## I. THE PROBLEM: COOPERATION IN A FEDERALIST SYSTEM

Our proposal investigates the impact of policy networks on cooperation among multiple government agencies and their clientele. We focus on joint projects in which two or more federal, state, or local agencies and related constituencies agree to work together for mutual benefits, and analyze the role of network contacts in facilitating the development of projects and constraining shirking behavior by participants.

Joint projects provide an excellent research site to examine the impact of policy networks on cooperation for several reasons. Pragmatically, joint projects are becoming increasingly important as the decisions of one specialized agency in our fragmented federalist system impose costs and benefits affecting the performance of other agencies and their clients (Bardach 1998). This creates an "institutional collective action" problem in which cooperation could potentially improve policy outcomes for multiple agencies and their respective constituents, but also exposes each agency to the risk that others will fail to fulfill their obligations to joint projects. The institutional collective action problem is particularly acute in local ecosystems, where many agencies exert authority over different aspects of the same local ecosystem (Lubell et al 2002). The externalities imposed by each agency's decisions on other agencies and their clientele increase exponentially as development pressures challenge the limited capacities of the natural system. Even in water-rich Florida, groundwater extracted by municipalities affects wetland habitats, agricultural and private wells, and permitted effluent discharge in rivers; costly, decades-long battles among the agencies and involved interests have accelerated the search for cooperation, which requires the development of joint projects designed to maximize joint returns within the unique constraints of the local ecosystem (Scholz and Stiftel 2005).

From a theoretical perspective, joint projects provide a site for studying the impact of policy networks on both formulation and implementation stages of the policy process, which correspond to the design and implementation phases of the project. Each phase imposes different obstacles to cooperation, so network characteristics important during one phase may not be important during the other.

Finally, from an empirical perspective, joint projects provide a unit of analysis that enables us to obtain the necessary level of detail to study the specific mechanisms linking networks to cooperation. Our prior NSF-funded research compared networks across policy arenas to establish the general importance of bridging networks for improving policy agreement and perceived policy success, but measuring network characteristics in multiple policy arenas imposes several restrictions discussed in detail below. By studying multiple projects in a single policy arena selected from the prior study—the Tampa Bay Estuary—we can fully document the relevant network characteristics and cooperative performance measures for each actor in every project in the policy arena. Our prior research has documented the large number of policy actors and projects in Tampa Bay and the rich variance in both network linkages and project performance, which will provide sufficient data for the sophisticated empirical analyses required to resolve the problems of inertia, lagged effects, and reciprocal causality inherent in the study of network effects on cooperation.

## II. The Theoretical Approach: Policy Networks and Cooperation.

Policy networks have attracted growing attention since being popularized by Heclo (1978). Most of the growing literature uses network analysis to determine who controls complex policy arenas (e.g., Heinz, Laumann, Nelson, and Salisbury 1993), particularly in Europe (Marsh and Rhodes 1992), or how networks evolve into advocacy coalitions (Sabatier and Jenkins Smith 1993, Weible and Sabatier 2005) but some studies have at least noted the potential role of networks in improving policy performance (Bressers and O'Toole 1998, Milward and Provan 1995, Provan and Milward 2001)

The two competing images of policy networks that have developed to understand how networks determine policy control (Dowding 1995, Marsh and Rhodes 1992) suggest very different mechanisms for mitigating organizational collective action problems. The *policy community* perspective emphasizes the role of a small, tightly-clustered, like-minded set of stakeholders (including political overseers, agencies, and their clientele) who know each other very well for controlling policy decisions. This perspective shares many assumptions with the theory that dense, clustered, overlapping networks of reciprocity provide a critical contribution to social capital (Coleman 1988, Putnam 1995, 2000). Tightly-clustered communities provide extensive monitoring and punishment opportunities that enhance the credibility of commitments to the rules of the community by network members (Ostrom 1990). Policy communities or advocacy coalitions in which all participants interact frequently with each other are assumed over time to promote agreement on policy beliefs, trust, and hence reliable cooperative actions among community members (Sabatier and Jenkins-Smith 1993).

The *issue network* perspective, on the other hand, emphasizes the role of more diverse, larger, loosely connected sets of stakeholders in resolving joint issues. This perspective notes that policy arenas seldom exhibit the like-minded, tight-knit network assumed in the policy community perspective, and argue that more loosely-coupled networks can still achieve some level of control through limited cooperation among its members. This perspective shares assumptions with network perspectives emphasizing the informational advantages of "weak ties" (Granovetter 1973), random, unclustered networks (Watts 1999), and links that span "structural holes" between tightly-clustered groups (Burt 1993, 2005).

Granovetter (1973) found that weak ties with distant friends provided more productive information for finding jobs than strong ties with close friends who know each other. Watts (1999) demonstrated that networks formed by those seeking like-minded individuals tended to be highly clustered, consistent with the policy community perspective. The consequence, however, was that, for any given number of total contacts in the community, the average number of links required for information to pass from any one individual in the community to another was considerably higher in clustered networks than in networks formed when individuals formed random links rather than seeking like-minded individuals. Finally, Burt (2005) argues that clustering does indeed promote consistency of norms and beliefs necessary to ensure trust and sustain cooperation, but the resultant conformity of ideas constrains the range of collective action that can be undertaken. Social capital is maximized when entrepreneurs form links that bridge the gaps between clusters, providing a richer source of information about potential activities not envisioned within the cluster.

Extending Burt's perspective, we argue that both network images are important for joint projects, with each providing greater advantages at different stages of the policy process. The *information-bridging hypothesis* suggests that the informational advantages of bridging networks are particularly important during the initial stage of developing joint projects. Bridging links allow a policy actor not only to discover a broader set of possible gains from others in the policy arena, but also to control information flow and hence shape joint agreements to the actor's advantage. From the transaction cost perspective on contracts (Heckathorn and Maser 1987), the informational advantage of bridging networks helps reduce the costs of developing joint projects, and information control provides an advantage in negotiating the contract. For both reasons,

**H1 (Information-bridging Hypothesis) : Actors with more bridging connections are more likely to participate in a greater number of joint projects and have more positive evaluations of performance in the design stage of these projects than actors with fewer bridging connections.**

The *credibility-clustering hypothesis*, on the other hand, suggests that the credibility advantage of clustered networks become increasingly important during project implementation, when shirking by other participants can impose great costs on cooperative participants who have already invested. From the transaction cost perspective, the credibility advantage of clustered networks helps reduce the costs of enforcing the terms of agreement during implementation and the risks associated with the asset specificity of project investments (Williamson 198?). Clustered networks increase the number of actors who could at least potentially observe and punish shirking, and shared beliefs and mutual reciprocity enhance the credibility that punishments would indeed be imposed even when costly to the punisher. Thus clustered networks impose constraints:

**H2 (Credibility-clustering Hypothesis): Actors with more clustered networks will be constrained to cooperate in joint projects more than actors with less clustered networks.**

We are concerned with these hypotheses not only to extend our understanding of the role networks play in resolving collective action, but also for the practical reason of improving performance in joint projects as a means of resolving the fragmentation problems of federalist systems. The credibility-clustering hypothesis can be readily applied to project performance — more clustered networks involving project participants will lead to higher levels of cooperation. Furthermore, since we are also interested in what network strategies participants can use to minimize the losses imposed when partners shirk, we also want to consider the role of clustering in improving levels of mutual cooperation in dyadic relationships that may involve multiple projects. We discuss the measures of bridging and clustering at the individual actor in the next section, and extend these measures to the project and dyadic levels in the research design section.

### Refining Hypotheses: Network Analysis

Network analysis has developed a broad array of potentially relevant concepts and related measures (Scott 1991, Wasserman and Faust 1994). Following the basic network analysis approach, we can represent the policy arena's network structure as an $N \times N$ matrix reporting all contacts among all N actors in the estuary. The entry $i,j$ equals 0 if actor $i$ has no contact with actor $j$, and can equal 1 to indicate the presence of a contact or can equal some measure of the frequency or intensity of contacts. To develop network measures for each actor (referred to as "ego"), we analyze the "ego network" that includes ego's set of direct contacts (*alters*) and indirect contacts through the contacts of alters and their respective alters.

Our proposal will measure two levels of network structure. The *resource network* measures relationships in which information and resources flow from one organization to another. This corresponds to the standard notion of networks measured through surveys that ask actors who they contact and for what reasons. The *contract network* measures relationships that are created through participation in joint projects, so entry $i,j$ represents the number of joint projects in which both i and j participate. This corresponds to standard associational networks.

Using the estuary matrix for either network, UCINET and other software packages can calculate each actor's score on several measures relevant for testing our hypotheses. *Size,* the number of alters in contact with ego, provides one of the most basic descriptive measures of ego networks. Size is related to the information-bridging hypothesis because more alters provide more possibilities of gaining information. Size does not differentiate the two network perspectives very well, however, because a larger ego network is also likely to lead to greater cooperative gains as long as the network is also clustered. Thus size is an important network characteristic for both network perspectives.

*Density,* the proportion of the ego's alters who know each other, comes closest to capturing the basic notion of the credibility-clustering hypothesis. If all of ego's friends know each other, ego's ability to shirk responsibilities with any friend is constrained by the knowledge that all other friends are likely to find out. To the extent that clustered friendships induce shared beliefs, values, and trust in support of mutual cooperation, higher density of ego's network should be associated with higher levels of agreement and cooperation. On the other hand, information problems would not favor redundant contacts with close associates (Burt 2005). Given a choice of potential alters each having the same network size, the contact with the greatest number of non-redundant links beyond ego's immediate contacts would provide the greatest source of non-redundant information. Higher density would thus be associated with lower information capacity, so actors with higher density should be involved in fewer projects.

*Bridging,* the number of actors in the estuary that are most directly connected through ego, provides one of several possible measures relevant to the information-bridging hypothesis. Freeman (1977) developed this "betweenness" measure as one of several measures of centrality. Assume that information is transmitted only between individuals connected in a network. The bridging measure first identifies all the shortest paths for information between every pair of actors in the estuary. The index then counts the total number of these shortest paths that include ego as one of the links. In the case of pairs with multiple shortest paths, the proportion of paths going through the investor is counted as that pair's contribution to ego's bridging score. For example, if a pair of stakeholders was linked directly to the investor and also to another common stakeholder, both the investor and the other stakeholder would provide bridges with length of two links. Since the investor provided one of the two shortest paths, this bridge would contribute 0.5 to the index for the investor.

The information-bridging hypothesis suggests that when information provides the critical barrier to joint action, highly motivated actors will seek to lower information costs and control the flow of information by investing in network contacts that maximize the number of bridges formed. Bridges not only allow the actor to learn more about available opportunities, but also to control the flow of information and hence increase the share of the net gain from joint projects, providing an added incentive to cooperate. Hence actors with high bridging scores are predicted to have a higher propensity to participate in joint projects, and to perceive projects as being well-designed and congruent with the actor's concerns.

### Refining Hypotheses: Prior Research Results.

The proposed research builds on three prior NSF grants that have shaped our research design. One project (SES-0125426) investigated whether local networks coopt or cooperate with federal agencies. We found that organized local policy networks increase both EPA enforcement and compliance by permit holders with the Clean Water Act (Wang and Scholz 2005). The extensive scope of this project (all relevant U. S. watersheds over a six-year period) bolstered the generalizability of this finding, but imposed the disadvantage of limiting network data to very basic measures (the presence of formalized networks (partnerships) and political, economic, and social indicators that served as proxies for network size).

A second study (SBR9815473) investigated the impact of federal programs on local networks and cooperative policy performance. We found that estuaries in which the National Estuary Program was implemented significantly increased the number of policy network contacts, the proportion of network subgroups (clans) that included multiple types of organizations, and the levels of perceived agreement on policy goals and the effectiveness of general estuary policies (Schneider et al 2003). By limiting the scope of analysis to 22 estuaries, the project was able to develop more detailed survey-based measures of networks and performance for samples of policy actors in each estuary.

Since the study was not designed explicitly for network analysis, our first survey only asked respondents about their organization's most important ally for estuary policy, with up to three follow-ups. Given the importance of this network measure in preliminary analyses, we added a question in the mail-component of the second survey that asked respondents to check all organizations they dealt with on a regular basis from the list (obtained from the first survey) of all organizations in their estuary. The excellent response to this procedure produced a reasonably complete list of contacts, providing the data necessary to complete the rows in the estuary matrix for all organizations represented in our sample (28 out of 102 in Tampa Bay, for example), but not for the remaining organizations.

Scholz et al. (2004) used this data to analyze the impact of network relationships on the respondent perceptions of "agreement among stakeholders in the estuary" and the organization's propensity to undertake collaborative activities (a scale including the sharing of information, sharing of analysis, sharing of personnel, collaboration on joint research projects with other stakeholders, collaboration on joint grant/funding proposals, creation of an interagency taskforce, signing of memorandums of understanding, and sharing permitting or regulatory activities).

Network scores for each organization included in the sample were calculated by using an estuary matrix for each estuary that was limited to respondent organizations. The analysis found that density was positively associated with perceived agreement in the estuary, as expected by the policy community perspective. On the other hand, both size and bridging were positively related to collaboration, while density was related negatively or not at all. These intriguing but ambiguous results suggest that the measure of collaboration reflects information-dependent processes that are assumed in the information-bridging hypothesis. But they may also suggest that bridging plays a more important role than density in supporting cooperative behavior even where credibility is critical. Alternatively, the measures of bridging and density based on samples rather than full networks may not provide a reliable basis for analysis.

To provide a clearer test of our hypotheses, our intensive research design will produce detailed and reliable measures of networks, as described later. To clarify the theoretical assumptions in both hypotheses, the evolutionary game theory models described in the next section will explore the dynamics of cooperative behavior in network settings.

Finally, to determine which of the many available network measures are most closely associated with formalized hypotheses, we simulate network development and analyze which measure best relates to each assumption. These simulations extend the transaction cost approach (e.g, Heckathorn and Maser 1987) as applied to formalized networks (watershed partnerships) in Lubell et al (2002) under NSF grant SBR9729505. We demonstrated that the existence and activity level of partnerships reflected the relative costs of developing networks and the expected benefits they might provide. Our model borrows the expectation that organizations invest in policy networks to minimize transaction costs for developing and implementing joint projects. When information is the limiting factor, organizations will seek contacts that maximize their bridging scores; when credibility is critical, they will seek clustered networks. We probe this issue initially with open-ended interviews to develop appropriate assumptions for the simulation analysis.

The simulation approach begins with a set of actors (comparable in size to the Tampa Bay case), models the incentives facing individual actors in selecting contacts, and measures the desired characteristics from the resultant network structure (Watts 1999). Dynamic network models inevitably require specification of an array of complexities not directly related to the critical analysis (e.g., who creates contacts at what time with what range of exploration and what information. cf. Monge and Contractor 2003), so Monte Carlo techniques that randomize over these conditions can be used to provide statistical evidence about relationships between microincentives and macro network structures. As an example of this technique, Scholz and Wang (2004) found that the number of actors in the policy arena and the network size had stronger impacts on cooperation (their dependent variable) than density.

Our primary exploration will systematically vary two dimensions--information and credibility—to generate large numbers of networks for each set of values on the two dimensions. The measure of each network variable for each of the resultant network provides one observation, so regression analysis can estimate which measure is most closely associated with the underlying incentive structure. This provides one foundation for selecting the most appropriate measures to test each hypothesis. We will also probe Watts (1999) conjecture that "small world" networks lying between the extremes of clustering and random networks can provide the advantages of both clustering and bridging. Since project design and implementation phases both involve mixed incentives, and particularly since organizational networks are likely to reflect concerns of both design and implementation, we suspect that observed networks will correspond to experimental conditions in which both information and credibility are present. Following Watts (1999) we suspect that real-world policy networks will resemble simulation results for conditions with intermediate values for both information and credibility.

### Refining Hypotheses: Evolution in Networked Games

The hypotheses discussed above are based on widely accepted qualitative theories by Burt, Coleman, and Putnam, to name a few. We propose to clarify these hypotheses by applying analytic and simulation techniques from evolutionary game theory to formally model the effect of network structures on the evolutionary dynamics of cooperation.

In general, a networked game can be represented by a set of agents, links among the agents, the learning rules of the agents, and the typical determinants of a standard game – strategies, payoffs, etc. Agents are defined by their strategies and/or preferences, a link represents a game between the agents in game theoretic sense, and the learning rules specify the changes in agents' strategies or preferences as functions of their payoffs, the payoffs of other agents, and links among the agents. The framework of networked evolutionary game can accommodate a wide rage of game forms, strategies, and learning rules. We will explore diverse combinations of these assumptions, from the simplest to more sophisticated strategies and learning rules, to represent the choice situations found in our empirical research. Using the empirically observed network structure, we then compare predicted and observed outcomes to determine which set of assumptions most closely matches the observed outcomes.

Let us consider a simple example of the kind of research we envision. Consider the comparison in Figure 1 between sub-networks of eight organizations in two estuaries. These networks were identified by asking policy makers in each estuary which other organizations they contact on a regular basis (data from Schneider et al 2003). Tampa Bay on the left corresponds to the policy community pattern of large, interconnected networks; St. Andrews Bay on the right corresponds to the issue network pattern of longer, more sparsely connected networks. Schneider et al (2003) found greater agreement and more positive assessments of environmental policies in networks with many interconnections, like the one in Tampa Bay.

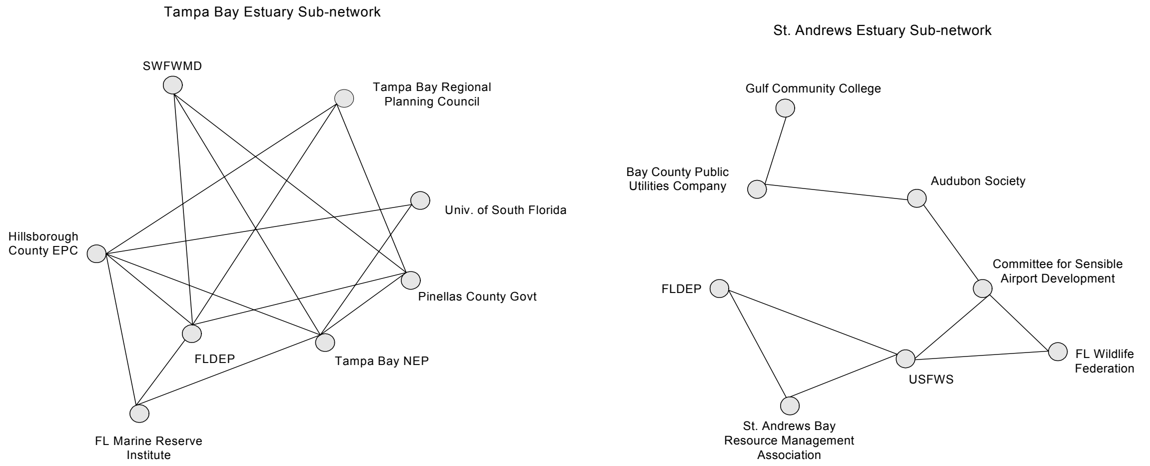


Figure 1. Policy sub-networks in Tampa Bay and St. Andrews Estuary

Consider the following assumptions and definitions of one possible model. First, each link in a network represents the three-times repeated prisoner's dilemma game in Figure 2a. Suppose that only two strategies are available to the agents: Tit for Tat, and All Defect, with payoffs indicated in Figure 2b below. Second, an agent learns locally and imitates the strategy of the most successful agent among its contacts. Third, an agent's success is measured by the average payoff over all its link games. Fourth, a network is said to be in *evolutionary equilibrium* if none of the agents in the network changes its strategy as a result of learning.

The stage PD game payoff matrix.

| | Cooperation | Defection |
|---|---|---|
| Cooperation | 2,2 | -1, 3 |
| Defection | 3, -1 | 1,1 |

Figure 2a

Payoffs for three repetitions of PD between TFT and ALL D.

| | TFT | ALL D |
|---|---|---|
| TFT | 6,6 | 1, 5 |
| ALL D | 5, 1 | 3,3 |

Figure 2b

Suppose all the agents in the two networks are TFT types. How resistant is this universal cooperation to an invasion of a single ALL D strategy? How is the stability of cooperation related to the characteristics of the networks at the individual agent and the network level? In the dense Tampa Bay network, if any of the 8 agents mutate to ALL D strategy, the mutated agent will retain the ALL D strategy, but its contacts will retain their TFT strategies. For example, if SWFWMD (Southwest Florida Water Management District) converts to ALL D, it obtains an average payoff among all its games of 5. The average payoff for the Pinellas County Government, one of SWFWMD's contacts, drops from 6 before the mutation to 4.75. Our assumption of local learning might seem to suggest that the Pinellas County Government would change its strategy to ALL D. However, some of its contacts (Tampa Bay Regional Planning Council, Hillsborough County EPC, and FL Marine Reserve Institute) are not linked to the mutated ALL D and, thus, continue to get an average payoff of 6. Thus, the invading ALL D is not the most successful type among the SWFWMD's contacts, even though SWFWMD does better than they do. Since no agent changes its strategy as a result of local learning, an evolutionary equilibrium is reached in which SWFWMD remains the sole mutant. The same conclusion results from all eight cases in which a single agent mutates to ALL D: the invading ALL D remains as a neutral mutant without further affecting the strategies of other agents in the network.

In the sparsely linked St. Andrew's network, however, ALL D strategy does spread up to three additional agents when a single ALL D invades at four of the eight locations. Due to the sparse nature of the network, the invading All D is more likely to be the most successful strategy among the contacts of an affected agent.

We can use this approach to examine how the individual agent's network conditions affect its likelihood of converting to the All D strategy after its neighbor converts to ALL D. Four agents in the St. Andrews subnetwork (Audubon, Bay County PUC, Committee for SAD, and USFWS) are never affected when a contact mutates to ALL D, while the other four always convert to ALL D. The number of contacts (size) appears to help an agent resist invasion, since the resistant agents have an average size of 2.75 compared with 1.75 for the nonresistant agents. On the other hand, the average density is considerably lower for resistant agents (0.13) than for nonresistant agents (1.0 for the three agents with defined density). In short, this illustration suggests that a stronger set of assumptions are required to support the credibility-clustering hypothesis, and that the combined role of size and density needs clarification.

The above illustration explores only one of the potentially large sets of assumptions regarding agents' decision-making rules and the learning mechanisms using on a specific network. To investigate the relationship between network structure and cooperation, we expand the simple model in our illustration in several ways. First, on the dimension of agent decision-making, we plan to move from assumptions of fixed strategies, such TFT and ALL D in the above illustration, to ones in which agents choose their strategies according to well-defined preferences and anticipate possible future impacts on other agents.

Second, on the dimension of learning, we intend to move well-beyond simple imitation of one's successful neighbors. We can explore different learning rules, in particular, the one in which agents learn not only from their immediate contacts, but also from their second or third contacts (with the weight of learning diminishing as the distance gets longer.)

Third, we will expand the scope of investigation beyond the invasion of already cooperative networks. In particular, we analyze the ability of invasion by two or more TFT (one alone can never invade) to compare the ability of network structures to encourage the spread of cooperation with their ability to resist the collapse of pre-existing cooperation. For example, in a simple linear network, we can show for payoffs above the necessary threshold that invasion by two adjacent TFT at any positions will convert the entire network to TFT.

Fourth, to simplify analysis, we begin with an assumption of 2-person games defined by each dyad $i, j$. In order to compare predictions from the formal model with observed behavior, this requires that we will gather network and performance data on the same dyad level. Analyses based on the dyadic structure assume that strategic choices focus on other organizations rather than on the group of organizations involved in a given project. While this assumption may reflect reality, particularly for dyads participating in multiple projects, we attempt to relax this assumption by analyzing the N-person game defined by a project with multiple participants, which would be most suitable for empirical analyses using the project as a unit of analysis.

The ultimate goal of our theoretical investigation is to establish the relationships between abstract network characteristics (such as size, density, and bridging) and the evolution of cooperation, given a reasonable set of assumptions about agent strategies and learning rules. For a uniform, repeating, non-looping, and open network, it is possible to solve for invasion resistance thresholds analytically (Esarey, 2004). For networks with more complicated structures, it will be necessary to use computational methods such as the one used by Wang and Scholz (2004). We will rely on our empirical observations on real world networks to limit the range for each structural condition.

Our empirical observations will also be used to test the validity of the alternative assumptions on strategies and learning rules of the agents. The most direct way is to apply our models to the observed contract networks (where a link indicates the presence of a common game between two actors). Each model will generate a cooperation potential score for every position in the network. We can then compare the potential scores with performance measures of the organizations in the real world to determine which set of assumptions fits the observed data most closely.

## II. RESEARCH DESIGN

Our empirical research strategy intensively analyzes networks relevant to one specific set of joint projects in one geographically-determined location over an extended period of time. This strategy overcomes problems identified in our prior research, as discussed above, by thoroughly documenting the full resource and contract networks and by measuring multiple dimensions of cooperative performance at the design and implementation stages in these joint projects. We limit the geographic scope to one estuary to enhance internal validity, which may raise concerns about external validity or generalizability if the range of observed network characteristics is limited or if some unique local factor influences the link between networks and behavior in that estuary. Fortunately, data from our previous study of 22 estuaries indicates that the range and variance of network measures for Tampa Bay is at least as great as in most estuaries, and preliminary research has shown that the number of projects is more than sufficient to support the estimation procedures discussed below. In addition, preliminary analyses using a dummy variable interaction term for Tampa bay do not indicate that the relationship between available network and performance measures is unique in Tampa bay. The data are available for further analyses if additional threats to external validity arise during the research.

We use data from Tampa Bay to develop relevant formal models of the two competing perspectives on policy networks and use regression analysis to test the implications of the formal analyses. The primary empirical analysis will use panel data regressions to analyze the impact of resource and contract network variables measured in 2005 on performance in 2007, accounting for potential endogeneity of performance in 2005 that may affect network variables in 2007. Specifically, we will focus on the 186 potential projects identified in the Tampa Bay Comprehensive Conservation and Management Plan of 1997 relating to the critical goal of managing nitrogen pollution (http://www.tbep.org). This list includes approximately 100 projects currently underway as well as projects that have now been completed or have not been undertaken, so we have observations at all stages of project development. We select Tampa Bay in part because the prior NSF project provides network information for 1999 and 2002 from 35 respondents in 28 organizations, providing a longer panel with at least rudimentary network information in earlier years to analyze network dynamics.

### Data

Data comes from archival sources, 25-30 open-ended interviews with selected joint project participants, two surveys in 2005 and 2007, and a panel of experts. The identification of projects and contract networks comes from archival data on joint projects documented by TBEP and Southwest Florida Water Management District. The archival data for each project identifies its current status, date of reaching project milestones (including initiation, design, implementation stages, and completion), lead and participating organizations with contact information, and budgetary contributions (if determined). Preliminary investigations indicate that the data appears to be reasonably complete, requiring only minor follow-ups to check validity and get missing data.

The two surveys provide our primary measures of resource networks (mail component) and performance evaluations (telephone component). To identify networks directly related to each project, we include as respondents the estimated 500-600 contact officials listed in the archival data for all private and public participating organizations in current joint projects—when a single contact person is listed for all projects of an organization, we will determine the most appropriate alternative within the organization most familiar with external contacts relevant to the project. To ensure that other individuals involved in relevant inter-organizational resource exchanges are also included, we directly approach directors in each of the estimated (based on previous 2002 survey) 120 relevant organizations to identify these individuals. Finally, we include individual stakeholders active on committees in the TBEP. If this comprehensive list does not include all 38 participants from the 1999 and 2002 surveys, we will include all active participants among them as well.

Open-ended interviews prior to the 2005 survey provide a means of verifying our respondent identification procedures and evaluating the mail and telephone questionnaires. In addition they are intended to clarify assumptions for formal analyses about incentives and payoffs relating networks to performance in joint projects, and to determine appropriate methods for empirically supporting assumptions used to develop formal models. We will interview all identified respondents from one selected organization (5-10 interviews) and select other respondents to represent the range of ego network values in the contract network (10-15 interviews).

Finally, we will develop an advisory board of experts familiar with the joint projects to review our research design and specifically advise on the evaluation of project performance. In particular, the panel will consider the possibility of utilizing objective criteria (e.g., tons of nitrogen reduction per dollar invested) for project performance based on data being generated as part of required project reviews. Initial inquiries suggest that reliable measures may be available by 2007 for at least some subset of projects in our study. The panel will include experts involved in developing monitoring and performance standards for projects that may determine the availability of this data. The panel will also provide legitimacy necessary to ensure a very high survey response rate.

Our data gathering emphasizes the development of the 2005-2007 panel, but we also develop three types to analyze policy dynamics. First, the open-ended interviews used for questionnaire development will also probe history and incentives leading the respondent and their organizations to forge the observed network relationships. Second, the small panel of 35 respondents from 28 organizations who completed the 1999 and 2002 surveys in Tampa Bay will be extended in the 2005 and 2007 surveys for surviving participant, providing an 8-year panel of changes in networks. Third, as noted earlier the TBEP record of projects listed in the 1997 Comprehensive Conservation Management Plan provides a continuous record of the full contract network over a 10-year period. This provides a unique data source to track the annual changes in the contract network over time for comparison with simulation results.

### Measuring Cooperative Performance

We measure several aspects of performance. To test both the information-bridging and the credibility-clustering hypotheses, we distinguish performance in the design and implementation stages of project. Since we are particularly interested in the effects of networks on cooperative behavior, we are concerned not only with outcome measures evaluating the overall success of a project and the relative gains for participating organizations, but also with measures of cooperative behavior to ensure that cooperation did indeed provide the hypothesized link between networks and outcomes. Finally, to verify alternative formal models in greater detail, we measure on overall implementation performance of the organization, the performance within dyadic relationships between two organizations, and ultimately the performance within and success of the joint project.

*Project Design:* Our primary measure of performance in the project design stage reflects the ability to create the project, as indicated by formal agreements to proceed. This is also the defining characteristic for the contract network, as already noted. The information-bridging hypotheses would therefore predict that an organization's bridging characteristics will significantly impact the number of joint projects in which the organization participates. The milestones reported for each project may provide an additional indicator of projects that have passed additional design requirements, although this data appears to be missing on smaller projects and therefore would require estimation techniques that would control for potential sampling biases. In addition, the surveys will ask for evaluations by all participant organizations of the project's design phase to provide secondary measures of design performance. This measure is less reliable because it requires recall of past events that current participants may not know, recall that is probably colored by intervening events.

*Project implementation:* We measure cooperative behavior and outcomes in the implementation process at the individual, dyadic, and project level. Respondents will be presented with a list all organizations participating in the project of immediate concern to the respondent. For each organization, *outcome* is measured with the question "How much has your organization benefited from its interaction with this organization in the context of the project?" The 0-10 response scale ranges from "my organization has not benefited at all" to "My organization has benefited to the greatest extent". *Cooperation* is measured with the question "How well has this organization met its obligation to your organization in the context of the project during the past year?" with a response scale running from "never met obligations" to always met obligations". In addition, we ask respondents how much they trust each organization to fulfill obligations in the coming year, and finally we ask how well the respondent's organization has fulfilled its obligations with each organization in the project during the previous year. These measures potentially form a single scale of cooperation, although we will investigate each dimension separately as well. To conserve space we include only one question in this format evaluating how well the respondent's organization has met its obligations with each of its partners.

Each implementation measure provides a directed measure for each link in the estuary matrix. In addition, the measures can be summed to produce measures of the perceived outcome and cooperation measures appropriate for the organizational, dyadic, and project level of analysis. For example, each organization will be rated by multiple partners, perhaps in multiple projects, so the average rating provides an overall score for that organization's cooperation. Similarly, performance ratings for dyad-level analysis (of the undirected link) average the evaluations made by the two organizations, and project-level ratings average the evaluations by all project members.

A number of alternative measurement strategies in a simpler format will also be included to ensure that multiple aspects of performance are evaluated. For example, to measure general cooperation at the organizational-level in a manner consistent with the 2002 survey, *collaboration* is measured by asking respondents to indicate how many activities commonly involved in joint projects that an organization undertakes, as noted above. Project-level performance on each of the above implementation measures will be rated by asking each respondent to evaluate the overall performance of all partners, and to rate the respondent organization's performance in the project. In addition, the subset of respondents identified as project managers will be asked to evaluate several dimensions of project performance including 1) extent to which participants fulfilled obligations, 2) willingness to resolve problems cooperatively when they emerge, 3) efficient use of the budget allocated to the project, 4) timely completion of the projected milestones, and 5) fair distribution of benefits to the stakeholders involved in the project.

Finally, we will work with an advisory committee of five experts involved in the evaluation and oversight of identified projects to develop objective measures of project success based on project milestones and other data available as part of the ongoing evaluation system required by many projects. The advisory committee will also review our research design and questionnaire, and will function as an intermediary to enhance the credibility of the survey for the targeted group of respondents. Objective measures are likely to be available only for subsets of projects, but can at minimum establish the relationship between respondent evaluations and objective measures of project performance for this subset. A large enough subset would permit estimations using Heckman selection bias estimation techniques.

**Measuring Networks**

To develop the matrix of contacts needed to calculate all network measures, we use archival data for contract networks and survey data for resource networks to calculate the ego network variables density, size, and bridging, as discussed above.

The matrix includes all organizations active in any project over the full time period from 1997-2007. The contract network matrix for a given year is determined by associations for all joint projects active (i.e., beyond initial development stage but not completed) in a given year. Contract networks for 2005 and 2007 are needed for our primary analysis, but we will also use the networks from 1997-2007 to study the dynamics of network development. The resource network is measured following the technique developed in the 2002 survey-- a mail survey instrument that asks respondents to identify from a list of all active organizations those with which the respondent's organization has had regular contacts regarding joint projects and related estuary issues. Since most organizations have multiple respondents, we sum contacts of all organizational members when enumerating organizational contacts.

We extend the measurement of resources network from the 2002 survey by distinguishing two dimensions for networks between project participants. To map the information or communication network (e.g., Carpenter et al. 1998; Schneider et al. 2003) we ask "from the list of organizations that participated in this project, please indicate how much each of them provided you with critical information to use in the project (where "0" is "no information provided at all" and "10" is "always provided useful information)". To measure remaining dimensions of the resource network (Provan and Milward 1995, Knoke et al. 1996) we ask a similar question rating "how much each of them provided you with resources such as staff, financial support, and different services required to fulfill your obligations to the joint project.

As noted above, the traditional ego network definitions for individual organizations may not capture the most relevant effects of networks on dyadic or project performance. We therefore calculate network variables based on the dyad and project network for analyzing the corresponding performance level.

At the dyad level, for example, the dyad density measure of size $S_{i,j}$ is the total number of other actors directly contacting either i or j. To capture the dyadic equivalent of the constraining notion reflected in the ego network density measure we calculate the proportion of mutual contacts among all dyadic contacts: the dyad density measure for two actors i and j is $D_{ij} = C_{i,j} / S_{i,j}$, where $C_{i,j}$ is number of other actors directly contacting both i and j. We hypothesize that this measure provides greater constraints than the more direct equivalent of density, which would reflect the proportion of actors mutual contacts who knew each other. To capture the dyadic equivalent of the ego network bridging measure, on the other hand, we believe that a direct extension of the bridging concept captures the way in which the joint dyadic network expands the informational opportunities from the ego networks: the dyad bridging network calculates the total number of shortest paths involving either i or j. Dyadic bridging will therefore be greater than the greatest bridging coefficient of i and j, less than the sum of the bridging coefficients, and generally will not equal the average of the bridging coefficients.

Project network measures extend the logic of these dyadic measures to the n-person relationship, where n reflects the number of project participants. Since our intensive research design fully maps all relevant relationships, we intend to further explore the empirical and theoretical connections between the measured discussed in this proposal and the range of alternative measures.

**Measuring Control Variables**:

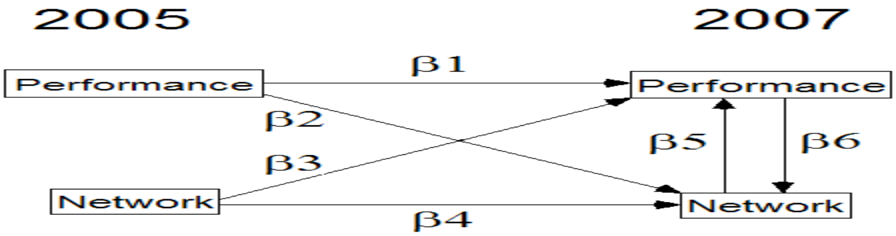
We need to include factors affecting both networks and performance to minimize spurious effects, to identify the equations to be estimated, and to enrich our general analysis of the evolution of cooperation in joint projects. Those variables include: perceived level of fairness towards the respondent's organizations in estuary issues (Schneider et al. 2003), respondent's organization type (Scholz et al. 2004), organizational concerns with the protection of the environment, performance in the previous wave of observation, trust in other stakeholders (Ostrom 1990; Scholz and Lubell, 1998; Dasgupta 2000), and financial and human resources available for the functioning of the organization (Wondolleck and Yaffee 2000; Steelman and Carmin 2002). The estimation of networks configurations at the organizational level will in turn include variables like trust in other stakeholders, the organization's financial and human resources, and organization type. In addition, variables included in previous studies (Schneider et al. 2003, Scholz et al. 2004) like evaluation of environmental problems' severity, evaluation of quality of scientific information, and the main goals advanced by the organization will be incorporated.

At the dyadic level, the study of performance demands the inclusion of the following group of controls: compatibility of beliefs of the organizations composing the dyad, budget and staff assigned by the dyad to the project in question, similitude of organizations' type, and joint participation in formal committees in the area. For the estimation of dyadic network measures, the controls are the same as those included at the individual organizational level. All of these variables will be recalculated for the dyad, simply adding the individual organizational values.

Finally, at the project level, the control variables are total budget and staff assigned to the project, number of stages at which the project can be contested or revised, number of organizations participating, and % of governmental organizations participating in the project.

**Estimation Techniques**

Estimating the impact of networks on performance with panel data provides several important advantages over estimates based on a single time period (Finkel 1995), the most important being the greater certainty in inferences about the causal relationship behind observed correlations. For our primary hypothesis testing, we use two stage least squares (TSLS) procedures to estimate the cross-lagged and synchronous effects model with conditional change (Finkel 1995, 37) on data for 2005 and 2007, as pictured below:



In this model, significant positive coefficients $\beta_3$ and $\beta_5$ for the appropriate network and performance variables would confirm hypotheses H1 (bridging and size impact on number of projects) and H2 (density impact on implementation performance). However, an OLS model estimating only these coefficients suffers several potential biases that the full model can avoid. First, including the lagged dependent variable provides estimates of conditional change ($\beta_1$ for performance and $\beta_5$ for network measures) or partial adjustment in the dependent variable over time, which accounts for the inertia expected in measures of both performance and networks that could lead to model misspecification if only cross-sectional data are available to estimate $\beta_5$. Second, the model assumes reciprocal causality between performance and networks, since the number of projects undertaken and the observed level of cooperation by others at time t can enhance or diminish the incentives to expand and maintain networks.

Third, the model accounts for delayed impacts of networks on performance (and vice versa), which can be examined by comparing the relative size of the lagged ($\beta_3$) and synchronous ($\beta_5$) effects. We assume that the constraining and enabling aspects of networks are imposed immediately, but that the impact on performance takes considerable time. For example, a change in density immediately increases the importance of reputation, but changing the organizational behavior requires changing attitudes, replacing individuals, and developing new standard procedures to bring behavior in line with the new importance of reputation. In addition, the reputational impact of changes in density is also likely to grow over time as group norms and individual willingness to invest in punishing defectors adapt to the new structural condition. Prior analyses in the NEP study suggest that the 2 year period between surveys was sufficient to capture these lagged changes.

Given these assumptions, the identification condition can be satisfied by exogenous variables that are fairly strongly linked to the endogenous performance or network variables but not linked to the other. This is the critical role played by the control variables described above. For example, location-specific variables reflecting social capital of the community in which a project is undertaken are likely to have a strong impact on the project (Lubell et al 2002), but only an indirect impact through project performance on the network structure of an organization working throughout the area. Similarly, organization-specific factors reflecting the culture, resources, and tasks of the organization are likely to be an important determinant of network structure (Scholz et al. 2004), but are less likely to impact a given project.

The following two equation system provides an example of the TSLS model test for H2:

$$\textbf{Cooperation}_t = \alpha + \beta_1\text{Cooperation}_{t-1} + \beta_3\text{Density}_{t-1} + \beta_5\text{Density}_t + \beta_7 Z_p + \varepsilon_p$$

$$\textbf{Density}_t = \alpha + \beta_2\text{Cooperation}_{t-1} + \beta_4\text{Density}_{t-1} + \beta_6\text{Cooperation}_t + \beta_8 Z_n + \varepsilon_n$$

where $Z_p$ and $Z_n$ are the respective sets of control variables such that each contains at least one variable strongly linked to the respective dependent variable but unrelated to the other. H2 implies that $\beta_3$ and $\beta_5$ should be positive and significant. Ideally we will simultaneously test the impact of the full range of network variables representing both hypotheses (e.g., density, bridging and size) on cooperation by adding them to the cooperation equation and adding additional equations for each endogenous network variable. If this process fails due to the difficult of finding a unique variable predicting each network variable but unrelated to the others, we can at least compare the results of estimating $\beta_3$ and $\beta_5$ individually for each variable across the range of performance conditions representing both hypotheses (design versus implementation for individual, dyadic and project performance)

To the extent that the selected controls fail to perform as expected, Finkel (1995) shows that a third wave of data can still be used to secure unbiased estimates when results from the two wave model raise doubts about full identification of the model. Since we anticipate that the set of control variables will suffice, we do not include a request funding for a 2009 survey, but will do so if a thorough investigation of the model raises sufficient doubts. By analyzing this model at the organizational, dyadic, and project levels, we can compare the results across analyses that use slightly different control techniques to provide an added dimension of robustness.

**Work Plan**

The two surveys are targeted for May-June in 2005 and 2007. By May 2002 Berardo will obtain the full data set on projects, extract and perfect the list of officials to be interviewed, and undertake 25-30 open-ended interviews to perfect the questionnaire, gather histories, and probe the motivations for maintaining network contacts and for undertaking joint projects. Scholz will lead in the development of the questionnaire and the creation of the advisory board.

The formal analyses, simulation studies, tests of the reliability of network measures under different sampling strategies, and other analyses of network measures will begin as soon as the 2005 survey data is available. We use the period between surveys to develop a solid foundation for the later analyses, to publish the results of these investigations in support of the future analyses, and to make required changes in the survey instrument for the final survey.

The primary panel analyses will follow the completion of the second survey in June 2007, and will be published in a series of papers presented to both academic and professional audiences. Our primary product will be an advanced graduate-level text on *Policy Networks and Cooperation* that lays out the methods of analysis and conclusions developed during the project. The first section includes chapters introducing the application of evolutionary analysis to network games, the simulation analysis of network dynamics, the problems of sampling, selecting appropriate empirical measures at the appropriate organizational-dyad-project level for testing hypotheses. The main section will introduce the information-bridging and credibility-clustering hypotheses, discuss their theoretical foundations and their role in current policy developments, present our analyses, and discuss the theoretical and practical implications of our findings. We anticipate the completion of seven dissertations at FSU that will be directly related to the data and techniques developed in this project, and the book will reflect the needs of this research audience.