2011

Cycles in Policy Network Structure and Policy Adoption-Implementation Processes: The Importance of Alignment

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Keywords: Policy adoption, policy implementation, policy network, bureaucracy, wetlands, science policy, policy innovation, social capital, collective action

Abstract

This paper investigates how aspects of policy networks facilitate or inhibit the efforts of public bureaucracies to adopt and implement science policy innovations. Three correlated dimensions of policy networks – permeability, size, and tie strength – strongly influence adoption and implementation outcomes. Policy networks tend to expand and contract cyclically along these network dimensions.

Policy adoption and implementation are not binary variables, but rather continually occurring processes that also cycle. Successful adoption and implementation outcomes are most likely when adoption-implementation and network expansion-contraction cycles are aligned such that adoption occurs when the policy network is more permeable, larger, and more laden with weaker ties, and implementation occurs when the network is less permeable, smaller, and more laden with stronger ties. When cycles are not optimally aligned, adoption and implementation efforts are more likely to fail or stall.

These arguments draw on literature concerning policy networks as well as collective action and social capital. They are illustrated with case sketches that describe the attempts by environmental bureaucrats in six U.S. Mid-Atlantic states to adopt and implement a type of science policy innovation for wetland management. The sketches draw upon more than 90 interviews with environmental bureaucrats and stakeholders in the region, as well as secondary-source analysis and survey research.

1.0 Introduction

This paper investigates how policy networks facilitate or inhibit the efforts of public bureaucracies to adopt and implement science policy innovations. Lubell and Fulton (2007); Balla (2001); True and Mintrom (2001), Young, Charns, and Shortell (2001); Mintrom and Vergari (1998); Lawton and Wholey (1993) and others suggest that such networks facilitate policy adoption. Pederson (2010), Tantivess and Walt (2008), Greenaway, Salter, and Hart (2007), Morris (2004), Hanf and O'Toole (1992) and others argue that they facilitate policy implementation. Nonetheless, how and why these networks facilitate these policy outcomes still requires greater exploration. This exploration should be grounded in theory and should provide tangible value to policy actors. This paper embarks on that theoretical grounding.

Section 1 presents the paper's propositions. Section 2 is devoted to theory. Section 3 describes data collection and use. Section 4 presents case sketches. Section 5 discusses topics for future inquiry. Section 6 concludes.

[1] Written with support from U.S. Environmental Protection Agency STAR Fellowship FP-91708801. All content is entirely the responsibility of the author and not EPA. Per Indiana University and EPA institutional review board protocols, names of interviewees have in some cases been omitted.

1.1 Propositions

1.1A) When state bureaucrats have *more numerous, weaker,* and *more permeable ties* with critical actors, *adoption* of a science policy innovation is more likely.

1.1B) When state bureaucrats have *fewer, stronger,* and *less permeable ties* with critical actors, *implementation* of a science policy innovation is more likely.

1.1C) When network expansion-contraction and adoption-implementation cycles are (not) optimally aligned, adoption and implementation efforts are more likely to succeed (fail or stall).

2.0 Theory

2.1 Definitions

The types of *public bureaucracies* this paper discusses are state governmental agencies tasked with regulating activities affecting the environment. A *state bureaucrat* is an individual employed by such a public bureaucracy.

A *science policy innovation* is a policy affecting issues typically studied by scholars in the non-social sciences, e.g., chemistry or biology. The policy is new to the public bureaucracy adopting or implementing it, though it may have been adopted or implemented elsewhere (Walker 1969). A science policy innovation frequently is technically or scientifically complex. Policy actions concerning it frequently require application of technical or scientific expertise and data. The paper specifically examines rapid wetland assessment tools, products which state environmental bureaucrats can use to evaluate the functions and services wetlands provide.

Critical actors include scientists with expertise relevant to the science policy innovation, regional and national policy experts, and bureaucrats in other states. The boundaries delineating who is a critical actor are explained below.

A *policy network* is made up of at least two nodes, linkages, and a setting variable. While in theory nodes can be individuals, organizations, or any other type of entity, in this paper they are people and are usually referenced as "network members."

Policy network linkages are conduits for dependency relationships through which nodes exchange information, resources, or other goods (Benson 1982). Linkages tend to be stable and nonhierarchical (Borzel 1998). Networks form and persist because they are the most efficient, least risky, or least costly mechanisms available to help nodes to meet their needs (van Waarden 1992).

The setting variable is a substantive policy issue that both affects and is affected by the activities of the network (Borzel 1998). Policy networks develop among nodes with expert knowledge in the issue area and also often foster such knowledge. In this paper, the setting variable is rapid wetland assessment tool adoption and implementation.

Network permeability is the ease with which a node can move in or out of the network. An entirely impermeable network would have compulsory and restricted membership. A highly permeable network would be characterized by entirely voluntary participation and no membership conditions (van Waarden 1992). Network permeability can refer to the network's resistance to or acceptance of new ideas as well as new individuals (Carolan 2007).

The boundaries of a network, and thus its size, are determined by members' perceptions; this is the "realist" approach to boundary drawing (Knoke and Yang 2008). Actors clearly enmeshed in the policy network, in this case state wetland bureaucrats, are asked about their connections to other actors relevant to the substantive issue area. Someone is included the network when those core actors find that person's inclusion reasonable (ibid.). The *critical actors* noted above are people included within the network boundaries but who are not state bureaucrats.

"The *strength of a tie* is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (Granovetter 1973, 1316, emphasis added). Stronger ties tend to occur when linked actors spend more time with one another and share similar personal characteristics (ibid.).

Implementation of a science policy innovation is the innovation's usage by state bureaucrats. Implementation is a continuous variable which can take values from 0, indicating no usage by anyone in a state bureaucracy, to 1, indicating usage by all bureaucrats in every situation to which the innovation is applicable. At intermediate values, only some bureaucrats might use the innovation, bureaucrats might use the innovation for some applications but not others, or bureaucrats might only use portions of the innovation.

Implementation is an ongoing process. It begins when the first bureaucrat deploys the policy innovation, continues as the innovation experiences wider use, and reaches an apex where the innovation is wholly implemented by all relevant staff. Reaching this apex is not inevitable. Implementation may falter or decline at any point.

Like implementation, *adoption* is not a binary variable, but rather a continuous one bounded by 0 and -1.[2] Adoption begins when a state bureaucrat who has learned of a potentially relevant innovation takes an initial step toward potential, eventual implementation of that innovation by his or her state agency. The adoption process includes the range of preparatory activities that lead from that first step to the first actual usage of the innovation, i.e., to the start of implementation. A bureaucracy where no one has taken that first step takes a 0 on the adoption variable, a state where an innovation has seen its first usage takes a -1 (at this junction, adoption and implementation share a maximum and minimum), and at intermediate values, state bureaucrats have made varying degrees of progress towards implementation. The adoption path is neither inevitable nor necessarily smooth.

2.1 How bureaucrats use policy networks in adoption and implementation of science policy innovations

Bureaucrats can obtain resources or information from policy networks. This paper is mainly concerned with information and secondarily with human and political resources, viewing the latter primarily as the vehicles by which information is conveyed. Bureaucrats turn to other bureaucrats, scientists, and experts in the private and public sectors for policy-relevant information because, in today's world of fast-paced information flows, bureaucracies rarely can generate independently all the information they need to make policy choices (Goldsmith and Eggers 2004). Bureaucrats rely on networks for data to inform science-based policies (Kerwin 1994, May 1992) and for political and strategic information they could deploy to professional or personal advantage (Meier and Bohte 2007). Bureaucrats may use networks to find out how other government entities are behaving vis-à-vis various issues and thereby gain transferrable lessons (Heichel 2005, Mintrom 1997, Bennett and Howlett 1992). Bureaucrats may achieve policy goals by fostering supportive contacts and coalitions outside their agency (O'Leary 2004).

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[2] The negative sign is required by the setup of the graphs used to illustrate the propositions, but has no other substantive meaning.

2.2 Policy network size, tie strength, and permeability are (imperfectly) correlated

A larger network usually has attenuated ties. As a group grows in size, members have more difficulty monitoring others' behavior (Olson 1965). Even in active networks where interactions are frequent, increasing network size increases the number of engagement options available to any one member and thus may reduce the frequency with which any two members interact.

When members have fewer repeated interactions, they may perceive the network as less cohesive and their connections to the network, and it to them, less consequential. They may be less interested in or able to learn the logics of appropriateness (March and Olsen 2004) and shared norms and beliefs that might otherwise guide their behavior as network members. Inter-member linkages in a larger network generally will be weaker than ties in a smaller network.

A large network reached its size by accepting members; at least at some point, it was relatively permeable. Permeability facilitates the introduction into the network of new perspectives from new members. Indeed, Reagans and McEvily (2003) show that members of networks with larger ranges, a concept closely related to network size, tend to be better at obtaining and transferring complex ideas. These new insights can further weaken network ties by revealing potentially divisive dissimilarities among members (see Heider 1958). Weak ties further encourage permeability of actors and ideas. Whereas members of tight-knit, highly internally socialized networks may share cognitive filters which screen out information that contradicts dominant policy narratives (Sabatier and Weible 2007), members of more permeable networks may have fewer such compunctions. In summary, larger networks appear likely to be relatively permeable and characterized by weak ties.

A smaller network's members are likely to interact with the same members more frequently than in a larger network. Iterated interactions create common expectations about how people will behave and the norms to which they adhere (Ferejohn 2003, Elster 1986). Coleman (1988) described networks which foster shared norms as achieving "closure," noting that these tend to be strong-tie networks. Intuitively, networks composed primarily of strong ties are likely to be smaller than those composed of weak ties because the investments of time and human capital required to forge strong ties often prevents actors from establishing as many such relationships.

Pinto (2006) argues that a low-permeability network is usually composed of strong ties, whereas a high-permeability network is more likely to have weaker ties. A network that is more permeable may have a membership characterized by shorter rather than longer tenures and greater tenure heterogeneity. Brown (2006) links time individuals spend within an organization to their development of collective identities that begin to meld members' narratives and worldviews. Individuals must spend time together to begin to perceive the logics of appropriateness and norms that apply to their actions as members of the group (March and Olsen 2004, van Maanen and Schein 1977). A low-permeability network thus is likely to be cohesive with strong ties, and stronger-tie networks appear more likely to be small than large.

The correlations between network size, strength of ties, and permeability are imperfect. A large network can be relatively impermeable if its membership rarely changes and its substantive focus is narrow and static. A small network can have weak ties if members interact infrequently, while a large network can have strong ties if its members interact quite frequently. This paper's argument simply is that the correlations described above are more likely than other combinations of permeability, size, and tie strength.

Other variables, such as time, can affect correlation strength and direction. For example, the argument that a large network must be permeable because it accepted many members is most tenable if the network just formed and added those individuals. If the network is mature, its current level of permeability may be different than its initial level. Similarly, arguing that heterogeneity among network members creates weak ties is most tenable if the network is new and members have just discovered the dissimilarities that make close relationships appear implausible. If members have worked in the same policy arena for a long time, their dissimilarities may become less important than shared norms fostered during their iterated interactions.

This paper assumes that the networks it describes can be observed from formation onwards, and that none are too temporally distant from that point. For states considering adopting and implementing wetland assessment tools, this assumption is plausible. Few states began to consider using such tools until the mid-1990s (Poeske 2010); policy networks concerned with wetland assessment and centered around state bureaucrats often can be traced to that era. However, the impact of time on this paper's propositions must be explored further.

2.3 Policy networks experience cycles of greater or lesser permeability and tie strength and smaller and larger size

A policy network may start out small and grow larger as members work to bring more people with more relevant expertise into the group. Or, people might push their way into the network upon realizing its existence and its relevance to them, as members of a neighborhood affected by a toxic substances leak might insist on being represented at relevant governmental discussions. Once the leak is addressed, however, the network may shrink as community stakeholders leave. A network of individuals who pick up litter in a community park may begin as a loose collectivity of occasional volunteers; those weak ties might grow strong if a tornado wreaks havoc on the town and the group pulls together to rehabilitate area green spaces. Network permeability, size, and tie strength are not constant. The variables change through two main mechanisms.

First, the settings of these variables may be manipulated by policy entrepreneurs or stakeholders. Policy entrepreneurs advantageously couple politics, policies, and problems to effect political change (Kingdon 1984). Entrepreneurs can negotiate between policy coalitions with competing preferences (Sabatier and Jenkins-Smith 1999; Sabatier and Weible 2007). A policy entrepreneur acts on behalf of some organization or public, inchoate or not, and receives some benefit in return; the benefit is likely intangible rather than monetary (Kuhnert 2001).

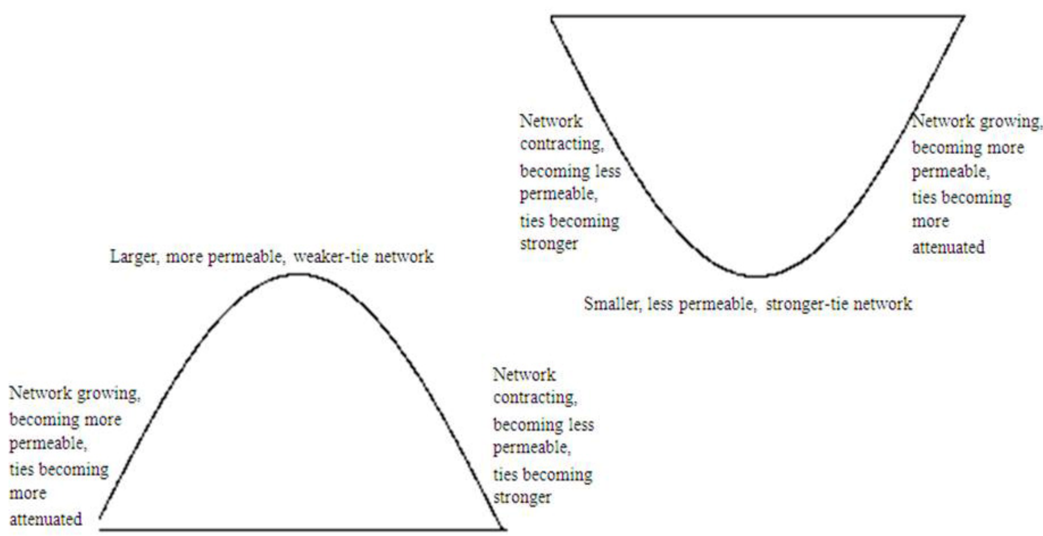
Knoke and Yang (1996) called for more research into the ways policy entrepreneurs can exert strategic influence in policy networks. Mintrom and Vergari (1998) find that when policy entrepreneurs leverage their involvement in networks, they are more likely to accomplish their goals of legislative reform. Greenaway, Salter, and Hart (2007) show that policy entrepreneurs involved in hospital siting decision can manipulate the nature and foci of implementation networks. Christopoulos (2006, 757) even argues that networks "provide the context within which these actors thrive" and that "political entrepreneurs are network-dependent [which] implies that their ability for political action is network-contingent."

A stakeholder is a particular type of policy entrepreneur. The stakeholder often is not involved in the policy network because of an intentional, professional interest. Rather, he found himself affected by the substantive activities of the network and wanted to participate in the choices impacting him. He can push and pull at the network's setting variables in the same way as a policy entrepreneur, but his motivations and perspectives often are different.

The second way in which network variable settings can be changed is through the influence of events beyond the scope of the network. In Ostrom's (2005) Institutional Analysis and Design (IAD) framework, events occurring in the action situation – the focal unit of the analysis, and in this case, the arena wherein the policy network is operating – are affected by larger forces: attributes of the physical world, the community context, and rules and institutional arrangements. These forces clearly can affect a policy network focused on a science policy innovation. If the relevant science changes (attribute of the physical world), this will affect the nature and activities of the network. If the innovation is adopted or implemented by other states (community context), this action and its outcomes will impact the policy network. If the state legislature passes a new law in the network's substantive area (rule/institutional arrangement), the network may become very active because there will be demand for science policy innovations to help implement legislation.

The ways in which policy network size, permeability, and tie strength change due to manipulation or external forces can be described visually:

Figure 1



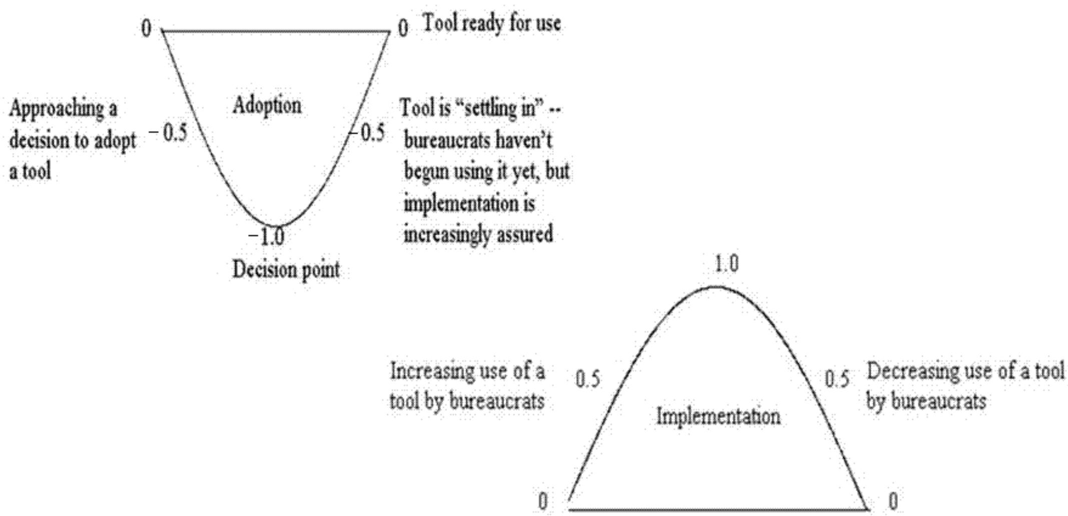
A network does not always expand (increasing in size and permeability and ties weakening due to attenuation), reach an apex, and then contract (decreasing in size and permeability, with ties growing stronger) or vice-versa. These cycles are not inevitable. However, when external forces or internal manipulators try to create change in a policy network, these are the paths along which those modifications frequently occur.

2.3 Adoption and implementation processes experience similar cycles

The adaptive management literature assumes that adoption and implementation are cyclically linked. In the classic model, a policy is adopted and then implemented. Its results are assessed and the policy is revised based on lessons learned. The revised policy is then adopted and implemented, its results are assessed, and the process iterates (Lee 1999, McLain and Lee

1996). Weimer and Vining's (2005) claim that policy implementation can be understood as a series of adoptions is consistent with this perspective, as is the argument of this paper that both adoption and implementation are continuous variables representing processes. The cyclical nature of adoption and implementation can be described visually:[3]

Figure 2



Adoption and implementation processes do not spontaneously flow from one parabola to the other. A state bureaucracy may move along these curves via manipulation by policy entrepreneurs, who may be bureaucrats or stakeholders. Literature supports the argument that such entrepreneurs facilitate policy adoption (e.g., Hays and Glick 1997, Mintrom 1997, Balla 2001, Shipan and Volden 2006) and implementation (e.g., Bardach 1977; Levin and Ferman 1986; Nakamura, Church, and Cooper 1991; Oliver and Paul-Sheehan 1997). Or, a bureaucracy may be propelled along the curves by external forces that can be captured by Ostrom's three categories. For example, if the community in which a bureaucracy seeks to implement a science policy innovation is skeptical of it (community context), implementation may stall. If an event in the biophysical world makes the science policy innovation immediately necessary (such as a flood making more vital a wetland assessment tool that could evaluate wetland flood storage), the bureaucracy likely will be spurred along the adoption path. If local zoning boards adopt ordinances (rules/institutional arrangements) that call for use of an innovation that is different from the one the bureaucracy was in the process of adopting, adoption may stall or be delayed.

2.4 Larger, more permeable, and weaker-tie networks facilitate adoption

Weak ties can serve as bridges among dissimilar individuals (Granovetter 1973, Burt 2001). Because of their diversity, these individuals are likely to bring a wider variety of resources and perspectives to the action situation than a group of more similar individuals. Policy adoption frequently requires coalition building (Burstein 1991) that weak ties facilitate.

The likelihood that an innovation will be adopted is in part a function of resources available to help those pushing the innovation overcome obstacles (Mohr 1969). A large policy

[3] The captions in Figure 2 refer to a rapid wetland assessment tool specifically but can describe a science policy innovation generally.

network has a large number of members who can bring information and resources to the task of surmounting organizational inertia and overcoming adoption-related resistance that may exist inside and outside the bureaucracy.

Relatedly, larger networks may be better than smaller networks at searching out adoption-facilitative information. Oliver and Marwell (1988) theorize that, although collective action (such as the acquisition of information that would help improve a science policy innovation and pave the way for implementation) is generally considered more difficult with larger groups, when the costs of a collective good such as information are relatively invariant, larger groups should be more successful in its acquisition because they "have more resources and are more likely to have a critical mass of highly interested and resourceful actors" (ibid.,1). And, indeed, the costs of seeking relevant information do not grow with network size. The amount of potentially relevant information available in the external world is unaffected by the number of policy network members looking for it. In fact, search costs actually decline as the network grows because costs are distributed among more searchers.

Members of a relatively permeable network often have less group cohesion than those in less permeable ones, thanks to fewer interactions and reduced ability to observe and monitor others. This disconnect limits Sabatier's (1978) "devil shift" or Janis's (1971) "groupthink." Both are phenomena that cause tight-knit groups to close ranks on ideas and discount or reject potentially more useful ones simply because they are different or not supplied by group members. Thus, a more permeable network more easily accepts new perspectives. Those new insights are valuable when bureaucrats are considering which science policy innovation to adopt and how to tailor an innovation to the state's needs; making smart choices about a relatively unknown quantity often requires previously unknown data.

2.5 Smaller, less permeable, and stronger-tie networks facilitate implementation

A network with fewer members can focus on pushing implementation forward because, relative to a larger network, its members have to spend less energy and resources managing intra-group coalitions and competing interests. Even if not all members of the network agree that on the advisability of implementing the innovation, when the network is smaller there will be fewer members whose disagreements could stall implementation. Changing the preferences and patterns of interactions among policy-relevant actors is one of the biggest challenges of policy implementation (Crosby 1996); networks which can do this more easily are more likely to experience successful implementation outcomes.

Because smaller, less permeable networks have more opportunity to build group cohesion, their members may be affected by Sabatier's "devil shift" or Janis's "groupthink." Members are more likely to close ranks on the innovation that has been adopted, devoting themselves to its success and discounting information that might distract them. This narrow focus is a double-edged sword, however. It might do a disservice to the innovation itself, since a relatively blinkered group of adherents could ignore data pointing to better innovations or more productive implementation modes. To the extent that flaws in the adopted innovation are not apparent or sufficiently salient to members of the policy network, and yet are fundamental enough to cause implementation problems, a smaller, more cohesive network could be a liability instead of an asset. It is likely there is some ceiling on the amount of network member buy-in that is facilitative.

Networks with strong ties that build cooperation and trust accumulate "bonding" social capital, in contrast to the "bridging" social capital associated with weak ties (Gittell and Vidal

1998). Bonding social capital strengthens existing in-network relationships. Intensification of these linkages is important because it fortifies members to face an implementation process inevitably fraught with challenges (Pressman and Wildavsky 1973).

2.6 The Goldilocks dilemma

In an ideal world, a policy network best positioned to facilitate adoption of a science policy innovation would have ties weak enough to facilitate the formation of bridging social capital, allowing network members to form vital coalitions and infusing the adoption process with the diversity of information and resources necessary to select, refine, and tailor a highly technical science policy innovation, yet not so weak that members' limited commitment would lead them to participate in network functions infrequently and fail to bring resources to the network because its activities would not be sufficiently salient to them. The network would be large enough to bring in the volume and diversity of information necessary to facilitate adoption and minimize search costs through distribution, but not so large that members' sense of disconnect from the network would cause them to shirk. The network would have enough permeability to accept the new members and ideas important for refining the innovation in preparation for adoption, but would not be so permeable that members' short tenures would inhibit follow-through or that the quantity and diversity of ideas introduced would be so large as to overwhelm.

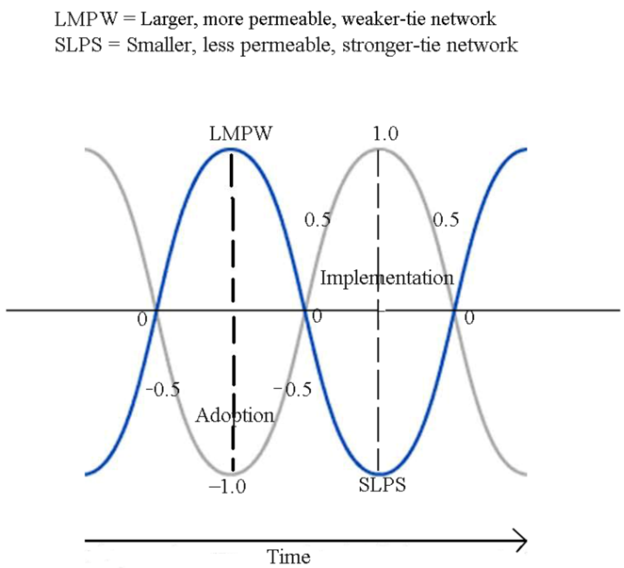
Similarly, a policy network best positioned to facilitate implementation of a science policy innovation would be small enough to minimize the amount of time network members spend on intra-group "cat herding," but not so small that it leaves out individuals with substantive expertise and interests whose exclusion could cause subsequent implementation problems in the form of unresolved objections or intransigent preferences and patterns of interaction. The network would have enough group cohesion to foster buy-in, but not enough to cause willful blindness. The network would have enough bonding social capital that members would be confident in and committed to the innovation despite the challenges of implementation, but not so much that, in the face of such challenges, they would be slavishly inflexible about the implementation process or even some aspects of the innovation itself.

Identifying one "correct" network size, level of permeability, and strength of ties is impossible. The optimal values for these variables will depend on characteristics of the innovation; policy network composition; the relevant organizational, political, and socioeconomic contexts; the history of the policy network; and other factors. Although it is not possible to find the point at which each variable's setting is "just right," it should be possible to make predictions about the conditions under which different the configurations might be more or less facilitative of adoption or implementation (see Ostrom 2007).

2.7 The ideal relationship between network expansion-contraction (EC) and adoption-implementation (AI) cycles

Figure 3 is a visual depiction of the claims in Sections 2.4 and 2.5 concerning the network variable settings that facilitate adoption and implementation of a science policy innovation:

Figure 3



The blue curve is the parabolas from Figure 1 connected so they intersect the x-axis, which for this curve represents some baseline levels of the network variables. The gray curve is the parabolas from Figure 2 connected so they intersect the x-axis, which for the gray curve represents (from left to right) the zero-point where adoption has not yet been initiated, the point where adoption is complete and implementation begins, and the point where implementation stops and the stage is set for adoption of a new innovation or a revised version of the original innovation. Adoption is best facilitated when the blue curve is at its maximum and implementation is best facilitated when the blue curve is at its minimum.

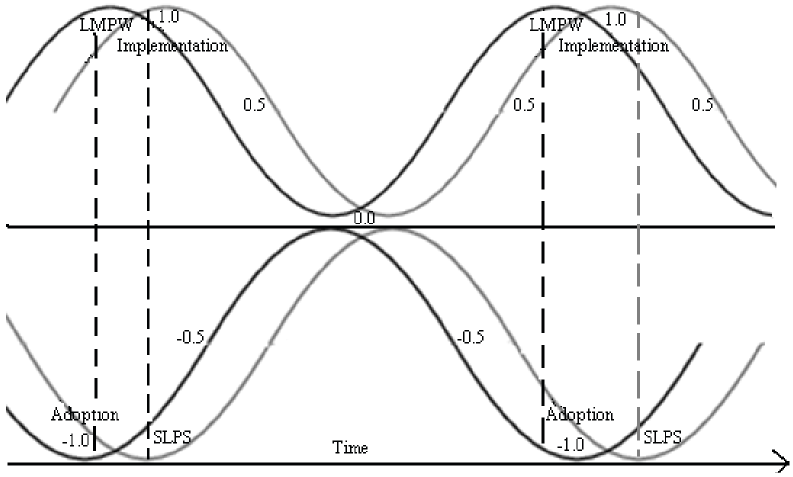
Time on the x-axis suggests that the curves show how quickly or slowly the AI or EC cycles occur. While the curves in Figure 3 ideal sine waves, in real life the curves may be steeper or flatter and are unlikely to be symmetric or perfectly 180 degrees of out of phase.

Two y-axes could be added. The first could have units corresponding to the magnitude of network change; the height of the EC curves then would indicate the degree to which the correlated network variables moved from some baseline. The y-axis for the AI curves would mark off intervals between the maximum (1 or -1) and minimum (0) for adoption and implementation. There may be other conceptual issues associated with adding y-axes; this paper does not explore them.

Adoption and implementation and network expansion and contraction are conceptualized as sequential processes, both for the sake of simplicity and because, in the real world, they often are. However, there is another potentially ideal alignment of AI and EC curves. This scenario may better approximate reality in some cases, but because it is more complex, it is not considered beyond its explication here.

The second ideal alignment recognizes that people often multi-task. Policy network members are simultaneously involved in separate implementation and adoption processes. The network splits, with a small group devoting itself to implementation while the larger group focuses on adoption; overlaps in group membership are possible:

Figure 4



This scenario would occur when policy network members pursue adaptive management in its ideal form. Preparation for adoption and implementation of the next iteration of a science policy innovation begins immediately upon implementation of the first iteration. As soon as the innovation is fully implemented (1.0 on the implementation parabola in Figure 1), network members can begin to observe and assess the its impacts. The 1.0 value then aligns with the decision point indicated in the adoption parabola in Figure 2. Network members now can make an evidence-based choice about the nature of the innovation in the next iteration. The troughs in Figure 4 are wider and flatter, indicating that at this point of alignment, there is less change in the extent of implementation, adoption, expansion, or contraction; relevant actors are pausing to see how implementation plays out and thus what adoption choices should be made. Then, almost as soon as implementation of the original innovation stops – with another flat portion of the curves representing potential delays or hitches associated with the change-over – implementation of the revised version of the innovation can begin. The adoption process delivers the next iteration just in time.

Section 4 shows how various kinds of alignment failures can cause implementation and adoption problems. Alignment and misalignment also are critical in this more complex picture.

2.8 Causality

This paper's propositions assume that network permeability, size, and tie strength are independent variables that affect the likelihood and nature of adoption and implementation. However, members of policy networks work with each other over time and on different tasks in their shared issue area. They may be involved in multiple adoption and implementation efforts.

When interactions are iterated, the outcomes of policy-related choices become the inputs into new interaction and decision processes (Ostrom 2005). Particularly given the complex, dynamic nature of the systems explored here, path dependencies – situations where initial choices have disproportionate influence over options subsequently available to decision-makers, and the direction and magnitude of outcomes may be unpredictable and not commensurate with inputs (Pierson 2000) – are likely. Path dependencies could create situations where, in later iterations, the dependent variables affect the independent variables. For example, a policy network may be small because its membership consolidated to facilitate implementation.

However, when that network next wants to adopt an innovation, it will be challenged by its lack of members. The implementation experience at time one affects network size at time two. Thus, the relationships described here are most realistically understood as correlations.

3.0 Methods

The goals of the empirical portion of this inquiry are to:

1) Describe the rapid wetland assessment tool adoption and implementation processes that have occurred in Mid-Atlantic states since 1995;

2) Quantify the size, permeability, and strength of ties in the wetland assessment policy networks that existed when the adoption and implementation processes were occurring; and

3) Trace the adoption-implementation and network expansion-contraction cycles and evaluate the extent to which they correspond with the theoretical propositions in Section 1.1.

3.1 Data collection

3.11 Interviews

More than 90 individuals in six states – Delaware, Maryland, Ohio, Pennsylvania, Virginia, and West Virginia – were interviewed between September 2010 and April 2011 concerning adoption and implementation of rapid wetland assessment tools for regulatory purposes in the states. The interviewees were state bureaucrats directly involved in wetland regulation; federal wetland regulators from the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers; state, regional, and national wetland scientists and policy experts; and environmental consultants who regularly worked in the six states.

Interviewees were initially selected because of their membership in an EPA-funded regional workgroup devoted to advancing the science and policy of wetland assessment; because their names were located on current and past state bureaucracy organizational charts, guidance documents, permit files, published versions of rapid wetland assessment tools, and other secondary sources; or because they were recommended by EPA wetland regulators. Subsequent interviewees were selected because they were mentioned by initial interviewees.

The interviews were semi-structured. One line of questioning inquired about the interviewee's network ties. State bureaucrats were asked about who they relied upon for assistance or advice when implementing a rapid wetland assessment tool or during the adoption process. They were specifically asked about their relationships with academics, members of the regional wetland workgroup, and other policy experts. Scientists and policy experts, federal regulators, and consultants were asked about the nature of their relationships with state wetland bureaucrats. Federal regulators also were asked how they would describe the bureaucrats' relationships with other sources of wetland assessment expertise. Consultants were asked about their overall perceptions of the functioning of the state wetland bureaucracy, especially in comparison to other states in which the consultants had worked. As of May 31, all but eight interviews were transcribed, but only one was coded.

3.12 Surveys

Two mixed-method surveys were launched between February and May 2011. The first survey was administered to a sample of individuals whose names have been associated, in published reports or anecdotal references, with tools whose use was reported in any of the states. These were individuals who, if state bureaucrats communicated with them, likely were members of those bureaucrats' wetland assessment policy networks. The sampling strategy was exhaustive in its aim rather than based on probability.

The goal of this survey was to explore the relationships between this group of potential critical actors and the state bureaucrats who may or may not have adopted and implemented their tools. Eligible respondents were asked multiple choice questions about how frequently they initiated contact with state bureaucrats to provide tool adoption or implementation assistance and how frequently state bureaucrats initiated communication with them. Respondents were asked about what they generally discussed when they communicated with state bureaucrats. Finally, respondents were asked multiple choice questions about how helpful bureaucrats in each state seemed to have found the respondent's tool.

Sample members were invited to the online survey via email or postal mail. Email addresses were obtained from online or print secondary sources. Postal mailing addresses were obtained using free and fee online people search engines. Sample members had approximately 1.5 months to complete the survey. Members contacted via email received two reminders, while members contacted via postal mail received one. The sample frame contained some individuals to whom the survey did not apply (for example, a postal recipient who had the same name as an assessment tool developer). The first question in the survey screened out ineligible individuals. At the end of the survey, respondents were asked to indicate the names of other assessment tool developers to whom the survey would apply. This question allowed a second round of email and mail surveying.

The survey cooperation rate, calculated using as the denominator an estimate of "the proportion of all cases interviewed of all eligible units ever contacted" (AAPOR 2011, 6), was 52.13%. This value is an estimate because the proportional allocation method (Smith 2009), the strategy for estimating unknown eligibility used by the American Association for Public Opinion Research's online response rate calculator, was used to approximate the number of ineligible cases among non-respondents. This estimation procedure was selected because it tends to be conservative (Smith 2009). The data from the first survey have not been analyzed further.

The second survey was administered via email and postal mail to individuals in the six states. The sample aimed to include all current or former state employees who at some point since 1995 worked in divisions or departments that engaged in wetland assessment for regulatory purposes.

The survey asked respondents to indicate up to four individuals upon whom they relied the most, in their professional capacity, for advice about wetland regulatory matters at some point since 1995. This is an approach commonly used in social science network research (Carrington, Scott, and Wasserman 2005). The respondent is the "ego" and each contact she reports is an "alter."

Egos were asked about the duration of their relationships with each alter. The duration questions were intended to access a dimension of network permeability; if relationships were generally long-lasting, the network may be relatively impermeable, and vice-versa. Egos also responded to multiple choice questions about nature of their relationships with each alter and the frequency of the interactions, measures intended to access tie strength.

Names of potential respondents were collected from secondary sources such as old permit files, regulatory letters, resource monitoring reports, and staff directories. EPA wetland regulators and current state employees contacted for interviews also provided contacts. Email addresses were obtained when possible from online and print sources. Postal addresses were located using the process described for the first survey. Postal recipients were invited to the same online survey as email recipients. The survey had an initial a screening question meant to ensure that only individuals who used or could have used rapid wetland assessment tools for a regulatory purpose were queried. Sample members had approximately one month to complete the survey. Members contacted via email received two reminders, while members contacted via postal mail received one. At the time of this writing, the last state survey deadline had just passed. The data are not yet analyzed.

3.13 Quasi-ethnographic research

Over the periods May-August 2008, 2009, and 2010, the author was a National Network of Environmental Management Scholars fellow at the EPA regional office responsible for federal wetland regulatory activities in five of the six states in the sample. From August 2010 through May 2011, the author was a volunteer at that same office. EPA regional wetland regulators spend a significant portion of their time working with their state wetland regulatory counterparts. Working with the EPA staff offered much insight on wetland regulation in the Mid-Atlantic states and unique access to data.

3.14 Secondary source research

The author was given access by EPA staff to all the documents that the regional workgroup on wetland science and policy has produced since its inception in the early 2000s and at least three years' worth of reports and budgets associated with wetland program development grants that have flowed from EPA to the Mid-Atlantic states. The author independently gathered other reports, tool copies, presentations, meeting minutes, and other relevant documents. As of this writing these data have not been coded.

3.2 Operationalizing key variables

This section describes the how key variables will be constructed for analysis. These approaches likely will be refined.

Network size will be measured by recording the names of individuals mentioned in interviews and survey data and noted in secondary sources concerning wetland assessment in a given state. The number of these individuals will represent network size.

Network permeability will be measured in part by reviewing the lists of member names and counting the number of members who appear to have entered the network after the 1995 baseline. Entrance into the network will be indicated by the individual's first appearance in secondary source or by interviewee comments on the timing of an individual's network entrance.

To this count will be added the number of individuals who appear to have left the network. This number is more difficult to estimate from secondary sources because absence of mention does not definitively indicate that a member has left. Thus, exits from the network will primarily be gleaned from instances when interviewees mention that someone stopped being involved in wetland assessment activities. The number of exits and entrances will be added; a higher score will indicate more permeability.

The permeability score may be adjusted up or down using two multipliers. First, the average duration of a bureaucrat-critical actor linkage, as indicated by the survey data, will be calculated and compared to the durations associated with other states in the sample. The duration values will be separated into *low*, *medium*, and *high* categories. These values will be assigned multipliers such that a *low* value increases the permeability score, a *medium* value keeps it constant, and a *high* value reduces it. Second, the permeability of the network to new ideas will be categorized as *low*, *medium*, or *high* depending on the author's qualitative impressions gleaned from interviews, and the values assigned multipliers that adjust the permeability score.

Tie strength will be measured primarily using survey data. Survey respondents were asked to use ordinal categories to report the frequency of their interaction with critical actors. The average proportion of interactions that fell into each category will be calculated for each network. Bureaucrats were asked to categorize the critical actors to whom they were connected as professional acquaintances, colleagues, or friends. The average proportion of linkages that fell into each category will also be calculated for each network. The policy networks will be compared vis-à-vis their distributions on these variables and ranked according to evidence of tie strength.

Adoption and *implementation* will be continuous variables bounded by 0 and +/-1. The thresholds that will determine the location of a state bureaucracy on the AI curves are substantive, such as the first instance of tool pilot testing or a specific percentage of state bureaucrats estimated to be using the tool. In the interest of space, the thresholds are not described here. Evidence supporting the placement of a state bureaucracy on the AI curves will come from interviews, survey data, and secondary sources.

4.0 Case Sketches

Since the data remain largely unanalyzed, the vignettes below are not full case studies. They rely on a limited number of interviews and secondary sources and not at all on the survey data. They are meant to illustrate how alignment or misalignment of the AI and EC cycles appears to facilitate or hinder the adoption and implementation of a science policy innovation. Each sketch is followed by a visual depiction of the dynamics the sketch explored.

4.1 Delaware

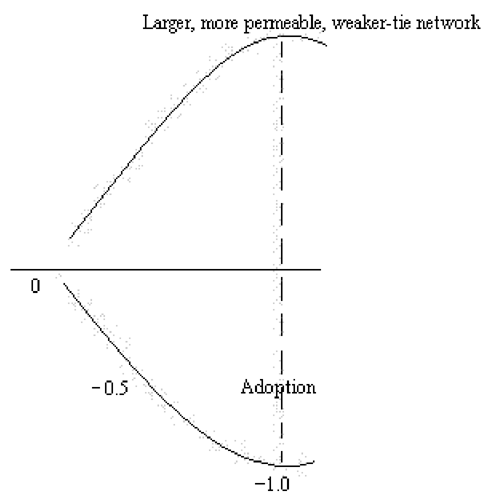
Delaware is in the middle stages of adopting a rapid wetland assessment tool for regulatory purposes, having recently passed the decision point where bureaucrats commit to such use. In 2009, the watershed assessment section of the Delaware Department of Natural Resources and Environmental Control secured EPA funds to adapt for regulatory use the rapid wetland assessment tool that has been used in Delaware for restoration and conservation purposes since 2001 (Biddle, Jacobs, and Herr 2009).

Unlike in the other states, the policy network surrounding wetland assessment in Delaware developed around a tool designed, revised, and used over many years for non-regulatory purposes. The Delaware Rapid Assessment Protocol (DERAP) is well known to wetland assessment experts regionally and nationally. Practically every person interviewed for this project who was familiar with both wetland assessment and the states in question mentioned DERAP, usually citing it as an example of a sophisticated, scientifically rigorous tool. One federal wetland expert said that no study of wetland assessment in the region would be complete without an examination of Delaware and DERAP, and that Delaware is a "poster child" for wetland assessment (Rhodes 2010). Aspects of the tool have been recently analyzed or profiled in national scholarly journals such as *Wetlands* (Sifneos et al. 2010) and *Environmental Management* (Herlihy et al. 2009).

As DERAP has developed and become nationally known, the bureaucrats responsible for it have collected a large and diverse (weak tie) network of scientists and policy experts interested in using, helping refine, or studying the tool. This network was accessible to Delaware's wetland bureaucrats as they moved to the adoption decision point and arguably facilitated that movement.

The question now is whether Delaware's policy network will be able to contract, becoming stronger and less permeable to facilitate implementation. There is evidence that this contraction may be delayed because of external influences of the types noted in Sections 2.3 and 2.4. A state wetland bureaucrat who has long been crucial to the assessment effort in Delaware recently left state government. The reshuffling of this individual's responsibilities and intra-agency regrouping seems to be causing general delays in the state's wetland regulatory efforts. For example, a project manager on the grant cited above recently pushed back by multiple months a check-in meeting with EPA staff, explaining that there was just no time. Also, in the summer of 2010, DERAP started experiencing heavy and often critical scrutiny by federal regulators. A developer attempted to use the tool to assess a wetland area in Delaware in preparation for a controversial project. Federal regulators' objections to the project seem to have negatively affected the way some of them perceive the tool. In part because of the interrelationships between state and federal wetland regulatory processes, it is helpful to state regulators when federal regulators approve of the former's work. Delaware's wetland regulators thus may be waiting for the DERAP issue to "cool off" before they attempt a push towards implementation of the tool in regulatory applications.

Figure 5



4.2 Maryland

From 1970 to roughly the early 1990s, Maryland was one of the nation's leading states vis-à-vis wetland protection and innovative tools for that purpose (Rhodes 2010); one retired state regulator stated that Maryland "had one of the most progressive wetland programs in the world." The state passed tidal wetland protection legislation in 1970 and a non-tidal wetlands protection act in 1989 (Gaddie and Regens 2000). Multiple interviewees noted that in the 1970s, 1980s, and early 1990s, Maryland's wetland regulators, particularly its program leaders, were well-connected to a variety of national, regional, and local critical contacts. Ties with a highly supportive governor, for example, facilitated the passage of the non-tidal legislation (ibid.).

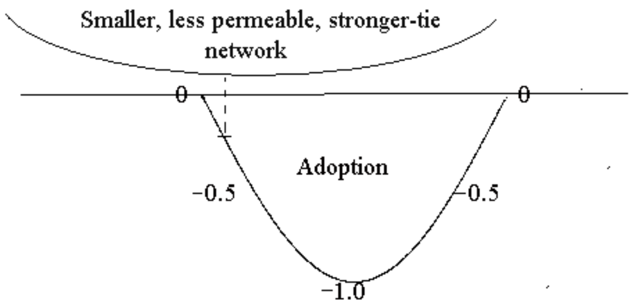
Today, however, Maryland's policy network devoted to innovations in wetland policy has changed. Minutes and attendance sheets from the Mid-Atlantic Wetland Work Group (MAWWG), the regional group devoted to advancing wetland assessment science and policy, suggest that there has been minimal turnover among the Maryland's assessment staff since MAWWG's inception in the early 2000s. The same individual has been responsible for the regulatory wetland assessment effort in the state since the mid-1990s; one interviewee said that this individual has "been there since the beginning of time." The policy network's current small size appears the result of a persistent failure to bridge a major structural hole, suggesting a dominance of bonding over bridging social capital and also limited permeability. More than one interviewee reported a history of non-cooperation between the state's regulatory environmental agency and its natural resource management agency. While both agencies pursue wetland-related activities, they pursue them largely in separate spheres.

The number of state staffers involved in regulatory-targeted wetland assessment in Maryland appears small relative to the number in the other states. One EPA expert called the state's assessment program fairly "insulated." Unlike in a state such as Ohio, where the state-specific technical workgroup devoted to assessment involved a variety of actors with different affiliations, Maryland's wetland assessment workgroup is almost entirely composed staff from state agencies (ELI 2008). When state bureaucrats tapped a public sector environmental think tank to help strategize about wetland assessment tool development, the expert with whom state staffers worked most closely was regarded by some EPA experts as "behind the times."

It appears that, over time, Maryland's policy network associated with innovations in wetland management shrank, becoming more ossified and less permeable. While this contraction probably facilitated the implementation of wetland innovations adopted in the 1970s and 1980s, it left Maryland less able to adopt new wetland innovations. Today, Maryland has begun the tool adoption process, but only barely.

In the mid-1990s the state failed in a major bid to adopt a high-profile wetland policy innovation: state assumption of the federal wetland permitting program (Gaddie and Regens 2000). Since then, Maryland has appeared largely to be "resting on its laurels" instead of keeping up with the latest wetland policy innovations (Rhodes 2010). Maryland's current assessment program has been described by some regional experts as "dead in the water" and "a fairly tragic story." Since the early 2000s, the state has received EPA funds to develop a rapid wetland assessment tool. It has used these funds to develop a series of monitoring plans, convene a state workgroup on wetland assessment, and commission external research entities to produce papers on assessment (Clearwater 2010). Maryland remains the only state in the region that has neither recently developed a rapid wetland assessment tool nor is considering adopting or implementing a specific one. Some EPA staff members report being frustrated with the way Maryland has used its grant monies and its lack of assessment tool progress. But Maryland's limited progress on adoption or implementation of a rapid wetland assessment tool makes theoretical sense; its policy network is the opposite of the type of network which appears to facilitate adoption.

Figure 6



4.3 Ohio

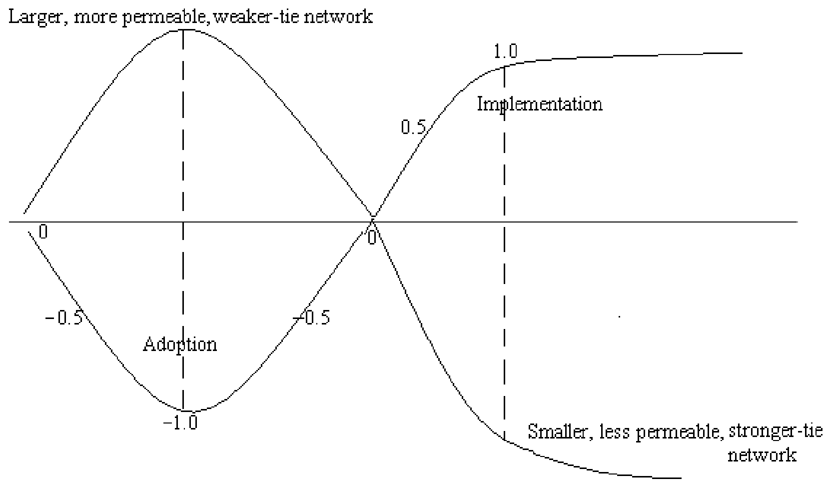
All the states have one or more intra-state technical workgroups devoted to wetland assessment issues. Members of these groups are almost certainly members of the states' policy networks surrounding wetland policy innovation. The Ohio workgroup, formed in the late 1990s, appears to have been most diverse and perhaps the largest among all the intra-state groups. This network consisted of roughly 20 people, and it grew out of a larger stakeholder group of 50–80 people (Mack 2010). The Ohio workgroup comprised scientists, members of environmental advocacy groups, representatives of the regulated community, and state bureaucrats from a variety of agencies. A scientist led the group's effort to find a workable assessment approach. The group extensively reviewed the scientific and gray literatures about assessment around the country, then decided that rapid wetland assessment tools already in use in two different states, Minnesota and Washington, would provide the best basis for Ohio's assessment effort (Fennessy 2010).

Presumably learning about assessment tools around the country, and obtaining assessment tools from Minnesota and Washington and learning how to use them, required members of the Ohio policy network to forge ties with bureaucrats and critical actors in other states. These likely were weak ties, which are best suited for conveying information and less suited for fostering close personal relationships (Granovetter 1973). Not only was the network that facilitated tool adoption large and characterized by weak ties, but it also clearly was permeable to new ideas.

This diverse technical workgroup facilitated the creation of the Ohio Rapid Wetland Assessment Method (ORAM) in 1998, then helped the state revise the tool five times between 1998 and 2001. Over that time period, the tool actually was being implemented while new iterations were being developed; this situation most closely parallels the more complex optimal alignment scenario described by Figure 4. Bureaucrats involved with implementation at that time report that their interactions with members of the policy network were regular, ongoing, and relatively intense (Mack 2010). On the other hand, the larger network of critical actors devoted to adoption was still conferring and drawing on a variety of sources to help improve the tool in its next iteration (Fennessy 2010). Thus, the small, less permeable, and stronger-tie network facilitative of implementation coexisted for a time with the larger, more permeable, and weaker-tie network facilitative of adoption.

ORAM was not revised after 2001. Legislative changes made revisions more difficult, though not impossible, and most members of the policy network agreed that the tool was in good shape (Micacchion 2010). The large network devoted to adoption mostly dissipated, leaving a small cadre of individuals who now do research and analysis in support of the ongoing, complete integration of ORAM into Ohio's wetland regulatory program. Today, all state wetland regulators must be familiar with ORAM and state wetland permit applicants have strong formal and informal incentives to use it (Mack 2010). The tool has become fully part of the state's wetland regulatory culture (ibid.) and is generally perceived by members of the wetland policy community as a major assessment success story.

Figure 7



4.4 Pennsylvania

In the mid- to late-1990s, Pennsylvania committed to developing a wetland assessment tool. It was supported in this effort by the Pennsylvania State Cooperative Wetlands Center, early participation in MAWWG, and an active intra-state assessment workgroup that brought together staff from the departments of environmental protection and natural resources, the fish and boat commission, the state transportation agency, and the game commission, as well as various members of the public and the private sectors. The Wetlands Protection Advisory Committee (WETPAC) met every three to four months. Led by a bureaucrat strongly committed to assessment, the group appeared to have been making good progress toward developing a tool that ultimately could be implemented. The policy network was relatively large, diverse, and apparently permeable.

However, larger political trends in the state as well as staffing changes at the Pennsylvania Department of Environmental Protection (PADEP) caused the network to begin to disintegrate in the early 2000s. Interviewees who used to participate in WETPAC activities said that meetings just tapered off, and that they stopped being called by PADEP bureaucrats seeking input about assessment. Importantly, this network disruption occurred before the group had reached final consensus on the nature of the tool. Adoption was still ostensibly in progress.

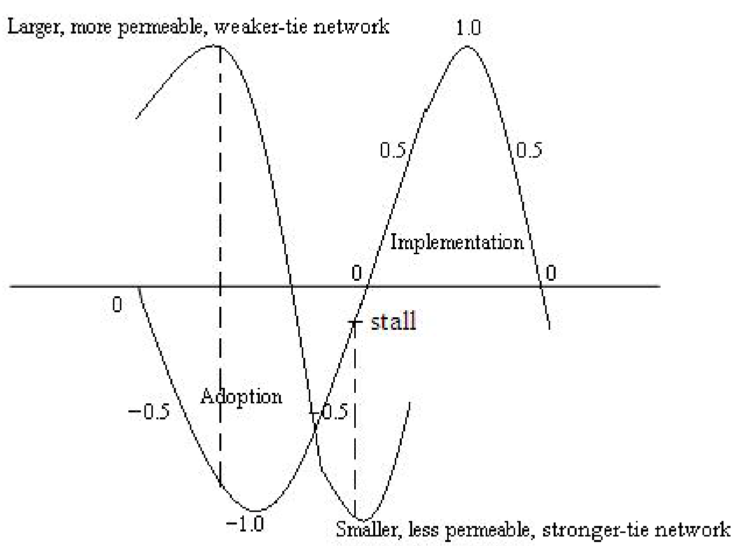
Today, the policy network surrounding wetland assessment in Pennsylvania appears to have shrunk significantly and become less diverse. The relationship between the Pennsylvania State Wetlands Center and state bureaucrats is no longer as strong or direct (Wardrop 2010). The leader of the assessment initiative in Pennsylvania now appears to be running it almost independently. It is not clear whether this individual has sought intra- or inter-agency support and been denied it, or has simply chosen to go it alone; some interviewees suggest the latter. The network is also notable for the structural holes it fails to bridge. State bureaucrats' jobs are usually much easier when they have a cooperative relationship with U.S. Army Corps of Engineers district regulators who also pursue wetland regulation in the state. However, one of the Corps districts that covers a wide swath of Pennsylvania has refused to engage with the state's assessment tool development process, and state bureaucrats involved in the assessment initiative have reportedly been equally unwilling to "court" that Corps district or any others.

There appears to be increasing skepticism among remaining members of the policy network concerning whether the state's assessment tool will ever actually be used in regulatory applications. Members worry over the conflict with the Corps, the viability of the now-insulated tool development process, and assessment initiative's recent history of delays and missed deadlines. One federal regulator recently worried that "things are going to get ugly" in Pennsylvania's assessment attempt fairly soon.

These troubling network trends clearly have affected adoption and implementation outcomes. Regional experts have described Pennsylvania's wetland assessment program as "confusing." One federal regulator asked this author, only half-jokingly, "when you figure it out, can you tell us?" A key official in the state's wetland assessment initiative reported that the state is planning to integrate its rapid assessment tool into regulatory use in the near future, but federal officials say that the state has been planning such a roll-out for years and has made little progress. In fact, a 2008 assay of the state's wetland programs reported that in 2006 the state had completed and was field-testing an assessment protocol in preparation for regulatory roll-out (ELI 2008); this is essentially the same status report that a state bureaucrat provided via interviewee four years later. Pennsylvania is currently holding trainings to familiarize stakeholders with the current version of the tool, but state officials have already told participants that the tool will be revised again before it is actually used.

The larger, more permeable, weaker-tie network that facilitated the early stages of tool adoption in Pennsylvania seems to have contracted too soon. The network reached potentially implementation-facilitating conditions while adoption processes still needed to occur. The associated withdrawal/consolidation of resources (information, human capital) and closing of ranks (cohesion) on an incomplete tool concept not yet suitable for implementation stalled the AI cycle before implementation could begin.

Figure 8



4.5 Virginia

Virginia is unique among the states in the sample in that state environmental agencies are in some cases legally required to rely on the Virginia Institute of Marine Sciences (VIMS) for technical advice. The research institute is roughly 60 years old, employs 450 staff with technical expertise, and has served as an objective scientific advisor to state agencies throughout its history (Hershner and Havens 2010). Virginia's non-tidal wetland regulatory program was established in 2001 and its bureaucrats immediately had access to VIMS' well-established, far-reaching network of experts interested in science policy innovation.

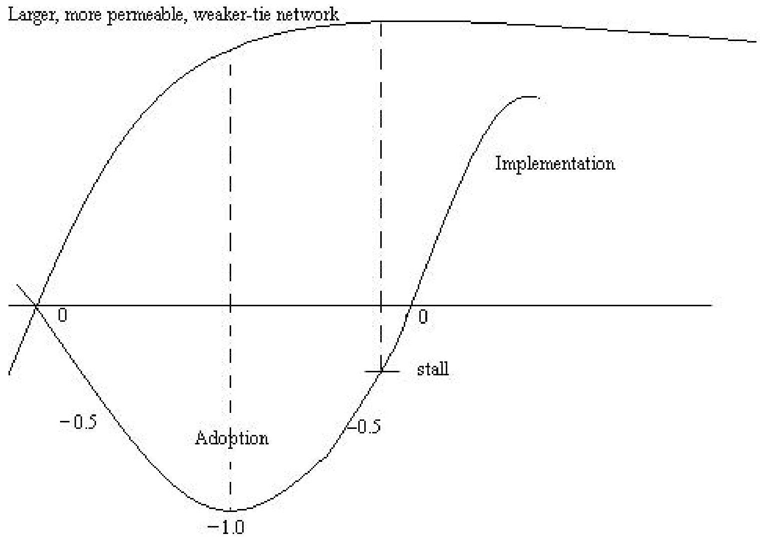
VIMS staff members appear to have multiple strong ties to wetland policy-interested researchers, policy experts, and bureaucrats across the region. Virginia wetland bureaucrats also work with researchers at Virginia Tech and staff at other state agencies, such as the Virginia Department of Transportation, on wetland assessment issues. State wetland bureaucrats have participated in MAWWG since the group's inception. The policy network that has surrounded Virginia's non-tidal wetland program since its establishment appears large, characterized by diverse weak ties, and permeable.

This network has helped Virginia adopt a sophisticated wetland assessment program. The Virginia approach incorporates a rapid wetland assessment component as part of a three-pronged strategy that also involves GIS analysis and intensive field-level verification. The assessment program has been in development since 2003 and is regionally recognized as scientifically advanced. However, Virginia's state agencies have not taken the final step and integrated assessment into regulatory activities despite an ostensible interest in doing so. Rather, state bureaucrats and members of the policy network seem stuck in late-adoption but pre-implementation phase of tool revisions.

VIMS and state wetland regulators are on their sixth round of revisions of the most current iteration of the rapid wetland assessment tool (Hershner and Havens 2010). State bureaucrats have pilot-tested the tool in some parts of the state and have begun introducing the tool to staff at other wetland regulatory agencies such as EPA. Bureaucrats recently contracted with Virginia Tech to review permit files against aerial photographs to determine where wetland impacts have occurred legally and illegally, and then build these data into the wetland assessment tool such that the tool would help a user evaluate cumulative impacts. Staff members also are applying for EPA funds to modify the assessment approach so that it can better apply to linear projects, a revision state staffers say will take three to five years. State staff members say that the first version of the rapid assessment tool should be ready for regulatory roll-out in two to three years, but note that they are consciously "taking baby steps" and "moving slowly" to ensure that they only use relevant, high-quality data and measures.

There are a variety of reasons why regulators in the state may be approaching implementation so slowly. This pace may not be strictly required by the state of the science or the tool itself; at least one regional expert noted that by this point, the state should be ready just to get on with implementation. One compelling argument is that state staff members find doing so difficult when their large and diverse policy network keeps bringing them interesting and innovative components that could be added to the tool, allowing them to delay an implementation process that is bound to be politically and potentially legally tricky. The policy network has never contracted, and thus members have never closed ranks on the rapid assessment tool and pushed it forward using the energies of a small, committed, tightly knit group.

Figure 9



4.6 West Virginia

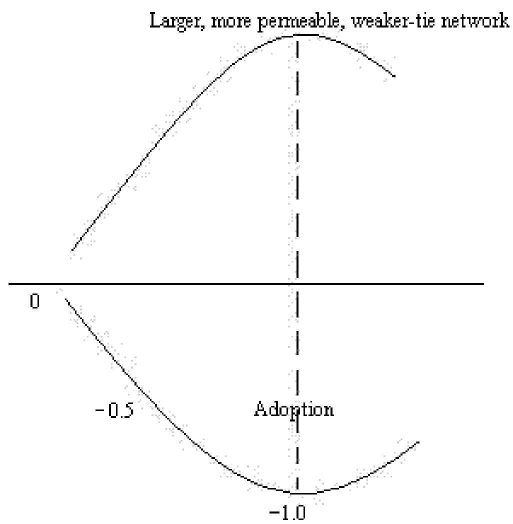
The policy network devoted to wetland assessment in West Virginia appears relatively large, diverse (weak ties), and permeable to ideas and staff. It is also relatively young; the state only began participating in MAWWG in 2004, the same year it requested its first grant from EPA to fund the establishment of reference sites that would allow the development of a wetland assessment tool. State bureaucrats themselves reported that they only began serious work on wetland assessment approximately four years ago. At that time, the wetland assessment policy network in the state was still rather small and tight-knit. It consisted mainly of state bureaucrats who did not necessarily have many connections to non-bureaucrats; a leader of the nationally recognized Association of State Wetland Managers, for example, reports having had limited contact with wetland regulators from the state (Christie 2010).

However, in the mid-2000s, bureaucrats at the West Virginia Department of Natural Resources began working with scientists at West Virginia University to develop a rapid wetland assessment tool (Anderson 2010). Those scientists then worked with wetland assessment experts nationwide to craft the tool, selecting from tools used in California, Ohio, Montana, Oregon and other states the pieces and parts that seem most amenable to West Virginia's resources (Anderson 2010, Veselka 2010). This tool "cannibalization" (in the words of one WVU researcher) expanded the policy network significantly.

Although West Virginia began its wetland assessment initiative later than other states in the region, one federal expert said that the state's pace toward adoption and implementation seems quicker than that of some other states in the region (Poeske 2010). The West Virginia Rapid Wetland Assessment Procedure was developed and internally quality checked by the end of 2009 (WVDNR 2009). In 2010, field crews tested the tool on 100 randomly selected sites statewide, and aim to have tested the tool at 1000 different sites by the end of the summer of 2012 (ERC 2010). Once the tool is finalized, it is the "vision and hope" of policy network members that it will be used in wetland regulatory permitting (Kordek 2009).

Consistent with theory, the expansion and increased permeability and diversity of the state's policy network allowed for tool adoption. Now, members of the policy network are steering the tool towards implementation. There are some possible signs that the policy network is contracting in an implementation-facilitative manner. For example, after drawing on wetland expertise in other states, West Virginia tool developers turned their attention inward, focusing on which elements were best suited to West Virginia (Kordek 2010) and thus giving less attention to their regional and national weak ties. In interviews, state bureaucrats responsible for the wetland assessment initiative emphasized the importance of getting a collection of key individuals "onboard" with the idea of regulatory use, including staff members from the U.S. Army Corps of Engineers and at the West Virginia Department of Environmental Protection. Core members of the network thus may recognize that bonding social capital and strong ties with a select, small group of highly relevant actors facilitates tool implementation; however, it remains to be seen whether the policy network will achieve this transformation:

Figure 10



5.0 Discussion

The case sketches illustrate the correlations between adoption-implementation and policy network expansion-contraction cycles theorized at the outset. However, there are some important considerations this analysis does not address.

First, the composition of the policy networks likely impacts adoption and implementation, but in this analysis, "critical actors" remain undifferentiated. It may be consequential whether the policy network is dominated by government actors, for example, versus university scientists. Also, in Delaware, Ohio, Maryland, and Pennsylvania, there were or are one or two actors who clearly were linchpins in progress toward or delays in adoption and implementation. The way these network "stars" (Carrington, Scott, and Wasserman 2005) influence AI and EC cycles should be more closely examined.

Second, and relatedly, when the policy network expands or contracts, it is likely that some actors on the periphery of the network take on more central roles, and vice-versa. For example, in a network facilitative of adoption, scientists who can bring innovative ideas to the table appear to play a valued role. However, in a network facilitative of implementation, bureaucrats who can "bulldog" the assessment program through implementation challenges will be more active and valued (Sumner 2011). Scientists will move to the periphery, perhaps only consulted when there is a substantive question about the tool. Which actors shift location in the policy network, and how and when, is an issue that requires more study.

The third issue is one touched on in Section 2.2: the age of the policy network. A recently formed policy network may behave differently than a more mature one. The ways in which networks collect, retain, or shed members and the kinds of bonds that develop among members may change over time. These dynamics must be explored further.

Fourth, while the ways policy entrepreneurs or larger external forces affect the pace and trajectory of AI and EC cycles can be observed in hindsight, it remains unclear whether these propositions are predictive. More data and analysis are necessary to explore this question and to test the theory beyond the cases from which it was developed.

Finally, this analysis treats the likelihood and extent of adoption and implementation of a rapid wetland assessment tool as separate from the suitability of the tool for the resource, the scientific rigor of the tool, the tool's fit with the standard operating procedures of the bureaucrats who must implement it, and the relevant socioeconomic or political contexts. These variables enter the analysis when bureaucrats consider them when contemplating whether and how to adopt and implement. In reality, though, these are consequential independent variables which may matter more to practitioners than the network variables, particularly to the extent that these variables affect resources directly (e.g., if the science behind a tool is flawed, the tool's "successful" adoption and implementation, as defined by a policy scholar, may actually harm the resource). A fundamental challenge of this research is finding a way to evaluate the impact these variables have on adoption and implementation outcomes relative to, or in combination with, the network variables.

6.0 Conclusions

The permeability, size, and tie strength of policy networks appears to affect whether and the pace at which state bureaucracies adopt and implement science policy innovations. Adoption and implementation are continuous rather than binary variables; they are processes that are linked cyclically. Networks expand and contract cyclically along the noted policy dimensions. A correct alignment of adoption-implementation and network expansion-contraction cycles increases the likelihood that adoption and implementation will occur and progress. Policy entrepreneurs as well as larger external influences contribute to alignment or misalignment.

These propositions were illustrated by case sketches describing the attempts of six states in the Mid-Atlantic region of the United States to adopt and implement rapid wetland assessment tools. The policy outcomes in the case sketches are largely supportive of the propositions. However, the propositions must address some potentially important variables for which they currently do not account. The propositions require further development and out-of-sample testing.

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