Understanding What Shapes an Ecology of Policy Games

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Abstract

Recent research has shown that actors self-organize in networks and form certain configurations in responses to risky situations, with high risk leading to the formation of bonding structures, and low risk leading to the formation of bridging structures (Berardo and Scholz 2010). In parallel, a new strand of research proposes to study the management of natural resources as an inherently complex enterprise in which actors interact with each other in multiple forums where decisions are made on how to manage those resources (Lubel et al. 2010). In this paper, we bring these two research strands together by exploring what drives network activity in two-mode networks composed of actors and the forums where they interact. We show that weak bonding structures and bridging structures form in three research sites of varying institutional strength, but that the prevalence of one type of structure over the other depends on highly contextual variables such as the stability of the institutions and the sense of crisis provoked by events that negatively affect the environment.

Finding solutions to solve collective action problems in regional arenas where multiple users have access to a common-pool resource has been one of the main preoccupations of social scientists for many years. The path-breaking work of Ostrom and colleagues has improved our understanding of how the management of a wide range of natural resources can be optimized in complex social-ecological systems where multiple users interact with each other. Among the components of social-ecological systems that can help explaining the potential to find solutions to collective action problems are the networks that form when social and political actors communicate with each other (Ostrom 2005, 2009), which can contribute to the formation of social capital. Higher levels of social capital lubricate social and political relations in the form of increased trust and trustworthiness (Sabatier et al. 2005, Bromiley and Cummings 1995), favor the transmission of scarce resources among the components of a group (Agranoff and McGuire 2003), and produce the conditions that facilitate sustained cooperation in policy networks (Scholz et al. 2008).

In a recent contribution to the study of this topic, Berardo and Scholz (2010) examined the formation and evolution of networks in ten U.S. estuaries, linking the formation of specific structures in the networks to the types of problems the actors faced and the risk associated with them. According to their "risk hypothesis", in situations where defection by others is more likely, actors tend to create close-knit, *bonding* communication structures that facilitate the flow of redundant information more conducive to the solution of cooperation problems. On the other hand, when actors face lower levels of risk of defection, they create links that facilitate the emergence of *bridging* structures, which are more conducive to the solution of coordination problems that are likely to exist in the absence of incentives to defect.

In parallel to this work, Lubell and colleagues (Lubell Henry, and McCoy 2010a, 2010b) have revitalized the study of the complexity of decision-making in federal systems by adapting Norton Long's long-standing "Ecology of Games" metaphor (Long 1958) to the study of decision-making forums where policy actors interact repeatedly –and often contentiously. The framework –as applied by Lubell et al.- assumes a "policy game" occurs when policy actors participate in one or more rule-governed forum in which collective choices are made over key policy issues. In network analytic terms, the participation of organizations or individual actors in forums ("games") can be characterized as a two-mode network, where organizations (the first mode) connect indirectly to each other through their participation in forums (the second mode).

In this paper, we combine the study of the Ecology of Games and the Risk Hypothesis by examining the formation of structures that facilitate bonding among policy actors in three ecologies of games in high risk systems, where human activity has a high impact on the ecological balance of the areas. The three research sites we study vary in their overall institutionalization level, which gives us an opportunity to refine the expectations under the risk hypothesis in high-risk environments, since we expect the institutionalization level to condition the relationship between risk and formation of bonding structures in the two-mode networks of the ecologies of games. Additionally, we seek to explain how certain organizational attributes may affect participation in the EG. In particular, we are interesting in uncovering the relationship between organization-level uncertainty and perceptions of procedural fairness with the formation of ties in the two-mode networks we analyze. Our overall goal is to produce a more comprehensive picture of the endogenous and exogenous elements that drive participation in the Ecology of Water Policy Games in policy-making systems of different institutionalization levels.

The three research sites are the Tampa Bay estuary (Florida-U.S.), the Sacramento-San Joaquin delta (California-U.S.), and the Parana River delta (Argentina). The three sites are complex social-ecological systems (Ostrom 2009), but with variation in their institutionalization levels, which is likely to affect the structure of the ecology of water management games.

The Tampa Bay and Sacramento-San Joaquin delta are here characterized as strongly institutionalized systems, with a larger cadre of professional and technically-competent actors, a set of well understood rules on how to assign and enforce property rights, and extensive participation in decision-making processes of both multiple government agencies and non-governmental actors. Overall, actors face lower transaction costs as procedures for decision making and implementation of decisions are somewhat standardized, and forums where stakeholders may engage in meaningful discussions on how to address environmental problems tend to be more.

The Parana river delta, on the other hand, is an example of a weakly institutionalized system, where forums are less formal and usually are created to address specific problem, and the participation of governmental and technically-capable actors is marginal in many cases. Weakly institutionalized systems can be seen as “ground-up” collective action approaches as they are borne from the affected actors themselves, in the presence of some small government help. In these systems transaction costs tend to be greater since forums have a short lifetime and rules of procedure are not always clear, which in turn negatively affects the likelihood that actors can engage in sustained interactions through time (Aumann 1983; Axelrod 1984) and sets them on divergent paths that hinders efficient bargaining (Roth & Murninghan 1982; Farrell 1986).

Institutionalization and Inclusiveness in the Ecology of Policy Games

One of the defining characteristics of systems that are strongly institutionalized is that they have forums that are more stable and in consequence develop more clear rules of structure and decision-making mechanisms. Stability is a critical variable to examine the ecology of games, since it is only with stable forums that actors are likely to reduce uncertainty in the long term. A stable set of forums gives every participant the chance to lean about other actors' organizational goals, policy priorities, and –as relationships solidify in time- propensity to engage in cooperative behavior.

Thus the higher level of formality in the polycentric ecology of games should be associated with higher levels of participation because actors face lower transaction costs and can thus appropriate a greater share of the benefits drawn from bargaining with other stakeholders. The expectation for weakly institutionalized systems should be exactly the opposite. As described previously, the forums that develop in these systems are generally more ephemeral, and designed to solve specific issues for a subset of actors in the EG. As the forums are not formally embedded in the legal structure to manage natural resources, the rules and procedures that govern them will be somewhat unique to each setting and likely to be determined in an *ad hoc* manner by the most powerful actors that participate in them. The fact that the forums are more unstable should increase transaction costs for many actors who may hesitate in participating extensively in these interactions spaces, and thus our expectation is to observe a greater share of stakeholders in weakly institutionalized systems withdrawing from the Ecology of Games.

Hypothesis 1: The Ecology of Games in weakly institutionalized settings should be less inclusive of relevant stakeholders in comparison to strongly institutionalized settings

Bonding and Bridging in the Ecology of Games

Berardo and Scholz (2010) studied the self-organizing policy networks that form in estuaries where collective action problems in the management of natural resources are pervasive, and advanced the “risk hypothesis” which links risk to specific configurations that actors form. According to the hypothesis, when actors face high-risk situations, they tend to form bonding structures that allow for the flow of overlapping information more likely to help detect and punish defection. On the other hand, when actors face low-risk situations, assurance against defection is not a priority and thus actors tend to form bridging structures that facilitate access to non-overlapping information that comes from more distant parts of the network, which helps solving coordination problems.

Their findings showed that there was a tendency in the communication networks in the estuaries to the formation of star-like, bridging structures where a central node had the potential fulfill a coordination role. This tendency was explained at least in part by the fact that the regional governance systems in the estuaries were slowly developing in the relative absence of acute environmental problems (in comparison to other estuaries where these problems were present), which reduced the risk associated with interacting with other actors in the region. Their research design thus confirmed that low-risk situations are associated with the emergence of bridging structures in communication networks, but more research is needed to properly test whether high-risk situations are in fact associated with the creation of more bonding structures as it was originally predicted. Additionally, the networks examined in that research are all from the strongly institutionalized U.S. system, and were mapped by asking respondents to identify their top three sources of information, which cannot grasp the full complexity of the ecologies of policy games those actors play.

In this paper we aim is to better understand how the Ecology of Games in complex decision-making systems looks like when the level of institutionalization varies, and so we proposed to test the "risk hypothesis" in the two-mode networks that form when organizations participate in a multitude of forums where decisions can be made on how to manage water resources. However, we do so with a twist, by proposing a refinement to the "risk hypothesis" that takes into account two different types of bonding structures that could form, each of them dominant according to the level of institutional strength of the policy-making system. The two types of bonding structures are contained in figure 1, and represent what we term "weak" and "strong" bonding capital.

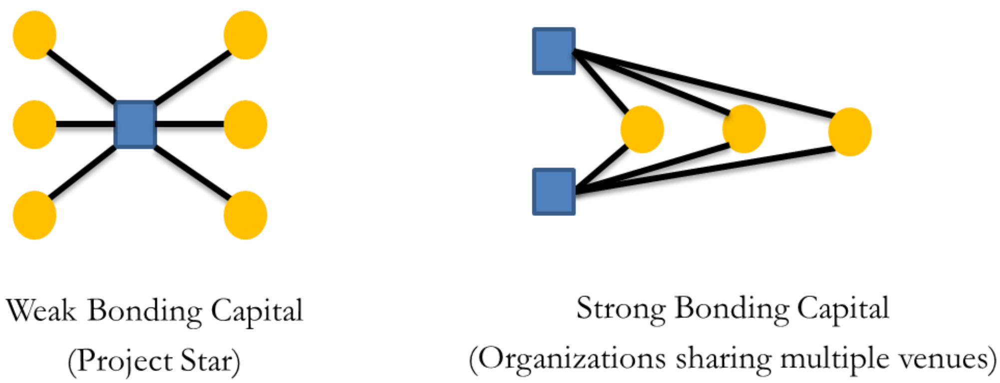

Figure 1. Weak and Strong Bonding Capital in the Ecology of Policy Games.

In figure 1 the blue squares represent forums and the orange circles the actors that participate in them (participation is represented by the black links). The configuration to the left of the figure represents weak bonding in the sense that actors engage with others by participating in a "popular" forum, but they do not share other forums with each other. When actors engage others this way, there is obviously a potential for improving the level of knowledge actors have about what others want and may do. In this sense, weak bonding leads to uncertainty reduction. However, the lack of recurring interaction in different forums reduces the likelihood of building strong cooperative reputations that are needed to solve collective action problems, and so policy learning is weak at best. Particularly in weakly institutionalized systems where forums are fleeting, it would be logical to observe a preeminence of this type of bonding structure.

The configuration to the right of figure 1, on the other hand, shows actors bonding in a stronger way, since they participate in two forums together. This gives each participant the chance to learn about others behaviors and interests, but also to reinforce or “update” expectations about others’ expected behavior. This stronger bonding should reduce transaction costs, and positively affect the likelihood of finding solutions to common problems. Since strongly institutionalized settings see more stable forums, with clear rules of engagement and steadier groups of participants, we would expect to observe more of these configurations than weak bonding structures.

Hypothesis 2: In weakly institutionalized settings, network configurations indicating weak bonding should be more common than those that indicate strong bonding. The expectation is reversed in strongly institutionalized settings, where configurations indicating weak bonding should be less common than those indicating strong bonding.

One of the conclusions reached by Berardo and Scholz (2010) was that bonding or bridging may be dominant according to the type of issue being addressed, but also that they are by no means mutually exclusive. In any given self-organized network, the argument goes, multiple problems may coexist, each of them representing varying degrees of risk for the actors. If that is the case, then both bonding and bridging structures can be expected to appear simultaneously in networks. In the two-mode networks of actors participating in forums, the most straightforward indicator of bridging is given by the configuration contained in figure 2.

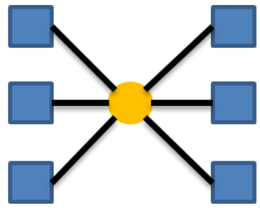

Figure 2. Bridging Capital in the Ecology of Games

In this figure, an actor participates in a large number of forums. Bridging capital occurs when an actor can link others that would be disconnected with each other in its absence. It is in this sense that the "bridger" fulfills a coordination role. In the Ecology of Games, when an actor attends different forums, it can gather information from any given one of them that can be used in the other forums where the actor participates. Assuming the actor is not just hoarding informational resources, but rather using them to enrich the discussions that take place in the different forums, then the structure in figure 2 indicates bridging network capital in two-mode networks.

Of course, participating in forums is not costless. In fact, having a strong presence in a large number of forums requires spending vast amount of resources. Organizations need to have the financial prowess to cement a strong presence in the EG, but also sufficient capacity on the field in the form of enough human resources to establish a strong presence in many forums at the same time. Given that weakly institutionalized systems usually exist in a context of depressed economic conditions, we expect to observe fewer bridging configurations when compared to weak bonding. In strongly institutionalized systems, we don't expect to observe this difference.

Hypothesis 3: In weakly institutionalized settings, network configurations indicating bridging should be less prevalent than bonding configurations. In strongly institutionalized settings, bridging and bonding configurations should be equally represented.

Organizational Attributes and Participation in the Ecology of Games

So far we have discussed the different configurations that we would expect to observe in strongly and weakly institutionalized systems, but activity in the EG should also be associated with particular attributes of participants. We expect three such attributes to drive participation in the EG: *Behavioral Uncertainty*, *Scientific Uncertainty*, and *Perception of Procedural Fairness*.

Behavioral Uncertainty.

Behavioral uncertainty refers to a lack of information about the preferences and strategies of other policy actors. Complete behavioral certainty is unobtainable by boundedly rational actors in complex social-ecological systems because no single actor is fully aware of all the other actors in the system and only has frequent contact with a small subset of them. In addition, actors with different preferences over the appropriate policy solutions to collective-action problems may strategically misrepresent or obscure their true policy preferences and strategies (Miller 1992).

Behavioral uncertainty increases the transaction costs of collective action because the space for Pareto-superior policy solutions is difficult to define, and the unknown bargaining positions and strengths of different actors makes is difficult to make political deals. Since participating in the ecology of games may help reduce such uncertainty given that actors are informed of others' positions when they participate in forums, we expect that actors facing higher uncertainty levels will be more aggressive in increasing their participation in the EG.

Hypothesis 4: greater behavioral uncertainty at the organizational level should be linked to more participation in the ecology of games.

Scientific Uncertainty

To solve the types of collective action problems that are typical in multijurisdictional social-ecological systems, actors with access to relevant scientific information can make better decisions (Ostrom 2005). In the practical policy world, normative models of science in the policy process assume that increasing the amount of scientific knowledge applied to policy decisions will result in better decisions and outcomes. A straightforward transaction cost argument is that scientific knowledge decreases the transaction costs of searching for mutually beneficial policy solutions, bargaining over the distribution of benefits, and monitoring and enforcing the resulting agreements. Although scientific knowledge may do little to alter conflicts about the desired outcomes, it can help forge agreements about the appropriate means to a desired end. In such a scenario, increasing scientific certainty (ergo, reducing uncertainty) should lead to more positive outcomes and greater expectations of positive outcomes (Diduck 2002, Koehler and Koonts 2008).

Given that forums may serve for the exchange of valuable scientific information about the ecological state of the system, we expect actors who face higher levels of scientific uncertainty to attend more forums in order to reduce such levels of uncertainty.

Hypothesis 5: greater scientific uncertainty at the organizational level should be linked to more participation in the ecology of games.

Perception of Procedural Fairness

Conflict is likely to occur in the EG since multiple actors seek to achieve different goals. One critical variable that has been identified as a key antecedent to cooperation when organizational goals collide is the perception of procedural fairness among the members of a group –the belief that the process of making decisions is fair to those involved in it (Tyler and Blader 2002, 2003).

Early research assumed that the members of a group are concerned mostly with a fair distribution of resources (Thibaut and Walker 1975), but subsequent findings demonstrated that perceptions of higher procedural fairness led to lower conflict *even when the actors did not entirely agree with the distributional outcomes* of the decision-making processes (Bolton, Brandts and Ockenfels 2005). This positive effect of the perception of procedural fairness on dampening conflict has led some to claim that institutions must be designed with an eye toward the establishment of procedural rules that are considered to be fair by the majority of participants (Lind and Tyler 1988).

Studies of collaborative partnerships and policy networks dealing with the management of natural resources have explored the relationship between perceptions of procedural fairness and variables that are thought to foster cooperation. For instance, Leach and Sabatier (2005) reported that perceptions of procedural fairness among participants in watershed partnerships in the U.S. significantly increased the level of trust that the participants exhibit toward others. Lubell (2003) examined the perceptions of policy effectiveness in multi-stakeholder partnerships in 22 estuaries in the U.S. and discovered that individuals who perceive high levels of procedural fairness tend to believe that problems are dealt with in a more effective way, hence inducing a favorable environment for real collaboration.

Applying this logic to explore participation levels in the EG, one should expect that actors who view the forums they attend as procedurally fair places should be more engaged than those for whom procedural fairness is faulty; the latter would likely withdraw from the EG given that they think their voices are not being properly taken into account when decisions are made.

Hypothesis 6. Perceptions of higher procedural fairness should be linked to more participation in the ecology of games.

The following sections describe the research sites, data collection, and analysis strategy.

Research Sites

We test our hypotheses with data collected in the Tampa Bay area in the state of Florida (U.S.), the Sacramento-San Joaquin delta in the state of California (U.S.) and the Parana River delta in Argentina. All three estuaries are geographically extended areas where multiple users of ecosystemic services hold stakes in decision-making processes that affect the management of natural resources at a regional scale. All three areas are highly populated, and have experienced a history of conflict-ridden policy making processes.

The study area in Florida is determined by the geographic boundaries of the Southwest Florida Water Management District, a regional governmental agency established by Florida in 1961 as a flood control agency (http://www.swfwmd.state.fl.us/about/mission/). The mission of the District has continued to expand, and currently includes oversight of all major water related issues such as flood protection, water use, well construction and environmental resource permitting, water conservation, education, land acquisition, water resource and supply development, and supportive data collection and analysis efforts. Because of its central role in water policy, the district boundaries provide a reasonable geographic definition of the local water policy arena. The District encompasses roughly 10,000 square miles in all or part of 16 counties and serves a population of more than 5 million people, the majority of whom live in the Tampa Bay watershed—for simplification we refer to the study area as Tampa, although it includes a few additional rivers to the north and smaller estuaries to the south of Tampa Bay (http://www.swfwmd.state.fl.us/data/map/). Rapid population and economic growth during the last five decades have accelerated conflicts between contending user groups, leading to increases in the number of groups, the geographic scope and the types of issues active in the water policy arena.

The second research site is the Sacramento–San Joaquin River Delta, located in Northern California. The delta is formed by the confluence of the Sacramento and San Joaquin rivers and spans across and area of around 1,100 square miles that was subject to considerable reclamation efforts since the 19th century. Numerous efforts have been undertaken in the area to restore wetlands and protect endangered species, but advances have been slow and usually conflict-ridden. A big contentious issue continues to be how to allocate the sizeable amount of freshwater produced by this water system, to water users both in the San Francisco bay area, but also in the center and southern areas of the state.

The third research site is the Parana River delta (technically a "littoral complex", see Iriondo 2004) covers approximately 5,200 square miles and extends from northwest to southeast in the eastern portion of Argentina.[1] This area extends through three provinces (Santa Fe, Entre Rios, and Buenos Aires) and is one of the most bio-diverse regions in the world. Both the upper and lower sections of the delta have been subject to considerable environmental stress in the last decades due to the growing expansion of different economic activities that have an impact on the

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[1] We use the term "delta" here for simplicity, but only the lower section of this littoral complex is technically a delta (Iriondo 2004). The upper section where the rivers stats progressively widening is more properly defined as a pre-delta zone. This distinction is not clear to a big majority of the policy actors in the area who refer to the whole complex simply as "the delta". Our use of the term delta (encompassing both sections) simply reflects this common usage in the area of study.

ecological balance of the region. Chief among them is the use of land in the delta for cattle grazing purposes. Cattle farmers usually rely on low-cost “slash-and-burn” practices to clean islands in the delta of their native vegetation, which obviously affects negatively the rich biodiversity in the area. In April of 2008, “slash-and-burn” practices scaled up like never before and many of the man-made fires got out of control, burning more than 170,000 acres in what was considered to be an ecological tragedy of great proportions. As a result of this critical event, the federal Secretariat of the Environment spearheaded an intergovernmental effort (involving the governments of the three provinces that share the delta) to create the Comprehensive Strategic Plan for the Conservation and Sustainable Use of the Parana River Delta (PIECAS in Spanish), which is currently being designed.

Data Collection

The Indiana Center for Survey Research conducted the web-based surveys in Tampa Bay and the Sacramento-San Joaquin delta from November 2010 to February 2011 (CSR 2011). The samples in both sites were developed through web and media-based search for all major water forums, with participant names gathered from eligible web sites as well as directly from the forums. In order to reach as many participants as possible, all names were included even from land use forums that only occasionally considered water issues, resulting in a considerable number of ineligibles in the list. In Tampa Bay, the original list of 966 names with available email addresses was extended by a snowball question in the survey that yielded an additional 71 names for a total of 1037 possible respondents. After multiple reminders, 259 respondents completed at least part of the survey and 31 refused for a 90% ratio of cooperation per respondent. Using the 97 respondents who reported ineligibility in the screening questions to estimate the number of eligible names among the 504 who did not respond at all to the email, the

AAPOR RR4 estimated response rates vary from 32% to 37% depending on the estimation method. In the Sacramento-San Joaquin delta the comparable response rates varied from 31% to 36% (Mark, complete description here).

As was the case with the two U.S. sites, the sample of participants in Parana was developed through web and media-based search of forums where water-related issues may be discussed, which were then used to identify participant names. This was complemented with searches in relevant web sites to identify further names for stakeholders interested in water issues in the area). A total of 261 individuals were identified and contacted over the phone to answer the survey by Gestion Consultora, a survey company based in the city of Cordoba.[2] Of these, 177 answered our questions, for a response rate approximating 68%.

The same survey questionnaire (with Spanish translation for Parana) was applied to the three research sites, and in order to fully identify the number of forums in which respondents could participate, each survey included the following question: "Water management issues can be addressed in different kinds of policy forums, venues, or planning processes where stakeholders and authorities make decisions about water-related policies, permits, projects, and funding. Please identify the different forums [you/your primary organization] has been involved with in the past year." Respondents were allowed to nominate as many forums as they wished, and with this information we built three two-mode matrices, containing actors *i* in rows and forums *j* in columns.[3] In each of these three matrices, a cell x_{ij} contains a value of 1 if

[2] We decided to administer the survey over the phone in Argentina given the likely lower percentage of individuals with access to the internet.

[3] Respondents were asked if they got involved individually or as members of organizations. When two or more individuals identified the same organization, their responses in this and other questions were

organization *i* attends the forum *j*, 0 otherwise. The graphical representations of the matrices are contained in the following figure.

[insert Figure 3 here]

In the three graphical representations of the EGs, again blue squares are forums and orange circles are the organizations that participate in them. The nodes are sized by their degree centrality, which means that forums that are attended by more organizations and organizations that participate in more forums are depicted bigger in the pictures. Organizations that don't participate in any forums according to the answers of their members are not depicted in the picture to improve readability. Labels are also removed.

Whereas is usually not easy to sort out meaningful information from graphical depictions of complex networks, the visual comparison of the three graphs at least allows the reader to detect some basic differences in the three EGs. Tampa's EG is dominated by an important organization (the Southwest Florida Water Management District), while the most important nodes in the Sacramento-San Joaquin Delta are a multitude of forums that attract a large number of participants, making this the most active EG of the three. Finally, the Parana river delta EG is the least active of the three, with the smallest number of forums and actors.

Table 1 provides a few descriptive measures illustrating these general differences, with the information in the last row being used as evidence to support our first hypothesis.

[insert Table 1 here]

Hypothesis 1 stated that one should expect less inclusion of stakeholders in the ecology of games in *weakly institutionalized settings* (Parana), in comparison to *strongly institutionalized*

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aggregated at the organizational level; mentions of forums were added in the matrices, whereas means are obtained for other variables described below.

settings (Tampa and Sacramento-San Joaquin). The results shown in the bottom row of table 1 provide initial support for our first hypothesis, since there is a larger percentage of actors in the EG in Parana (in comparison to the other two sites) who are not participating in any forums according to the information that was collected in the surveys. This particular result can be analyzed in concert with the smaller number of venues that exist in the Parana delta, and the overall lower level of activity, as indicated by the average number of edges per organization to arrive at the conclusion that the EG in Parana's weakly institutionalized system is in fact more feeble than in the other two places.

Exponential Random Graph Models to Test Hypotheses 2 Through 6.

To test hypotheses 2 through 6 we use Exponential Random Graph models (ERGm), which were first developed about a quarter century ago (Frank and Strauss 1986) and view observed network structures as possible realizations of stochastic network processes (Robins *et al.* 2007a; Robins *et al.* 2007b; Robins and Morris 2007; Robins et al., 2011; Robins 2011). Intuitively, in the case of the networks we examine, there is for each of them a network space χ which contains all possible realizations of networks with the same number of nodes the observed networks have.[4] The observed networks themselves are represented by a random variable X composed by a set of tie variables X_{ij} and a particular realization of X can be denoted by x, which is composed by a set of tie variables x_{ij} that connect the nodes in it. In this observed network, nodes have ties that are said to be *neighbors* if the existence or presence of one tie depends on the existence or presence of the other, and so a *neighborhood* is a *local configuration*

[4] The description contained in this and the following paragraph draws particularly from Wang et al. (2009) and Robins (2011).

in the network involving nodes that have ties which are conditionally dependent on each other. The Exponential Random Graph models we estimate in this paper have the following form:

$$\Pr(X = x | Y = y) = \frac{1}{\kappa} \exp\left\{\sum_{Q} \theta_Q \, z_Q(x) + \sum_{A} \theta_A \, z_A(x,y)\right\} \quad (1)$$

Where (κ) is a normalizing constant in the equation (κ), which is generated over the graph space χ and forces the probability of all graphs to add to 1. The first term inside the brackets represents the "endogenous" part of the model. In this term, Q is a given type of neighborhood or configuration, z_Q(x) is the network statistic that equals 1 when the configuration is present in the observed network, and $\theta_Q$its parameter. Substantively, nodes form local network configurations or neighborhoods when they communicate with other organizations; these configurations have parameters attached to them that represent just how likely they are given all the other configurations included in the model. If a particular configuration is a likely outcome of a social process occurring within the network, this will be reflected in a positive and significant coefficient, which will indicate that the configuration occurs at a higher frequency in the observed network than in networks where links are generated by "chance". The configurations we include in our models are those contained in Figures 1 and 2.

The second terms inside the brackets in equation 1 represents the "exogenous" component of the model, since ERGms allow for the modeling of dyadic independent processes that may lead to the formation or dissolution of ties based on particular attributes of the nodes (Robins, Elliott, and Pattison 2001). The term captures the interaction of ties (x) and nodal attributes (y), and so it represents the probability of observing particular configurations given the observed attribute vector *y* in the nodes. In this paper, we use this term to simply examine whether actors with certain attributes are more likely to create ties to forums, which would indicate that they are more active in the ecology of games. Doing so allows us to test hypotheses 4 through 6, which link particular attributes to activity.

Hypothesis 4 stated that greater behavioral uncertainty at the organizational level should be linked to more participation in the ecology of games. The variable behavioral uncertainty is measured with responses to the question “For water issues most important to [you | the organization you represent], would you say that [you know | your organization] know/s the policy interests of the most active water management stakeholders in the region?” Respondents placed their answers in a scale ranging from 0 (do not know their interests) to 10 (definitely know their interests), so lower scores represent more uncertainty and thus a negative coefficient should be expected. In Parana, the mean score for the variable was 6.43 (standard deviation of 2.03), reflecting more uncertainty than the mean score for Tampa (7.00, s.d. of 2.21), and Sacramento-San Joaquin (mean of 6.85 s.d. of 2.69).

Hypothesis 5 contained the expectation that greater scientific uncertainty at the organizational level would be linked to more participation in the ecology of games. *Scientific uncertainty* is measured by asking “In your opinion, how adequate is the currently available scientific knowledge to understand the future impacts of water policies?” Responses were placed on a scale from 0 (not adequate) to 10 (very adequate), so again lower scores represent uncertainty and thus a negative coefficient should be expected, reflecting that those actors who are more uncertain tend to participate more in venues. In Parana the mean value was 5.75 (s.d. of 2.15). The mean value for responses in Tampa was 5.76 (s.d. 2.37), while in Sacramento-San Joaquin the mean score was 4.53 (s.d. of 2.51).

Finally, hypothesis 6 stated that perceptions of higher procedural fairness should be linked to more participation in the ecology of games. We measured *perception of procedural fairness* by asking the following question for every forum where the respondents claimed to have participated: “How fair would you say that the process of reaching decisions in the forum is for all stakeholders?” Responses were places on a scale ranging from 0 (very unfair) to 10 (very fair). Answers were then averaged across all forums identified by the respondent. The mean value for this variable was 7.44 in Parana (s.d. of 1.77), 7.01 in Tampa (s.d. of 2.24), and 6.28 in Sacramento-San Joaquin (s.d. 2.38).

Control Variables

We also include a number of control variables that could help explain activity in the EGs we study. The first control variable is called *Work on Environmental Issues*, and captures how active the organizations are in dealing with environmental topics. The variable is measured with a battery of questions that asked the respondents whether their organizations (or themselves, if they acted individually) had worked on the following topics in the 12 months before the survey was administered: water provision for human uses, water quality, protection of biodiversity, land use, flood control, climate change, and educational campaigns (this last option was only asked in Parana). Respondents answered “yes” (value of 1), or “no” (value of 0) for each of these questions, and then we simply obtained a count adding all the values of the questions. Thus the variable ranges from 0 to to 6 in Tampa and Sacramento-San Joaquin (means of 2.48 and 2.94 and standard deviations of 1.31 and 1.78, respectively) and 0 to 7 in Parana (mean of 3.88, s.d. of 1.71). We expect organizations or individuals who score higher in this variable to be more active in the EGs.

A second control variable is the *Level of Involvement in Water Issues,* which differentiates (on a 1-5 scale) between respondents who have little experience in water issues (value of 1) and the professionals whose job is primarily dealing with these issues (value of 5). Tampa has a mean value of 3.08 (s.d. 1.58), Sacramento-San Joaquin a mean 3.01 (s.d. 1.61), and Parana a mean of 3.00 (s.d. 1.58). Again, we expect a positive relationship between this variable and the level of participation in the EGs.

A third variable we control for is the *Participation in collaborative activities* of the actors. Respondents were presented with a list of collaborative activities that match closely those described in Bardach (1998) and asked to identify in which of them they had participated in the previous year. The list of activities contains: 1) exchange of data and technical information with other actors, 2) sharing of personnel, 3) collaboration on joint research projects, 4) collaboration on joint grant writing, 5) participation in work groups, 6) signing of cooperation agreements or memos of understanding, 7) exchange of information about laws and regulations that affect the management of natural resources, and 8) joint legal actions with other stakeholders against a third party. We added the positive responses into a count variable (minimum value of 0, and maximum value of 8), expecting nodes that score higher values in this variable to be more active in the EGs. Mean and standard deviations scores are 2.41 and 1.46 for Tampa, 2.77 and 1.81 for Sacramento-San Joaquin, and 5.11 and 1.68 in Parana.

We also include a variable called *Governmental Actor*, which is a simply dummy variable that captures whether the organizational node is a governmental actor (value of 1) or not (value of 0). We include the variable to control for the reasonable expectation of observing more activity in the EGs concentrated around governmental actors. These actors usually have a greater amount of resources available at their disposal in comparison to non-governmental actors, who must carefully pick a smaller number of forums in which to participate. 40% of the actors in Tampa are governmental, while the number climbs to 67% in Sacramento-San Joaquin. In Parana the value drops to 38%.

Finally, and as a control only in the model for Parana, we include the dummy variable *Active in the Issue of Land Use*, with values of 1 for actors that claimed to be involved in this issue and 0 otherwise. As it was mentioned when we described the three research sites, the Parana river delta was subject in 2008 to widespread fires that created a heightened sense of environmental crisis, which in turn resulted in the creation of many new forums specifically designed to discuss the topic of land use in the delta's islands. Thus we expect a positive relationship between this variable and the level of participation in the EG in this particular research site. 73% of the actors in Parana mention being active on this issue.

Estimation Technique.

We estimate three ERG models, one for each research site, using PNet.[5] The software implements a Markov Chain Monte Carlos Maximum Likelihood (MCMCML) estimation that proceeds in three phases. During the first phase, it produces a vector of estimates that generates a graph (network) distribution with expected values for all the effects included in the model (bonding and bridging configurations, plus activity effects for all nodal attribute variables) equal to those in the observed graph.

When the estimation is concluded, a second phase follows during which many simulations (1000 in this case) are performed with the parameter estimates obtained in phase 1 to determine whether they can generate the graph distribution centered at the observed network. The parameter estimates are adjusted multiple times as needed in different sub-phases, with the

[5] The software can be downloaded at: http://www.sna.unimelb.edu.au/pnet/pnet.html.

procedure stopping after a pre-set number of sub-phases have taken place (8 in the case of the runs presented in table 2).

The third and last phase simulates graphs from the final parameters obtained at the end of phase 2. Standard errors are also estimated during the last phase, and convergence checks are performed. A t-ratio is produced for each coefficient that captures how much convergence exists in this process. Values of $t < 0.1$ are interpreted as a sign of good convergence –the observed values lie in the center of the graph distribution of model-predicted network characteristics.

If the model converges successfully, one can then interpret the values of the coefficients similarly as one would do it with the coefficients of a logistic regression. For instance, if the parameter for the organization-star contained multiple transitive triads contained in figure 3 were positive and significant, one would conclude that the log likelihood of observing multiple triads is higher in the communication network of the San Antonio river basin than would be expected in a random process of tie formation. This, according to the theoretical argument presented in this paper, would indicate the presence of more bonding capital.

Results

Table 1 presents the results of the estimation of the model, which converged properly with *t* values smaller than 0.1 for all the coefficients. Coefficients can be understood as conditional log odds, and thus they represent the likelihood to observe the formation of particular network configurations, given all other configurations represented in the model.

Results show partial support for a few of our hypotheses only, but they help create a more nuanced understanding of how the EG is shaped in policy-making systems of varying levels of institutionalization. In regards to hypothesis 2, only the portion that applies to weakly institutionalized systems finds empirical support. The hypothesis stated that weak bonding should be prevalent in this type of systems, and that's what the evidence shows since the coefficient for configurations that indicate weak bonding is positive and significant. On the other hand, the results do not go in the expected direction for strongly institutionalized systems, since they show that in the two EGs of the U.S. weak bonding is prevalent, while strong bonding represented by configurations where actors share multiple venues is not significantly present – and in the case of Tampa its inclusion in the model even precludes proper convergence.

For hypothesis 3, results are also mixed. On the one hand, the fact that bridging and weak bonding configurations are both significantly present in the three sites confirms the idea that both cooperation and coordination problems may coexist in complex social-ecological systems, and that different configurations are likely to emerge from this dual threat. But the relative importance of weak bonding configurations in relationship to the bridging configuration is only the expected one in Parana and Sacramento-San Joaquin. According to hypothesis 3, the expectation for Parana was that bridging structures based on popular actors that attended multiple forums would be less common than structures for weak bridging, and that expectation is supported. The man-made fires that spread out of control in 2008 created a profusion of informal forums that were heavily attended (many of them were one-day workshops that had the goal of informing stakeholders about the ecological problems associated with certain economic activities in the delta). This tipped the scale in favor of weak bonding, which takes place when actors have limited opportunities to meet others in specific forums. For both Tampa and Sacramento-San Joaquin, the expectation was to observe a similar presence of both bridging and bonding, and whereas that is the case in Sacramento-San Joaquin, in Tampa we observe a clear preeminence of bridging structures. The coefficient for the bridging configuration in Tampa is much larger than the coefficient for weak bonding mostly due to the fact that there are a number of actors (governmental in the majority) that tend to have an active presence in the EG, participating in a large number of forums. The Southwest Florida Water Management District is the preeminent actor in this ecology, with others such as the Florida Department of Environmental Protection trailing closely. These results suggest that a "one size fits all" explanation of how networks are shaped in highly institutionalized policy making systems is not available, and more theory needs to be generated to account for the differences that exist in the Ecology of Games when local and regional "recipes" are applied to deal with the management of natural resources in general and water resources in particular.

Results also show that support for hypotheses 4 and 5 is lacking. More behavioral and scientific uncertainty is not associated with greater participation in the EG as was expected. It is not possible to determine with absolute certainty why this is the case, but it may be the case that actors get involved in the EG simply because they see it as a political space where decisions are made that affect multiple stakeholders and thus require a presence, regardless of how well they know others or how much they need to improve their science-driven understanding of pressing environmental problems.

Hypothesis 6 finds support only in Parana, where actors who perceive procedural fairness in forums to be higher participate more in the EG. Again, it is difficult to assess why there exists this difference between weakly and strongly institutionalized systems, but a plausible explanation lies in the fact that many of the forums in Tampa and Sacramento-San Joaquin are more formalized, as explained in the front end of this paper. Formal forums provide an incentive for actors to have a sustained presence in them because –regardless of how fair procedures are- decisions that are reached in the forum clearly affect most of the participants. For instance, regional planning councils, city councils, task forces created by law where participation is mandated, etc., almost force the participating actors to stay active regardless of how fair the process of making decisions is. On the other hand, most of the forums in the EG in Parana are very informal in nature. In fact, there is not a single forum in this EG where participation is mandated by law. In such a system, where actors are not compelled by exogenous forces to stay active in the system, perceptions of procedural fairness are more likely to play an important role in determining participation.

In regards to the effects for the control variables included in the model, there are some rather surprising results. The most puzzling of them is that actors that engage more on collaborative activities don't necessarily participate more in the EGs. This is a result repeated across the research sites, and at the very minimum indicates that participation in forums does not reflect cooperative tendencies. What effect this has in designing and implementing policy to better manage water resources in the complex social ecological systems we study is a matter for future research.

Also, those actors that work extensively on environmental issues and who are more involved in water management issues are not more likely to participate either, except in Tampa. In Parana, the lack of significance of this coefficient can be examined under the light of the heightened public attention to the issue of land use in the delta's islands after the fires in 2008. The sense of environmental crisis that spread quickly with the fires and was solidified after it became evident that the provincial and national governments had no clear plan to manage the delta sustainably brought many new actors to participate in forums. The fact that many of these new actors were concerned citizens, or representatives of organizations for which the environment is one of many topics of interest is perhaps the clearest explanans for the lack of significance of this effect in Parana. A similar explanation is possible in the Sacramento-San Joaquin, where in the last few years widespread conflict has erupted over the likelihood that the freshwater resources of this system can be allocated not only in the San Francisco bay area, but also in central and southern California.

Concluding Remarks

Our analysis of the three EGs shows that the shape and inclusiveness of the two-mode networks involving forums and the actors that participate in them are contextual on the institutionalization strength of these complex social-ecological systems. These contextual forces at play enrich our descriptive understanding of why the EGs look the way they do, but also force us to be cautious about the chance to generalize results based on a small number of cases.

The Parana river delta EG is more fragmented or less inclusive than those in the strongly institutionalized systems of Tampa and Sacramento-San Joaquin, and it sees more weak bonding than bridging, as expected (and no strong bonding). The fleeting character of many of the most popular forums in this site are evidence of the difficulties actors may have in establishing solid cooperative reputations and reducing the transaction costs of negotiating agreements with others that have similar or more importantly, dissimilar interests in the management of natural resources in the delta.

In Tampa and Sacramento-San Joaquin, strong bonding is absent and weak bonding is present, which is counter to our expectations, but that’s where the similarities stop. In Tampa there are central governmental actors that drive the prevalence of bridging configurations (most notably the Southwest Florida Water Management District and the Florida Department of Environmental Protection), and general levels of participation are driven by professionals devoting a good deal of time working on water related issues. The Sacramento-San Joaquin EG, on the other hand, is embedded in a strongly institutionalized system as well, but it does not share Tampa’s particular drivers of participation. Here, the distribution of bridging and weak bonding structures is more similar, reflecting on the fact that there are many forums that are heavily attended, and many actors that are very active in attending different forums. Given that conflict over water allocation seems to be at an all-time high, the greater activity level in this EG by actors who do not devote most of their time to water management issues seems to indicate that actors get activated when they perceive a crisis or regional proportions. In this sense, the Ecology of Games may be not so much a place to solve problems but rather a way of channeling the conflict that is likely to erupt when particular events expose the dissimilar an even colliding goals of myriad stakeholders.

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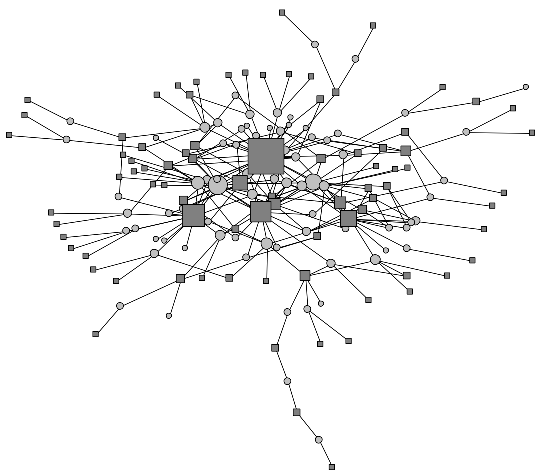
Table 1. Activity and Inclusiveness in the Ecologies of Games

	Parana	California	Tampa
Number of venues	107	271	336
Number of organizations	135	255	167
Number of edges	266	692	600
Average number of edges per organizations	1.970	2.714	3.593
Number of Isolate organizations (% of present organizations)	31/135 23%	35/255 14%	29/167 17%

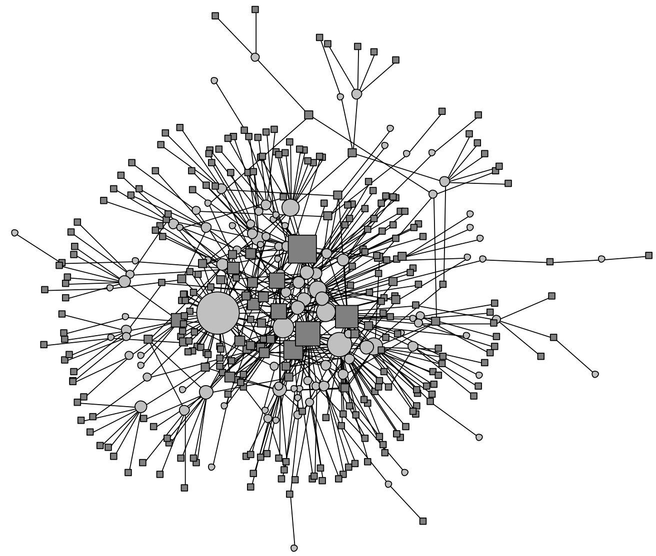
Table 2. ERGM Model Parameter Estimates

	Parana	Tampa	Sacram-S. Joaq.
Weak Bonding (Forum Stars)	0.714* (0.123)	0.183* (0.086)	0.929* (0.072)
Strong Bonding (Organizations share multiple venues)	0.045 (0.063)	No convergence	-0.043 (0.046)
Bridging (Actor Stars)	0.536* (0.220)	1.059* (0.105)	0.851* (0.168)
Density	-6.304* (0.296)	-6.924* (0.180)	-7.198* (0.171)
Actor Attributes Effects on the Formation of Ties			
Behavioral Certainty	0.028 (0.020)	0.014 (0.011)	0.003 (0.002)
Scientific Certainty	-0.003 (0.024)	-0.001 (0.001)	-0.001 (0.001)
Procedural Fairness in Forums	0.047* (0.022)	0.013 (0.011)	0.001 (0.001)
Work on Environmental Issues	-0.021 (0.023)	0.004* (0.001)	0.001 (0.001)
Level of Involvement in Water Issues	0.004 (0.021)	0.032* (0.010)	0.003 (0.002)
Participation in Collaborative Activities	-0.028 (0.023)	-0.001 (0.002)	0.002 (0.002)
Governmental Actor	0.026 (0.112)	0.447* (0.076)	0.186* (0.063)
Active in the Issue of Land Use	0.582* (0.169)	-	-

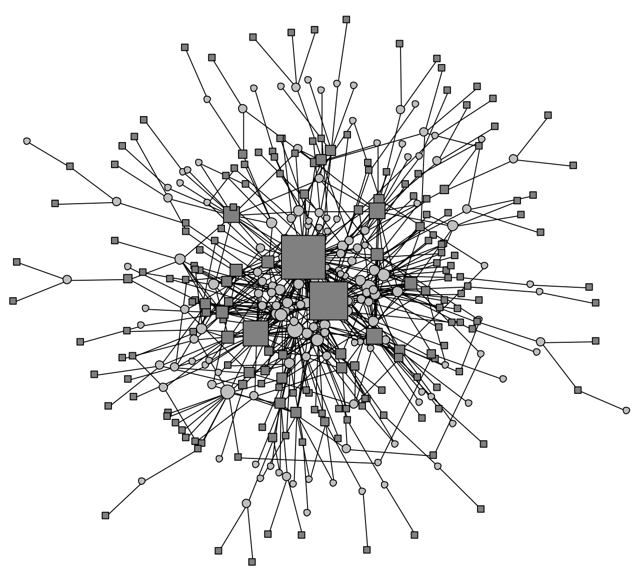
Note: SEs are reported in parenthesis. Asterisks denote parameters that are significant at the .05 level.



Parana River delta



Tampa Bay estuary



San Francisco delta

Figure 3. The Ecologies of Games in the Three Research Sites