scientist	**1**	**1**	**1**
	S11: Created scientific advisory group	**0**	**1**	**1**
	S12: Adapted research (scale)	**1**	**1**	**1**
	S13: Adapted research (scope)	**1**	**1**	**1**
	S14: Systematic engagement with local knowledge and perspectives	**1**	**0**	**1**
	S15: Engaged in adaptive management	**1**	**1**	**1**
	S16: Government involvement	**1**	**1**	**1**
Legitimacy[41]	S17: Scientific knowledge dissemination	**1**	**1**	**1**
	S18: Managed scientific uncertainty	**0**	**0**	**0**
	S19: Enhanced transparency (research)	**0**	**0**	**0**
	S20: Joint visits to research sites	**0**	**0**	**0**
	S21: Dissemination of research/data to public	**0**	**0**	**1**
Credibility[42]	S22: Conflict resolution	**0**	**0**	**1**
	S23: Skill development	**0**	**0**	**1**
	S24: Systematic research evaluation	**0**	**0**	**0**
	S25: Enhanced transparency (process)	**0**	**0**	**0**
	S26: Systematic spanning process evaluation	**0**	**0**	**0**

[38] Co-production was defined as knowledge is co-produced by scientists and policymakers (Jasanoff, 2004).

[39] Informality was defined as inter-personal, relationship driven contact and/or networking during science-policy process (Lemos and Morehouse, 2005; Otronen, 2003).

[40] Saliency was defined as when a boundary organization or spanning process engaged in activities designed to enhance the "relevance of the assessment to the needs of decision makers" (Cash, 2003:8086).

[41] Legitimacy was defined as when a boundary organization or spanning process engaged in activities aiming to create the "perception that the production of information and technology has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of opposing views and interests" (Cash, 2003:8086).

[42] Credibility was defined as when a boundary organization or spanning process engaged in activities to enhance and/or communicate the "scientific adequacy of the technical evidence and arguments" (Cash, 2003:8086).

Table 5.4: Formal Science-policy Other, Georgia Water Policy Case Studies, Results

Other	Variables	GW	RIP	SWP
Policy Window	Oth1: Window of policy opportunity existed	**0**	**0**	**1**
Type of Science Utilized	Oth2: Social Science Only	**0**	**0**	**0**
	Oth3: Economics Only	**0**	**0**	**0**
	Oth4: Biophysical Science Only	**0**	**0**	**0**
	Oth5: Mixed Evidence/methods	**1**	**1**	**1**
	Oth6: Quantitative Only	**1**	**1**	**1**
	Oth7: Qualitative Only	**0**	**0**	**0**
	Oth8: Quantitative *and* Qualitative	**0**	**0**	**0**

Table 5.5: Formal Science-policy Outcomes, Georgia Water Policy Case Studies, Results

Outcomes:	Variables	GW	RIP	SWP
Awareness	O1: Awareness among policymakers	**0**	**0**	**1**
Awareness	O2: Awareness among public	**0**	**0**	**1**
Government Committee	O3: Creation of governmental committee	**0**	**0**	**0**
Judicial	O4: Evidence of judicial impact	**0**	**0**	**0**
Judicial	O5: Evidence of judicial impact	**0**	**0**	**0**
Executive Order	O6: Evidence of executive order impact	**0**	**0**	**0**
Legislative	O7: Evidence of legislative impact	**1**[43]	**0**	**1**[44]
Implementation	O8: Evidence of implementation	**1**	**0**	**0**

[43] The merits of the science which shaped the 2012 groundwater moratorium is debatable.
[44] The merits of the science which shaped the SWP and subsequent Regional Water Plans is debatable.

CHAPTER 6

CONCLUSION

This dissertation research investigated the relationship between environmental science and policy, with the aim of finding common ground for strengthening the role of scientific evidence in policy development. This project is important as humanity faces increasingly intractable environmental problems characterized by high uncertainty, complexity, and swift change (Crona and Parker 2012). How science is developed and applied to policy-making is one major factor influencing "humanity's environmental future" (Caldwell 1990). Yet, science is currently underutilized in environmental policy despite the growing call for effective scientific engagement in public policy (NSF 2002). How to effectively research and address these obstacles is a top priority in the twenty-first century.

This research followed a three-phase approach. The first phase consisted of a meta-synthesis of existing literature of boundary organizations and boundary spanning to assess formal variables shaping the effectiveness of science-policy integration. Phase two involved an in-depth ethnographic inquiry of three water policy case studies in the state of Georgia. The ethnographic phase provided a deeper look into the informal social and political factors shaping environmental policy in the state. The third phase was analytical, consisting of an analysis of the formal features of the science-policy interface for the three water policy case studies in Georgia, and its juxtaposition with an analysis of informal factors shaping the science-policy interface based on the ethnographic analysis. This comparative assessment gives deep insight into water policymaking in the state of Georgia, while also enabling theory-building by exploring what is

gained and lost through different theoretical lenses and thus putting into question some of the fundamental assumptions of formal-instrumentalist views of the science-policy interface—such as that advocated for by boundary organization theorists.

This chapter provides a summary and synthesis of the main findings from the research presented in this dissertation. I begin with a discussion of the findings from Chapters 3-5. I then discuss the theoretical implications of the findings in terms of their contribution to the science-policy interface and policy processes literatures. Next, I discuss these findings within the context of recommendations for both policy and academia. I close the chapter with future research questions that emerged from the findings of this dissertation.

Meta-synthesis of science-policy case studies

Chapter 3 investigated science-policy linkages through a meta-synthesis of published case studies on boundary organizations and boundary spanning processes. Overall, 39 published case studies were analyzed through a systematic grounded theory approach and 39 structured interviews were performed with authors to validate the grounded theory results. During the grounded theory phase of research, 47 explanatory science-policy variables were identified and evaluated using aggregated and disaggregated statistics to determine correlation with science-policy outcomes. Variables associated with the scale of boundary organizations and/or boundary spanning processes, media involvement, and creating salient, legitimate, and credible information for policymakers positively correlated with science-policy outcomes. The meta-synthesis further develops the possibility that successful science-policy linkages may be less about utilizing formal boundary organizations and spanning processes and more about fostering the *process* through which science and policy are intermingled.

A critical assessment of water policymaking in Georgia

Building on the meta-synthesis, Chapter 4 explored the relative influence of science-policy factors in contentious environmental arenas through an ethnographic inquiry. Specifically, I examined how water policy was created in Georgia and the extent to which various factors significantly influenced policy trajectories. Overall, the findings support the conception of policy through critical-based political theories rather than purely instrumental and political theoretical lenses, as evidence of a web of multifaceted dynamic policy processes and influences structure water policy decisions in Georgia. Although hundreds of individuals and stakeholder groups were involved in the state of Georgia in each water case study, those associated with agricultural, industrial, and governmental entities significantly influenced water policy efforts. The handful of stakeholder groups who structure water policy decisions in Georgia provide a deeply embedded power core. Though formal institutions (e.g., Georgia Legislature and Georgia Department of Environmental Quality) provided a structure for interaction, the established systems of social and informal relationships within, among, and outside of various institutional capacities ultimately shaped each water policy case study in Georgia.

A comparative science-policy assessment

Chapter 5 examined whether and how formal and informal factors influence the science-policy interface in Georgia and whether advantages exist to including an extensive analysis of informal science-policy factors. The three Georgia water case studies provided the basis for the formal and informal comparison to provide a nuanced and more holistic analysis of the science-policy factors significantly influencing water policy. Our results support the advantages of conducting a deeper-level of science-policy analysis through an informal approach as the formal analysis provided little detail surrounding water policymaking efforts in Georgia. The extensive

informal approach provided evidence of the politicization of science before it was dispersed through stakeholders for water decisionmaking efforts. It also uncovered scientists' lack of understanding of how to effectively influence environmental policymaking in Georgia.

Theoretical implications

Overall, this dissertation advanced theory building on boundary organizations while testing core assumptions and identifying limitations of boundary organization theory. It expanded our understanding of what informal factors and processes shape the science-policy interface. Fundamentally, this research provided additional information on how knowledge and information becomes policy and which mechanisms enhance/hinder the incorporation of sound science into environmental policy.

In addition, the meta-synthesis provided detailed processes and variables associated with boundary organizations and boundary spanning, while providing the necessary conditions to further develop the theory of science-policy linkages, and boundary organization theory specifically. The frequent and positive correlations between science-policy strategies associated with saliency, legitimacy, and credibility and outcomes emerged at the forefront of this study. A shift in focus from development of formal/institutional boundary organizations and/or spanning efforts to the science-policy processes—especially those mechanisms which bolster saliency, legitimacy, and credibility—may be fruitful to overcome current science-policy interface obstacles. The focus of boundary work as seemingly separate from formal institutions or organizations may enhance its perception (and reality) of being distant from political interference, thus bolstering its potential credibility to influence science-policy efforts. By concentrating on the process itself, the alignment of different types of knowledges from different actors (e.g., citizens, professionals, bureaucrats, experts) may be better exercised to ultimately

coordinate the effective production, dissemination, and acceptability of knowledges for political decisions.

The ethnographic inquiry contributes to the body of work on political theory and environmental policy analysis through providing a deconstructed policy analysis of the processes at play during water policy efforts in the state of Georgia. Our findings support the conception of policy through critical policy theories rather than purely instrumental and political lenses, as evidence of a web of multifaceted dynamic policy processes and influence structure water policy decisions in Georgia.

Finally, the formal and informal science-policy comparison uniquely contributes to a nuanced understanding of the various problems associated with the uptake of science discussed in the science-policy literatures. Explicating fine-tuned details of science-policy linkages within wider political and institutional contexts through in-depth ethnographic inquiry ultimately demonstrated how science is politicized during science-policy integration efforts and which entities dominate science-policy arena in Georgia. This work provides a detailed analysis of why certain obstacles commonly discussed in science-policy literatures may continue to exist.

Policy implications

Overall, in examining the role of science within the wider hierarchy of influences on decision-making, and the role of formal and informal factors in shaping outcomes, actors engaged in environmental issues in Georgia (the legislature, citizen groups, scientists) and nation-wide are better equipped to address environmental concerns in the future. This project shed light on the more politically-sensitive arenas, like environmental science in conservative political arenas, where science is often marginalized and consensus often difficult to achieve. It

contributes to our understanding of the conditions under which science can play a meaningful role in the successful implementation of sound environmental policy.

Drought and increased water demand from population and industrial growth have brought water issues to the forefront of environmental policy-making in Georgia. This project informs efforts to strengthen the science-policy interface, both in the state of Georgia and more broadly. This work demonstrates how scientists in Georgia need to make concerted efforts to engage in political arenas if they are to inform the science utilized to shape decisionmaking efforts in the state. Chapter 3 provides a basis of information for scientists with regard to whom, and which entities, they should begin communicating with and building bonds. This work also stresses the need for scientists to engage with governmental agencies (USGS and GAEPD) in their scientific efforts (both in structuring and executing studies and in disseminating knowledge).

Future Questions

Our work provides a starting point for understanding the crucial role played by science-policy variables, but additional work is required to understand the nuances and dynamics involved within each of these processes. Academic and applied researchers should focus on exactly *how* science-policy variables result in successful science-policy integration, while investigating other explanatory variables (alone and in combination) which may also significantly influence the uptake of environmental science in policy.

Future research should also critically assess:

(1) Whether and how stakeholders on the periphery of policy spheres (i.e., environmental groups, scientists, etc.) may be able to effectively access and establish political networks in conservative and contentious environmental arenas;

(2) Long-term implications of powerful social and informal political spheres and how these impact environmental policy efforts in Georgia and nationwide;

(3) Whether and how entrenched political establishments can be subverted to influence environmental policymaking in politically divided arenas.

Finally, the results of this dissertation recommend:

(1) Building on the efforts of our informal analysis to develop criteria to critically analyze political orientations of boundary organizations and boundary spanning processes, and how political agendas influence science-policy integration efforts (*see* Hoppe 2010; 2013);

(2) Developing criteria to more strategically analyze broad political biases present at science-policy interfaces, and how these impact science-policy linkages;

(3) Further developing the history of the politicization of science, to determine whether and how scientific endeavors have transcended political spheres, especially as science in the 21st century faces sharp scrutiny and competes with false scientific claims;

(4) Continuing scholarship which develops how perceptions and measurements of academic "success" can be altered to include effective science-policy collaboration; and

(5) Piloting new models of academic engagement in policy spheres, with the aim of enhancing validity of the "data" used to justify policy choices—whether as partners or critics of the policy process.

APPENDIX A

Environmental Science and Policy: Meta-synthesis Search Strategy

Database Searches	• Google Scholar • University of Georgia's Library Multi-search tool (which includes 134 databases: Academic Search Complete, ERIC, JSTOR, MLA Bibliography, Project Muse, Sage Reference Online, among others) • Science Direct (all sciences) • Web of Science (all sciences) • Environment Complete (articles related to environmental topics).
Key Words and Phrases	• environmental AND "boundary organization" AND case study • environmental AND "boundary organisation" AND case study • environmental AND "boundary institution" AND case study • environmental AND "science-policy interface" AND case study
Citation Tracking	• Reference list searches • Manual searches of five key journals (*Environmental Policy & Science, Journal of Environmental Policy & Planning, Forest Policy and Economics, Global Environmental Change,* and *Science and Public Policy*)
Expert Contacts	• David Guston, Maria Lemos, Kathy Jacobs, David White, Rob Hoppe, Elizabeth McNie, and Lisa Dilling

APPENDIX B

Environmental Science and Policy:
Articles Reviewed by Meta-synthesis Inclusion Criteria

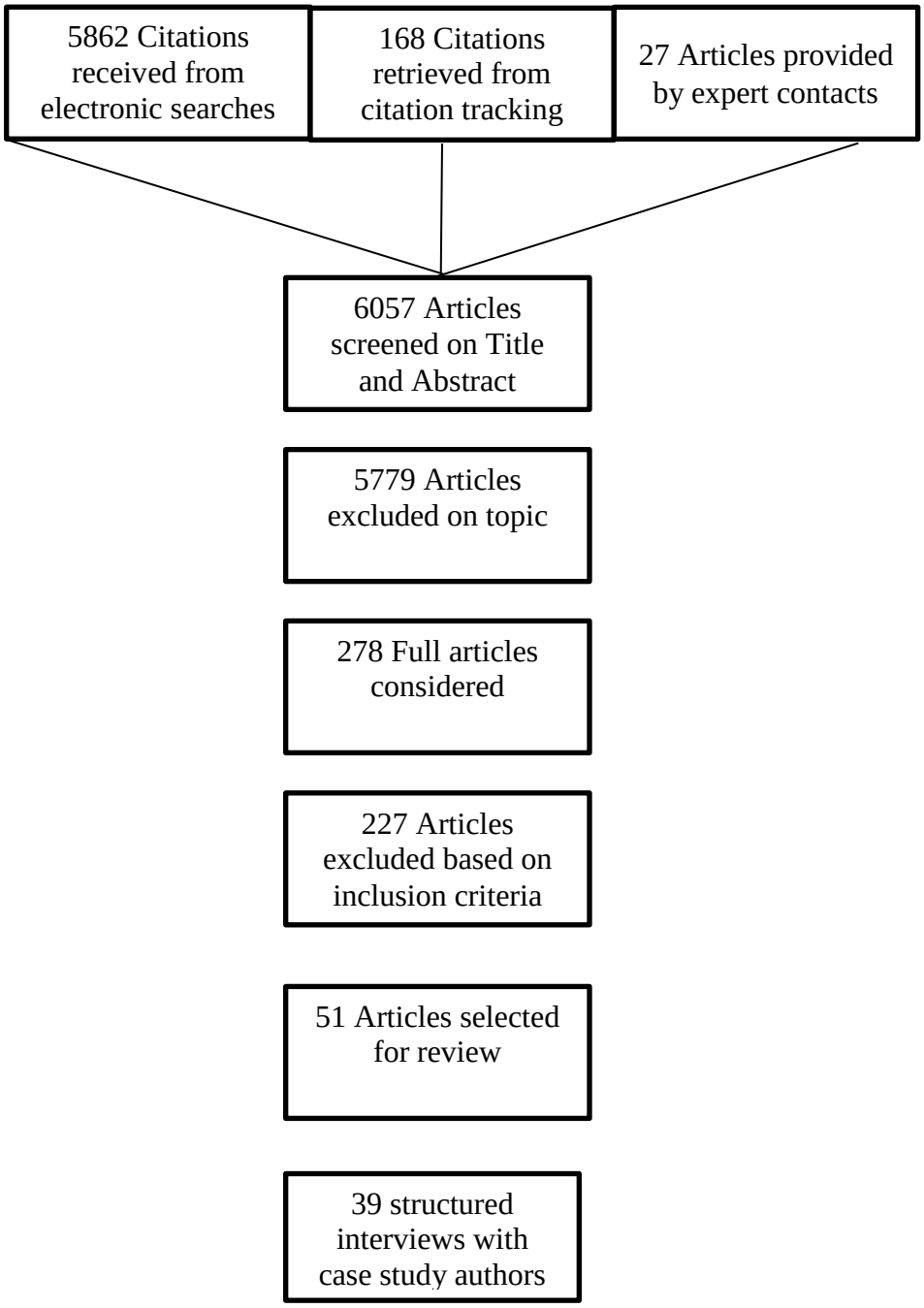
Key Bodies of Literature	Key Sources
Boundary Spanning and Boundary Organization Literature	Affolderbach et al 2012; Agrawala 2001; Armitage et al. 2011; Barreteau 2011; Bauler 2012; Boezeman et al. 2013; Bosselmann and Lund 2013; Breuer et al. 2010; Brunel et al. 2013; Candemir and Van Lente 2007; Carden and Neilson 2002; Carr and Wilkinson 2005; Cash 2001; Clark et al 2011; Crona and Parker 2011, 2012; Cutts et al. 2011; Dammann and Gee 2011; Davenport and Leitch 2005; Desveaux et al. 1994; Drimie and Quinlan 2011; Driscoll et al. 2011; Eckley 1999, 2000; Eden 2011; Enserink et al. 2013; Feldman and Ingram 2009; Fogel 2005; Franks 2010; Giebels et al. 2013; Goldberger 2008; Gopal and Gosain 2009; Grainger and Obersteiner 2011; Guston 1999, 2000; Guston et al. 2001; Hahn et al. 2006; Harvey and Stocker 2014; Hastings 2011; Heikkila and Gerlak 2005; Hellström and Jacob 2003; Holmes and Lock 2010; Hoppe 2008; Hoppe 2014; Hoppe et al. 2013; Hoppe and Wesselink 2014; Howells 2006; Hudgik and Arch 2003; Hughes and Romero-Lankao 2014; Jolink and Niesten 2012; Kallis et al. 2009; Keller 2010; Kirchhoff et al. 2013; Kirchoff et al. 2013; Klerkx and Leeuwis 2008, 2009; Kueffer et al. 2014; Lee et al. 2014; Leith et al. 2014; Lemos and Morehouse 2005; Levina and Vaast 2005; Logar and Conant 2007; Mahony 2009; Marrone 2010; Miller 2001; Niederberger 2005; Norgaard et al. 2009; O'Mahony and Bechky 2008; Osmond et al. 2010; O'Toole et al. 2013; Parker and Crona 2012; Pesch et al. 2012; Pham et al. 2010; Pietrie et al. 2011; Santoro et al. 2013; Sapsed et al. 2007; Sarkki et al. 2013; Schultz 2009; Shaw 2005; Shaw et al. 2013; Siebenhüner 2003; Souren et al. 2007; Sternlieb et al. 2013; Taylor and Short 2009; Thomas et al. 2012; Timotijevic et al. 2013; Tomich et al. 2007; van der Molen et al. 2015; Varady et al. 2013; Vignola et al. 2013; von Heland et al. 2014; Williams, in press;
Science-policy Interface	Acreman 2005; ApSimon et al. 2002; Archie et al. 2014; Arnold et al. 2005; Ascher et al. 2010; Boehmer-Christiansen 2003; Boesch 1999; Booth 1990; Boulton et al. 2008; Bourgeois 2002; Bracken and Oughton 2013; Bremer and Glavovic 2013, 2013; Brooks 2003; Brown 1991; Cash et al. 2002; Cash et al. 2003; CGIAR 2009; Clapp and Mortensen 2011; Cortner 2000; Cossarini 2014; Côté et al. 2001; Crouch and Smith 2011; Dalrymple 2006; Davoudi 2006; DeFries et al. 2012; Deelstra et al. 2003; DeLange et al. 2007, 2010; DeMeritt 2006; de Vries et al. 2010; Dilling 2007; Dilling and Lemos 2011; Donovan and

	Oppenheimer 2014; Donovan et al. 2012; Driscoll et al. 2007; Durant 2006; Edelenbos et al. 2011; Eden et al. 2006; Eden and Tunstall 2006; Ellefson 2000; Eriksson et al. 2010; Fish et al. 2010; Floor et al. 2013; Fritz 2010; Funtowicz and Strand 2006; Garrelts et al. 2005; Gober and Wheater 2014; Godfrey et al. 2010; Guay 1999; Guildin 2003; Guldin et al. 2004, 2005; Guldbrandsen 2008; Halffman and Hoppe 2005; Hegger et al. 2012; Henstra 2010; Herrick 2004; Hickey et al. 2013; Hirsch-Hadorn et al. 2004; Holifield 2009; Holmes and Clark 2008; Holmes and Savgård 2009; Hoppe 2010; Hueston 2013; Imeson et al. 2006; Innes 2003; Irvine 2009; Ison et al. 2011; Jacobs 2002; Jacobs and Holway 2004; Jacobs and Pulwarty 2003; Jacobs et al. 2005; Jagtap et al. 2002; Jakobsen 2000; Janse 2008; Janse and Konijnendijk 2007; Jones et al. 1999; Joyce 2003; Kamelarczyk and Gamborg 2014; Kinzig et al. 2013; Konijnendijk 2004; Lach et al. 2003; Lahsen and Nobre 2007; Lahsen 2009; Lange and Garrelts 2007; Larson et al. 2009; Lavis et al. 2003; Lemmons and Brown 1995; Lemos 2003; Lemos 2007; Lemos et al. 2002; Lemos et al. 2012; Lemos and Rood 2010; Lewis 2006; Liu et al. 2008; Lopez-Rodriguez et al. 2015; Lövbrand 2007; Mayer and Rametsteiner 2004; McFadden 2007; McNie 2007; McNie et al. 2008; Merideth et al. 1998; Michaels 2009; Milad et al. 2011; Mills and Clark 2001; Naylor et al. 2012; Niemeijer 2002; Norse and Tschirley 2000; Nursey-Bray et al. 2014; Oliver et al. 2005; Olsson et al. 2007; Olsson et al. 2004, 2004, 2006; Osmond et al. 2010; Owens 2005; Owens et al. 2006; Pahl-Wostl 2013; Pannell and Roberts 2009; Perrings et al. 2011; Peterson and Shriner 2004; Petrokofsky et al. 2010; Petts et al. 2008; Pielke 1995; Pihlajamäki and Tynkkynen 2011; Polacheck 2012; Pouyat et al. 2010; Pregernig 2000; Pulwarty 2003; Pulwarty et al. 2009; Quay 2004; Quevauviller 2010, 2010; Quevauviller et al. 2005; Rabalais et al. 2002; Rice et al. 2009; Robinson et al. 2012; Ruckelshaus et al. 2002; Runhaar 2009; Saraweitz and Pielke 2007; Saraweitz et al. 2000; Schaefer and Bielak 2006; Schmolke et al. 2010; Schut et al. 2013; Schwach et al. 2006; Selin and Eckley 2003; Selin and Hjelm 1999; Serrat-Capdevila et al. 2009; Shaw et al. 2000; Shaxson 2009; Slob 2007; Soomai 2013; Soomai et al. 2011; Spies et al. 2010; Spilsbury and Nasi 2006; Spray et al. 2009; Steel et al. 2004, 2006; Sterk, B. et al. 2009; Storch and Winkel 2013; Sundqvist et al. 2002; Surridge and Harris 2007; Swart and Van Andel 2008; Szaro et al. 2000; Tett et al. 2012; Thompson et al. 2011; Thrift et al. 2009; Tomlinson and Davis 2010; Totlandsdal et al. 2007; Tuinstra 2005, 2007; Tuinstra et al. 2006; Turner 2000; Udovyk 2014; van Kerkhoff 2005; van Kerkhoff and Lebel 2006; Vasileiadou 2011; Vervier et al. 2010; Vogel et al. 2007; Weichselgartner and Kasperson 2010;

	Weiss 1978; Wilkening 2004; Willems and de Lange 2007; Wilson and Delaney 2005; Yearley 2006; Young et al. 2014; Zehr 2005; Zhong et al. 2013;

APPENDIX C

Environmental Science and Policy: Search and Appraisal Process Flowchart



APPENDIX D

Environmental Science and Policy: Published Case Studies Included for Evaluation in Meta-Synthesis.

Key Bodies of Literature	Key Sources
Boundary Spanning and Boundary Organization Literature	Breuer et al. 2010; Brunel et al. 2013; Carden and Neilson 2002; Carr and Wilkinson 2005; Cash 2001; Clark et al 2011; Crona and Parker 2012; Cutts et al. 2011; Driscoll et al. 2011; Eden 2011; Franks 2010; Guston 1999; Hahn et al. 2006; Hastings 2011; Holmes and Lock 2010; Hoppe 2010; Hoppe et al. 2013; Kallis et al. 2009; Kirchoff et al. 2013; Klerkx and Leeuwis 2008, 2009; Kueffer et al. 2014; Lee et al. 2014; McNie et al. 2008; Niederberger 2005; Sarkki et al. 2013; Shaw et al. 2013; Timotijevic et al. 2013; Tomich et al. 2007
Science-policy Interface	Arnold et al. 2005; Bracken and Oughton 2013; Bremer and Glavovic 2013; Clapp and Mortensen 2011; Donovan and Oppenheimer 2014; Holmes and Savgård 2009; Innes 2003; Kamelarczyk and Gamborg 2014; Lahsen 2009; Lopez-Rodriguez et al. 2015; Naylor et al. 2012; Quay 2004; Rice et al. 2009; Schut et al. 2013; Schwach et al. 2006; Shaw et al. 2000; Thrift et al. 2009; Tuinstra et al. 2006; Tuinstra 2007; Turnhout 2008; Udovyk 2014; Vogel et al. 2007; Zehr 2005

APPENDIX E

Environmental Science and Policy: Detailed Description of Published Case Studies

15 of the 51 (29.4%) case studies were non-Western in their scope. One was conducted in the Mediterranean region (Brunel et al. 2013), three in Brazil (Hastings 2011; Kirchhoff et al. 2013; Lahsen 2009), three in Africa, including Zambia (Kamelarczyk and Gamborg 2014), Mozambique (Schut et al. 2013), and South Africa (Vogel et al. 2007), and finally, eight case studies were broadly international in their scope and all, interestingly, discussed issues of global climate change and its relation to resource scarcity, vulnerability, and agricultural practices (Buizer et al. 2010; Carden and Neilson 2002; Clark et al. 2011; Hoppe 2010; Hoppe et al. 2013; Kueffer et al. 2014; Lee et al. 2014; Tomich et al. 2007).

36 of the 51 (70.58%) case studies focused on Western countries including the United States (Breuer et al. 2010; Crona and Parker 2012; Cutts et al. 2011; Driscoll et al. 2011; Eden 2011; Guston 1999; Kallis et al. 2009; Quay 2004; Rice et al. 2009; Zehr 2005), Australia (Carr and Wilkinson 2005; Cash 2001; Shaw et al. 2013), Canada (Clapp and Mortenson 2011; Innes 2003; Thrift et al. 2009), the United Kingdom (Timotijevic et al. 2013; Bracken and Oughton 2013), the British West Indies (Donovon and Oppenheimer 2014), New Zealand (Bremer and Glavovic 2013), The Netherlands (Franks 2010; Klerkx and Leeuwis 2008, 2009), Sweden (Hahn et al. 2006;), Switzerland (Niederberger 2005), Finland (Sarkii et al. 2013), Spain (Lopez-Rodriguez et al. 2015), and generally, Europe (Holmes and Lock 2010; Arnold et al. 2005; Holmes and Savgård 2009; Naylor et al. 2012; Schwach et al. 2007; Tuinstra 2007; Tuinstra et al. 2006; Turnhout et al. 2008; Udovyk 2014).

Over half of the case studies (n=28, 54.9%) utilized semi-structured interviews and document/archival analyses (n=27, 52.9%) to obtain data. Eight articles employed surveys or questionnaires to obtain data (15.7%), three engaged in focus groups (11.8%), and 13 participated in some form of observation whether coined "participant observation," "direct observation," "meeting observation," and "observational analysis" (25.5%). In addition, 15 case studies (29.4%) used some form of comparative evaluation in their research with most centered on science-policy integration efforts for a respective environmental topic (e.g., Hoppe 2010; Hoppe et al. 2013; Kallis et al. 2009; Kirchhoff et al. 2013; Kueffer et al. 2014; Niederberger 2005). Four case studies (.08%) (Cutts et al. 2011; Holmes and Lock 2010; Holmes and Savgård 2009; Lopez-Rodriguez et al. 2015) utilized a mix of participatory research methods including research question and theoretical formation (Cutts et al. 2011; Holmes and Savgård 2009), data collection and knowledge integration (Cutts et al. 2011; Lopez-Rodriguez et al. 2015), mapping exercises (Cutts et al. 2011:980), participatory communication (Holmes and Lock 2010; Holmes and Savgård 2009; Lopez-Rodriguez et al. 2015), and public commentary and evaluation (Holmes and Lock 2010; Holmes and Savgård 2009; Lopez-Rodriguez et al. 2015). Most of the articles employed a mixed-method approach toward research (n=36, 70.6%). However, 15 case studies employed a single method to their approach focusing on surveys (Breuer et al. 2010), interviews (Carr and Wilkinson 2005; Clark et al. 2011), a

comparative evaluation (Driscoll et al. 2011; Hoppe 2010; Hoppe et al. 2013; Kallis et al. 2009; Kirchhoff et al. 2013; Klerkx and Leeuwis 2009; Niederberger 2005), document analysis (Timotijevic et al. 2013; Naylor et al. 2012; Quay 2004; Tuinstra 2007), and finally, participatory research methods (Lopez-Rodriguez et al. 2015).

The type of analysis conducted in the case studies varied. Few studies (n=2, 3.9%) explicitly discussed qualitative data analysis tools (e.g., Atlas.ti, QWeftQDA, and NVivo) (Hastings 2011 and Crona and Parker 2012). The majority of case studies (n=40, 78.4%) seemed to apply an *ad hoc* method of content analysis while still performing credibility checks. Additionally, few case studies employed descriptive and causal analysis of qualitative and quantitative data (n=5, 9.8%) (Breuer et al. 2010; Cash 2001; Kirchhoff et al. 2013; Shaw et al. 2013; Rice et al. 2009). Those studies that utilized a grounded theory technique were also few (n=4, 7.8%) (Franks 2010; Hastings 2001; Bracken and Oughton 2013; Udovyk 2014). Other methodological approaches included Secondary Thematic Analysis (Carr and Wilkinson 2005), a Multilevel Conceptual Framework Model (Hoppe 2010; Hoppe et al. 2013), and Discourse Analysis (Bracken and Oughton 2013).

The topics of each case study were diverse. Unsurprisingly, the most common topic centered on climate change (n=10, 19.6%), then water management (n=9, 17.6%), and finally, agricultural issues (n=6, 11.8%). Other topics included fisheries management (n=4, 7.8%) (Bracken and Oughton 2013; Holmes and Lock 2010; Schwach et al. 2007; Turnhout et al. 2008), forest conservation (n=3, 5.9%) (Tomich et al. 2007; Innes 2003; Clark et al. 2011), ecosystem management (n=3, 5.9%) (Bracken and Oughton 2013; Driscoll et al. 2011; Franks 2010 Kueffer et al. 2014), coastal issues (n=3, 5.9%) (Bremer and Glavovic 2013; Clapp and Mortenson 2011; Naylor et al. 2012), marine management (n=2, 3.9%) (Hastings 2011; Holmes and Lock 2010), air pollution (n=2, 3.9%) (Tuinstra 2007; Tuinstra et al. 2006), persistent organic pollution (n=1, 2%) (Thrift et al. 2009), Bisphenol A (BPA) and environmental health (n=1, 2%) (Udovyk 2014), drought (n=1, 2%) (Vogel et al. 2007), acid rain (n=1, 2%) (Zehr 2005), biofuel (n=1, 2%) (Schut et al. 2013), general conservation (n=1, 2%) (Sarkii et al. 2013), and finally, volcanic disasters and the science-policy interface (n=1, 2%) (Donovon and Oppenheimer 2014).

APPENDIX F

Environmental Science and Policy: Characteristics of Selected Studies for Meta-synthesis

Authors	Study	Methods	Analysis
1. Breuer et al. 2010	Cooperative Extensions Service: Climate Forecasts, Florida, USA	1. Surveys	1. Content Analysis 2. Descriptive Statistics
2. Brunel et al. 2013	European and Mediterranean Plant Protection Organization (EPPO): Pest risk analysis and plant protection, Europe and Mediterranean Region	1. Interviews 2. Focus groups	1. Content Analysis 2. EPPO Pest Risk Analyses
3. Buizer et al. 2010	Climate and Societal Interactions (CSI) Program and International Research Institute for Climate and Society (IRI): ENSO Forecasts, Australia, Hawaii, Pacific Islands, USA, Brazil	1. Comparative Evaluation 2. Focus groups 3. Participant Observation	1. Content Analysis
4. Carden and Neilson 2002	International Development Research Center (IDRC): Science-policy integration, International	1. Comparative Evaluation 2. Interviews	1. Content Analysis
5. Carr and Wilkinson 2005	Agriculture Extension Specialists: Natural Resource Management (NRM), Australia	1. Interviews	1. Secondary Thematic Analysis 2. Content analysis
6. Cash 2001	Cooperative State Research, Education, and Extension Service (CSREES): Water management for irrigated agriculture, Australia	1. Structured Interviews 2. Surveys	1. Comparative Analysis 2. Descriptive and Causal analysis of Qualitative and Quantitative Data
7. Clark et al. 2011	Consultative Group on International Agricultural Research (CGIAR): Alternative to Slash and Burn Program (ASB), International	1. Interviews	1. Comparative analysis of previously published CGIAR work
8. Crona and Parker 2012	Arizona State University Decision Center for a Desert City (DCDC): Water management, Southwestern USA	1. Interviews 2. Documentary 3. Participant Observation	1. Ethnographic Content Analysis 2. Qualitative Analysis Program (Atlas.ti and QWeftQDA)

9. Cutts et al. 2011	DCDC: Urban climate adaptation, Southwestern USA	1. Participatory Research Methods 2. Interviews 3. Focus Groups 3. Survey	1. Content Analysis
10. Driscoll et al. 2011	Hubbard Brook Research Foundation Science Links Program: Integrating ecosystem science and environmental policy, USA	1. Comparative Evaluation	1. Comparative analysis of previously published Science Links work
11. Eden 2011	Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA): Water management decision making, Southwestern USA and northern Mexico	1. Document analysis 2. Interviews 3. Participant Observation	1. Evaluative Frameworks
12. Franks 2010	Dutch Environmental Co-operatives (ECs): eco-system management problems, The Netherlands	1. Interviews 2. Participant Observation 3. Document analysis	1. Grounded Theory Analysis 2. Content Analysis
13. Guston 1999	Office of Technology Transfer (OTT): science-policy interface, USA	1. Document Analysis 2. Interviews	1. Content Analysis
14. Hahn et al. 2006	Ecomuseum Kristianstads Vattenrike (EKV): Adaptive comanagement of wetlands, Sweden	1. Interviews 2. Document Analysis	1. Content Analysis
15. Hastings 2011	Conservation International's Marine Management Area Science Program (MMAS): Conservation, Brazil	1. Document Analysis 2. Direct Observation 3. Semi-structured Interviews	1. NVivo qualitative analysis software 2. Grounded Theory
16. Holmes and Lock 2010	MariFish Network: Marine Fisheries Policy and Management, Europe	1. Semi-structured interviews 2. Participatory research techniques 3. Questionnaire	1. Content Analysis
17. Hoppe 2010	IPCC: Climate change, International	1. Comparative evaluation of science-policy integration efforts	1. Multilevel Conceptual Framework Model

18. Hoppe et al. 2013	IPCC, UNFCCC: Climate change, International	1. Comparative evaluation of science-policy integration efforts	1. Multilevel Conceptual Framework Model
19. Kallis et al. 2009	CALFED Water Program: Adaptive water management, California	1. Comparative evaluation of science-policy integration efforts	1. Comparative analysis of previously published CALFED Water Program work
20. Kirchhoff et al. 2013	US Regional Integrated Science and Assessments (RISAs) and Brazil's River Basin Councils (RBCs): Climate change and water management	1. Comparative evaluation of science-policy integration efforts	1. Descriptive and Causal analysis of Qualitative and Quantitative Data
21. Klerkx and Leeuwis 2008	BioConnect: Agricultural Research, The Netherlands	1. Semi-structured interviews 2. Meeting Observation 3. Document Analysis	1. Content Analysis
22. Klerkx and Leeuwis 2009	Innovation Brokers: Agricultural Research, The Netherlands	1. Comparative evaluation of knowledge brokering efforts	1. Content Analysis
23. Kueffer et al. 2014	The Mountain Invasion Research Network (MIREN): Ecosystem management, International	1. Comparative evaluation of science-policy integration efforts 2. Document Analysis	1. Content Analysis
24. Lee et al. 2014	UNEP Risø Centre (URC): Climate change, International	1. Document Analysis of program data from UNEP website 2. Semi-structured interviews	1. Content Analysis
25. Niederberger 2005	Advisory Body on Climate Change Research and Policy: Switzerland	1. Comparative evaluation of science-policy integration efforts	1. Content Analysis
26. Sarkii et al. 2013	PAN Parks: Conservation, Oulanka National Park, Finland	1. Semi-structured interviews 2. Questionnaire	1. Content Analysis

		3. Mapping Exercises	
27. Shaw et al. 2013	OceanWatch and Northern Agricultural Catchments: Climate science, Australia	1. Survey 2. Participant Observation	1. Observational Analysis 2. Descriptive and Causal analysis of Qualitative and Quantitative Data
28. Timotijevic et al. 2013	Scientific Advisory Committees (SACs): United Kingdom	1. Document Analysis	1. Content Analysis
29. Tomich et al. 2007	ASB, the Partnership for the Tropical Forest Margins: International	1. Document Analysis 2. Survey	1. Content Analysis
30. Arnold et al. 2005	Harmoni-CA, European Water Framework Directive: Water management, Europe	1. Document and Modelling Analyses	1. Content Analysis
31. Bracken and Oughton 2013	Freshwater pearl Mussel, North Yorkshire, UK	1. Participant Observation 2. Document Analysis 3. Interviews	1. Discourse Analysis 2. Grounded Theory
32. Bremer and Glavovic 2013	Integrated Coastal Management: New Zealand	1. "Desktop study" 2. Document Analysis 3. Semi-structured Interviews	1. Coding/Content Analysis in accordance with conceptual framework
33. Clapp and Mortenson 2011	British Columbia's Central Coast Land and Resource Management Plan (CCLRMP): Adversarial science, BC	1. Participant Observation 2. Interviews	1. Content Analysis
34. Donovon and Oppenheimer 2014	Volcanic Disasters: Montserrat, British West Indies	1. Semi-structured Interviews 2. Participant Observation 3. Archival Analysis	1. Coding/Content Analysis
35. Holmes and Savgård 2009	Scientific Knowledge for Environmental Protection Network (SKEP-NET): Science-policy interface, Europe	1. Document Analysis 2. Semi-Structured Interviews 3. Participatory Research Methods	1. Content Analysis

36. Innes 2003	Innovative Forest Practices Agreements: Forest policy, British Columbia	1. Document Analysis 2. Comparative study of forest programs	1. Content Analysis
37. Kamelarczyk and Gamborg 2014	REDD+: Science-policy interface, Zambia	1. Semi-structured and open-ended interviews 2. Document Analysis	1. Coding/Content Analysis
38. Lahsen 2009	Carbon Sinks and Science: Science-policy interface, Brazil	1. Interviews 2. Media Analysis	1. Content Analysis
39. Lopez-Rodriguez et al. 2015	Environmental problems: Science-policy interface, Spain	1. Participatory Research Methods	1. Content Analysis
40. Naylor et al. 2012	Coastal Infrastructure: Europe	1. Document Analysis	1. Content Analysis
41. Quay 2004	North Sonoran Collaboration: Ecological Research and land use policy, Arizona	1. Document and Archival Analysis	1. Content Analysis
42. Rice et al. 2009	Western Water Assessment (WWA): Water Management, Western USA	1. Semi-structured Interviews 2. Surveys	1. Content Analysis 2. Descriptive and Causal analysis of Qualitative and Quantitative Data
43. Schut et al. 2013	Biofuel Sustainability: Research-policy interface, Mozambique	1. Semi-structured and informal interviews 2. Participant Observation 3. Policy Analysis	1. Content Analysis
44. Schwach et al. 2007	EU's Policy and Knowledge in Fisheries Management (PKFM): Fisheries Management, Europe	1. Document Analysis 2. Policy Analysis	1. Content Analysis
45. Thrift et al. 2009	Persistent Organic Pollutants (POPs): Canada	1. "Knowledge-action methodology" 2. Document Analysis 3. Interviews	1. Content Analysis
46. Tuinstra 2007	European Thematic Strategy: Air Pollution	1. Document and Archival Analyses	1. Content Analysis

47. Tuinstra et al. 2006	UN's Economic Commission for Europe's Convention for Long Range Transboundary Air Pollution (CLRTAP)	1. Document Analysis 2. Participant Observation 3. Interviews	1. Content Analysis
48. Turnhout et al. 2008	Science-policy interface: Wadden Sea, The Netherlands, Germany, and Denmark	1. Document Analysis 2. Policy Analysis	1. Content Analysis
49. Udovyk 2014	Science-policy interface: Bisphenol A (BPA) and environmental health, EU	1. Document Analysis 2. Policy Analysis 3. Semi-structured interviews	1. Content Analysis 2. Grounded Theory
50. Vogel et al. 2007	Environmental Vulnerability: Drought, Southern Africa	1. Vulnerability Assessments 2. Document Analysis	1. Content Analysis
51. Zehr 2005	Science-policy Interface: Acid Rain, USA	1. Policy Analysis 2. Interviews	1. Content Analysis

APPENDIX G

Environmental Science and Policy: Preliminary Meta-synthesis Conceptual Framework

Element	**Variables**	**Sources**
Features	Dual accountability and utility, hybrid composition, durability, formality.	Crona and Parker 2012; White et al. 2010; O'Mahony and Bechky 2008
Strategies	Creation of boundary objects, allowing divergent interests to co-exist, providing dual accountabilities, incentives.	White et al. 2008, 2010; O'Mahony and Bechky 2008; Crona and Parker 2012
"Outcomes" or Effective Policy Influence	Evidence of legislative or policy change, evidence of implementation, evidence of environmental outcomes	IAD Framework, Polski and Ostrom 1999

APPENDIX H

Guiding Questions for the Document Review and Analysis, adapted from Scott (2006)

Preliminary Questions	Theoretical Questions	Practical Questions	Guiding Questions
• Who were the main actors involved? • What were their interests? • What were the main arguments made? • How did they frame these arguments discursively? • How did they interact with other actors? • Did the process allow for the inclusion of other actors? • What was the political and historical context in which these developments occurred? • What data cannot be observed?	• How can these documents be explained through boundary organization and social network/informal hierarchy lenses? • How can theoretical concepts be improved in accordance with empirical findings?	• Who wrote the document? • For whom? • For what purpose? • How can findings be compared and contrasted? • Are there other data sources that can strengthen findings? • Is there a need for other methods of data collection to strengthen these findings?	• What do these findings reveal about boundary spanning processes in the state of Georgia? • What do these findings reveal about which actors and processes are most influential in environmental policy-making in Georgia? • What do these findings reveal about where science fits (if at all) within the hierarchy of influences? • What do these findings reveal about addressing the *problems, policies, and politics* associated with each case study? • What do these findings reveal about how informal and contextual factors interface with boundary spanning processes?

APPENDIX I

Media Analysis Sources for Georgia Water Case Studies

News Sources	Athens Banner-Herald, Athens Flagpole, Atlanta Business Chronicle, Atlanta Daily World, Atlanta Journal-Constitution, Atlanta Voice, Atlanta Courier Times, Atlanta Fulton County Daily Report, Augusta Chronicle, Blairsville North Georgia News, Savannah Business Journal, Savannah Herald, Savannah Tribune, and Watkinsville's Oconee Enterprise
Magazines	Atlanta Magazine, Atlanta Tribune, Blue Ridge Country Magazine, Augusta, North Georgia Magazine, Season Magazine, Georgia Family Magazine, Savannah Magazine, Georgia Southern Magazine, Valdosta Magazine
Archival Radio Programs	WBMQ, Savannah, GA, News WGAC-FM, Harlem, GA, News WGST, Atlanta, GA, News WSB, Atlanta, GA, News WJUL, Hiawassee, GA, News WRCG, Columbus, GA, News WRGA, Rome, GA, News WVGA, Lakeland, GA, News Georgia Public Broadcasting
Archived Television Files	WSB-TV Atlanta, Athens FOX 5 Atlanta 11Alive Atlanta CBS46 Atlanta WSAV Savannah WTOC Savannah 14MAZ Macon WALB South Georgia News WJBF-TV Augusta WTVM Columbus WGXA Macon WUGATV Athens

APPENDIX J

Georgia Regional Water Councils, Questionnaire

(Two Sided Page)

Name:

Regional Water Council Affiliation:

Current Work Position:

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1. When did you begin your involvement with a Regional Water Council? Were you a part of the original planning process or have you been newly appointed for the current renewal phase?
2. As a member, what activities did you engage in during the Statewide Water Planning (SWP) process?
3. Did the role you played meet your expectations? Why or why not?
4. Were you given any information to aid your decision-making in your role as member of your Regional Water Council? If so, what kind of information?
5. For the information sources identified in Q.4, who gave you this information and how was it disseminated?
6. Did scientific information play a role during this process? If so, please describe what information specifically, and the role it played. If not, please explain.
7. Has the Statewide Water Planning (SWP) process helped you meet your regional water goals? If so, please describe how. If not, please indicate what barriers may have kept the planning process from meeting goals specific to your council's jurisdiction?
8. What are your general views on water policy in the state of Georgia, and the processes through which water policy is made?