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Author(s): Mark Lubell, Mark Schneider, John T. Scholz and Mihriye Mete
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Watershed Partnerships and the Emergence of Collective Action Institutions

Mark Lubell Florida State University
Mark Schneider SUNY at Stony Brook
John T. Scholz Florida State University
Mihriye Mete Michigan State University

This article examines the emergence of local cooperative institutions—watershed partnerships—that resolve collective action problems involved in the management of natural resources. The political contracting approach to institutional supply suggests that watershed partnerships are more likely to emerge when potential benefits outweigh the transaction costs of developing and maintaining new institutions. We analyze the impact of social, political, economic, and ecological features of watersheds that affect benefits and transaction costs on the emergence of 958 watershed partnerships in the more than 2100 watersheds in the United States. Our findings demonstrate that watershed partnerships are most likely to emerge in watersheds confronting severe pollution problems associated with agricultural and urban runoff, with low levels of command-and-control enforcement, and containing the resources to offset transaction costs.

The intervention of higher levels of government into the policy process has traditionally been justified in situations that require collective action but where local governments, interest groups, and bureaucratic agencies have difficulty in reconciling their interests. This has been clearly evident in the management of natural resources, where externalities have made cooperation particularly difficult. It is therefore surprising that, in the administration of many policies, the United States government no longer seeks to resolve externalities by imposing uniform standards on all local communities. Instead, agencies throughout the federal government increasingly favor the growth of new governing institutions that encourage cooperation between local actors with conflicting interests, divergent geographic bases, and overlapping administrative jurisdictions to resolve continuing disputes over resource management (Bardach 1998). Thus we are faced with a theoretical puzzle: despite the long intellectual and policy tradition of creating centralized institutions to deal with conflict between local actors, why is the policy process moving toward cooperative, decentralized institutions, and what factors make these solutions viable?

To answer these questions, we investigate the move towards cooperative institutions using a primary example from environmental policy: the emergence of watershed partnerships designed to manage resources at the ecosystem scale. Kenny et al. define watershed partnerships as:

> A primarily self-directed and locally focused collection of parties, usually featuring both private and intergovernmental representatives, orga-

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Mark Lubell is Assistant Professor of Political Science, Bellamy 542, Florida State University, Tallahassee, Florida 32306-2230 (mlubell@garnet.acns.fsu.edu). Mark Schneider is Professor of Political Science, SUNY at Stony Brook, Stony Brook, NY 11794-4392 (Mark.Schneider@sunysb.edu). John T. Scholz is Professor of Political Science, Florida State University, Tallahassee, FL 32306-2230. Mihreye Mete is Assistant Professor of Political Science, Michigan State University, 303 South Kedzie Hall, East Lansing, Michigan 48824 (mete@msu.edu).

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> nized to jointly address water-related issues at the watershed level or a similarly relevant physical scale, normally operating outside of traditional governmental processes or forums, and typically reliant on collaborative mechanisms of group interaction characterized by open debate, creativity in problem and solution definition, consensus decision-making, and voluntary action. (2000, 2)

The theoretical advantages of partnerships are similar to those of successful local "common-pool resource" management institutions analyzed by Ostrom (1990, 1999; Ostrom, Gardner, and Walker 1994). Proponents argue that watershed partnerships offer potential benefits to both environmental and economic interests. For environmental interests, watershed partnerships address problems that are outside the scope of centralized regulation, such as habitat destruction and nonpoint source pollution. For economic interests, watershed partnerships allow the adoption of flexible policy tools for addressing environmental impacts in a cost-effective manner while reducing the threat of ever more stringent regulatory policies.

We focus in this article on the central issue of how such institutions emerge in our complex federalist system. Extending North (1990) and Libecap (1989), we view watershed partnerships as political contracts developed by actors seeking to minimize the first-order collective-action problems associated with the use of local common-pool resources. However, regardless of potential benefits, partnerships will emerge only if participants can overcome the second-order collective-action problems inherent in institutional supply (Bates 1988; Ostrom 1990). As with all voluntary exchanges, partnership contracts are most likely to emerge when potential benefits are high and the transaction costs of developing, negotiating, monitoring, and enforcing the political contract are low (Heckathorn and Maser 1987; Taylor and Singleton 1993).

In the next section, we discuss the political economy of watershed partnerships to illustrate this problem of institutional supply in more detail. Building on Ostrom's IAD framework, we then identify the factors affecting benefits and transaction costs and hence the likelihood that partnerships will emerge. We then test empirically the significance of these factors in predicting the number and level of activities of partnerships, using the 2149 watersheds that cover the lower forty-eight states as designated by the U.S. Geological Survey and the 958 watershed partnerships identified by the Conservation Technology Information Center (CTIC).

The Political Economy of Watershed Partnerships

Since the 1960s, the growing collective-action problems associated with environmental issues have stimulated the development of federal and state "command-and-control" institutions that use a combination of ambient environmental quality standards, technology requirements, emissions criteria, and other restrictions to control use of natural resources (John 1994; Rosenbaum 1998). Most commentators agree that command-and-control institutions have successfully reduced pollution from well-defined point sources like factories and sewage treatment plants. However, they have been less successful in regulating the remaining nonpoint sources of pollution: geographically diffuse, numerous, and heterogeneous resource users who jointly affect the environmental quality of a watershed (Davies and Mazurek 1998; John 1994; Lubell 1999; NAPA 1997). Command-and-control institutions also have difficulty addressing problems such as habitat destruction that involve multiple environmental media (e.g., air, water, land) and span political and administrative boundaries (John 1994; Marsh and Lallas 1995).

These administrative limitations are exacerbated by regulatory battles that polarize watershed resource users into what Sabatier and Jenkins-Smith (1993; Sabatier 1994) call competing "advocacy coalitions." The resulting fragmentation, gridlock, and legal combat impose considerable costs and uncertainty on all resource users (Rabe 1986; Weber 1998). Economic interests complain about excessive regulatory costs, delays, inflexibility, and the uncertainty of future coercive regulations, while environmental interests worry about accumulating damage to ecosystems caused by unresolved problems.

The limitations of current institutions provide a niche in which partnerships can develop, at least to the extent that the theoretical advantages analyzed by Ostrom (1990, 1999) can be realized. By enlarging the set of relevant actors within the watershed boundary involved in the policy-making process, partnerships can fashion innovative policy tools to target problems beyond the scope of existing regulations. Partnerships can build on local knowledge and craft specialized policies congruent with local watershed problems. Voluntary participation by local actors allows for the development of self-monitored norms of cooperation that circumvent costly legal and administrative compliance mechanisms.

In short, from the contractual perspective, watershed partnerships emerge because they produce mutually beneficial solutions to resource conflicts in the watershed

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that are (Pareto) superior to command-and-control institutions. However, benefits accrue only if watershed actors overcome the second-order collective-action problem of institutional supply (Bates 1988). The greater the transaction costs of developing and maintaining partnerships, the less likely partnerships will emerge. We next consider factors affecting benefits and costs that we use to predict the emergence of partnerships.

Benefits, Transaction Costs, and the Emergence of Watershed Partnerships

We analyze the emergence of 958 watershed partnerships identified by the Conservation Technology Information Center (CTIC 1997). Watershed partnerships emerged at an accelerating rate over the last four decades: of the 465 partnerships reporting their date of inception, 4 percent began prior to 1970, 5 percent between 1970 and 1979, 15 percent between 1980 and 1989, and more than three-quarters (75.8 percent) between 1990 and 1997 (see also Yaffee et al. 1996). Watersheds provide a natural unit for analyzing partnerships because they define the geographic scope within which water-related resource conflicts take place. Watersheds are defined by the United States Geological Services (USGS), which has created a hierarchical classification of hydrological units that divides regions into major river basins like the Missouri or Mississippi rivers, and then subdivides the regions into successively smaller units.[1] The smallest unit is the hydrological accounting unit (HUC), or watershed; there are 2149 HUCs that fully cover the United States. We use event count regression techniques to analyze factors explaining the number of partnerships that occur in the 2111 watersheds in the lower forty-eight states for which data are available.

We use two different dependent variables to measure the development of partnerships, as indicated in the first horizontal panel of Table 1. More detailed descriptions of all variables are included in the appendix. First, we count the number of partnerships in each watershed as a baseline measure. Our second dependent variable sums up the number of activities taking place in each partnership across all partnerships in a watershed. The activity count includes all ten activities covered by CTIC: adopting best management practices, issue assessment, cost sharing, education, monitoring, issue identification, issue prioritization, plan development, goal setting, and developing a common vision. It differentiates between watersheds with the same number of partnerships but different levels of activity within those partnerships.

To identify those factors that affect the benefits and transaction costs of watershed partnerships, we build on Ostrom's (1990; 1999) IAD framework. In our analysis, watersheds constitute the *action arena* "where individuals interact, exchange goods and services, dominate one another or fight" (Ostrom 1999, 42). Within an action arena, the *action situation* and *characteristics of actors* jointly determine the benefits and transaction costs of partnership development. The action situation includes the nature and distribution of resources, existing institutional arrangements, and action-outcome links. Actors are defined in terms of the resources they bring to a situation, their preferences over various states of the world, their knowledge, and their information-processing capabilities. Collective outcomes (including levels of resource degradation and conflict) are a result of actors making decisions within the structure of the action situation that determines the payoffs for various strategies. Table 1 summarizes the characteristics of action arenas and actors that we use to represent potential benefits and transaction costs to be discussed in the next section. The plus/minus signs in parentheses after each measure indicate the expected direction of influence of that measure on the number of partnerships and activities.

Features of Watersheds Affecting Benefits

Watershed partnerships seek to reduce losses from the overexploitation of common-pool resources provided by watersheds and their associated ecosystems. As environmental problems become more severe, the benefits from entering into partnerships increase. We use five variables to measure the concept of *problem severity*. The first is a direct measure of problem severity based on the quality of ecosystem conditions, which should be positively related to partnership formation. The second and third measures reflect the potential damage to water quality posed by agricultural and urban run-off. These variables are particularly important because they measure the kind of nonpoint source environmental problems for which partnerships have the greatest comparative advantage over command-and-control institutions (John 1994, see also NAPA 1997); the environmental damage is generated by multiple sources, migrates across ecological and administrative boundaries, features complex cause-effect relationships, and has many options for control. The final two variables represent watershed characteristics associated with more intensive exploitation of water resources—the population pressure in the watershed, and

[1]See http://water.usgs.gov/public/GIS/huc.html.

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TABLE 1 Factors Affecting the Emergence of Watershed Partnerships

Variable Name	N	Minimum	Maximum	Mean	Standard Deviation
Dependent Variables					
Partnerships (post-1990)	2055	0	6	.33	.76
Activities (post-1990)	2055	0	79	1.37	3.97
Features of Watersheds Affecting Benefits					
Problem Severity					
Adverse Ecosystem Conditions (+)	2055	0	27	10.33	6.95
Agricultural Runoff (+)	2054	0	2	1.02	.70
Urban Runoff (+)	1942	0	50.08	1.13	3.92
Population Density (1000s; +)	2055	0	7.21	.11	.38
Active NPDES Permits (+)	1848	0	1466.87	88.32	168.93
Institutional Opportunities					
Integrated Agency (–)	2035	0	1	.17	.38
Ecosystem Management (–)	2035	0	1	.48	.50
Wetlands Program (–)	2035	0	1	.22	.41
NPDES Primacy Time (+)	2035	1	26	9.62	10.16
NPDES Enforcement (–)	1777	0	1.37	.06	.10
Water Debt ($ per Capita; +)	2049	0	577.49	7.95	38.44
Political Incentives					
Agriculture (–)	2052	0	93.08	11.23	13.34
Mining (–)	2052	0	69.65	2.43	5.55
Farm Concentration (+ for rent-seeking hypothesis)	2052	0	41.10	6.49	5.84
Features of Watersheds Affecting Transaction Costs					
Institutional Support					
Prior Partnerships (+)	2055	0	5	.07	.32
Prior Neighbors (+)	2055	0	12	.51	1.23
Federal Aid (+)	2038	0	61.72	3.35	5.23
State Aid (+)	2038	.22	76.26	29.97	16.69
Local Aid (+)	2038	0	21.42	1.61	2.08
LCV 1993–1994 (+)	1999	0	99.89	39.22	25.34
Public Water/Sewer (+)	2052	0	100	58.12	23.14
Characteristics of Actors					
Per Capita Income ($1000; +)	2052	2.95	33.25	11.27	2.81
High Education/Occupation (+)	2049	0	40.74	10.65	3.42
Black (–)	2052	0	72.83	6.27	11.91
Hispanic (–)	2052	0	97.69	6.61	13.10
State Natives (+)	2052	7.48	97.06	68.36	16.68
Watershed Area (Control)	2052	.04	82.47	14.13	8.95

the number of facilities permitted to directly discharge effluents into the water.

For a given level of problem severity, *institutional opportunities* determine the relative gain in benefits over the previous status quo. Watershed partnerships fill a niche in fragmented policy domains by providing a new institutional setting in which diverse interests can negotiate mutually beneficial rules to govern the use of CPR. Other collective-choice institutions that provide similar services at the state or federal level compete within the same niche and therefore reduce the expected benefits for watershed partnerships.

For example, active and innovative state environmental programs may already fill the niche watershed partnerships might otherwise occupy. States that have integrated their environmental protection and natural resource divisions into a single agency may provide an alternative forum for the negotiation of mutually beneficial solutions to watershed problems. Our empirical analysis also looks at other indicators of state institutional development that

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might reduce the institutional niche partnerships can fill: the development of an ecosystem management program, wetlands protection legislation, and the number of years it takes a particular state to meet EPA "primacy" standards for administering the NPDES permit system.

Similarly, the benefits of watershed partnerships should be lower in watersheds where EPA and state enforcement effectively control pollution. Point sources of water pollution are managed by the National Pollution Discharge Elimination System (NPDES) authorized by the 1972 Clean Water Act. An active enforcement presence provides fewer incentives for actors to organize new institutional structures. Thus, as the number of pollution control enforcement actions per permitted facility in a watershed increases, the rate of partnership formation should decrease. Weak enforcement, ironically, provides greater incentives to create institutional structures that can potentially resolve problems that EPA rules do not address.

Finally, we include the extent of debt for water supply utilities within the county, since local governments with such debt are more likely to benefit from the financial rewards that often flow from watershed partnerships.

Problem severity and institutional opportunity reflect conditions of the action situation that affect benefits, while *political incentives* reflect actor characteristics that also influence potential benefits. One of the most enduring conflicts affecting partnerships is between competing advocacy coalitions built around environmental interests versus economic growth/property rights interests (Sabatier and Jenkins-Smith 1993; Sabatier 1994). Note that the overlap between the advocacy coalition framework and the rent-seeking hypothesis of "capture theory" (Buchanan, Tollison, and Tullock 1962; Stigler 1971) suggests that dominant economic interests create watershed partnerships to forestall additional command-and-control regulations and to minimize enforcement of existing standards. Indeed, more radical environmental groups use this argument to condemn partnership collaboration with economic interests.

To test the capture hypothesis, we include a variable measuring employment in agriculture (including farming, forestry, and fisheries) and in mining. Since these industries are heavy users of watershed resources and major sources of nonpoint source pollution, the capture approach predicts that a larger, more powerful sector will increase the likelihood of partnerships. Given the well-known problems of organizing agricultural workers, the concentration of power in a smaller number of large farms provides an additional measure of power to test this hypothesis, since larger farms could more easily overcome the collective-action problem of organizing interests (Olson 1965). At least one of these measures should be positively related to the number of partnerships if capture is a primary motivating force in partnership formation

Although the rent-seeking hypothesis appears sensible when applied to regulatory policies, the extension to partnership formation raises difficult questions. Control of a state agency may allow an industry to use the coercive powers of the state to extract rents, but control of a partnership cannot be used to coerce partners who have the option of leaving. Thus this hypothesis is incompatible with our contract perspective, which assumes that partners will only join when mutual benefits based on Pareto-superior outcomes outweigh transaction costs.

What are the calculations that affect this calculus of consent? Economic interests may participate in watershed partnerships in order to avoid even higher costs and economic uncertainties generated by conflict in regulatory agencies, the courts, and the federal/state legislative processes. Similarly, environmental interests may prefer clear local agreements for managing all watershed resources over the possibility of piecemeal victories in agencies, courts, and statutes that still fail to protect large-scale ecological processes and habitats. A watershed partnership based on voluntary agreement between competing advocacy coalitions, which provides restricted but better-defined access to ecosystem resources, may be preferable to the uncertain outcomes of protracted legal and political battles at the state and federal level.

Voluntary agreements are not the end of competition: partners still compete over the gains realized from cooperation. And like the capture hypothesis, the contract perspective suggests that the expected benefits from partnerships depend on the relative strength of each advocacy coalition and the nature of the local industrial base—but the direction of the relationship is reversed. When extractive industries dominate the local regulatory arena, they have little concern with local environmental groups and hence little interest in local partnerships. The incentive to cooperate arises only when a competing advocacy coalition gains sufficient strength to challenge them in state and federal regulatory arenas. Contrary to the capture perspective, the contract perspective suggests that a *smaller* agricultural sector, as measured by employment, will increase the rate of partnership formation. Thus, a negative relationship would support the contract perspective we believe to be most relevant to partnerships, while a positive one would support the capture perspective.

Features of Watersheds Affecting Transaction Costs

We next consider the characteristics of the action situation and actors that affect the transaction costs of developing and maintaining partnerships. In particular, we fo-

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cus on watershed characteristics providing *institutional support* within the action arena that can reduce transaction costs and on *characteristics of actors* affecting the resources they can contribute to offset transaction costs.

We consider four ways in which institutional support within a watershed can offset transaction costs. First, prior institutional structures can provide a model and patterns of behavior that facilitate future cooperation. While partnership activity has dramatically accelerated during the 1990s, about one-quarter of the partnerships under study were created before 1990. The avenues of communication and negotiation established in watersheds with a history of partnerships reduce the transaction costs of forming new partnerships. In addition, as suggested by state-level studies of policy diffusion (e.g., Berry and Berry 1990), the existence of partnerships in neighboring watersheds may provide models that reduce the costs of developing new partnerships. Thus, watersheds with prior partnerships or with neighboring watersheds that had prior partnerships are more likely to have additional partnerships and greater partnership activities.

Second, in a federal system, the institutional rules and resources determined by higher levels of government affect the benefits and transaction costs of cooperation at lower levels (Bendor and Mookerjee 1987). Intergovernmental transfers from state and federal governments can help local governments pursue environmental protection, an activity otherwise limited by local government competition for economic development (Peterson 1981; Chubb 1985; Schneider 1989). Many partnerships receive funding from specific state and Federal assistance programs such as the Clean Water Act's Section 319 (h) nonpoint source pollution grants, or state Clean Water Revolving Loans. These monies finance projects that local governments would not otherwise undertake and can significantly offset the costs of cooperation in partnership activities.

Third, elected representatives in state and Federal legislatures that are supportive of environmental policy can use their legislative powers to funnel information, personnel, and money towards partnerships. We measure local Congressional support for environmental policy using the League of Conservation Voter (LCV) scores that reflect voting patterns of watershed representatives on important environmental legislation. We argue that higher mean scores on these variables for a watershed's Congressional representatives reflect greater support for environmental action, easing transaction costs.

Finally, the type of technology used to access natural resources may influence costs. For example, watersheds with decentralized systems involving homeowner wells and septic tanks face greater challenges in coordinating activities than watersheds with a single authority delivering drinking water services. Like migrating fish species (Schlager, Blomquist, and Tang 1994), decentralized technologies feature a significant amount of spatial heterogeneity that increases transaction costs. The greater the percentage of residents serviced by public water and sewer authorities, the lower the transaction costs and hence the greater the likelihood of partnerships.

Differences in *characteristics of actors* will also influence the transaction costs of partnership formation and activities. The characteristics of policy elites directly involved in partnership formation would be most relevant to analyze actor support, but are unavailable. Consequently, we include five measures of population traits that reflect the general level of support for partnerships. First, the contract perspective suggests that higher socioeconomic status is associated with higher stocks of human and social capital that can overcome the transaction costs of political contracting. Increasing socioeconomic status is also linked to a shift towards managerial and professional occupations, which provide a potential pool of public entrepreneurs who can further coordinate collective action (Schneider and Teske 1995). In addition, individuals with higher socioeconomic status are likely to have stronger preferences for environmental preservation (Inglehart and Abramson 1994) and may provide more active support to partnerships concerned with preservation. We include measures of income and education/occupation to test these hypotheses.

Heterogeneity of preferences raises bargaining costs, since diverse populations are difficult to organize for collective action (Hackett 1992; Libecap 1989). One of the indicators of population heterogeneity we think most important is the size and distribution of racial minority populations in a watershed. Minority populations may affect the development of new institutions not only because population heterogeneity increases transaction costs, but also because of other factors that account for administrative decisions that locate many environmental "bads" (e.g., toxic waste dumps and other waste treatment facilities) in minority communities (Ringquist and Clark 1997). From the contract perspective, minority populations lack the political resources that would allow them to resist administrative actions that adversely affect them.

Finally, population stability leads to a "sense of place" that may enhance support for environmental protection (Beatley and Manning 1997; Snyder 1990). People with a sense of place value ecosystem integrity because their current and future quality of life (and often their economic well being) depend heavily on access to local resources. A sense of place also reduces transaction costs in two ways: people have local knowledge of natural systems that can be integrated into institutional rules,

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and they are more likely to be embedded in local networks of civic engagement (Ostrom 1990). Furthermore, the longer "shadow of the future" for stable populations increases the emergence of cooperative equilibria (Axelrod 1984). We assume the percent of the population within a watershed born in the state provides a proxy for a sense of place and the associated factors that reduce the costs of collective action.

Estimation Procedures: Zero Inflated Negative Binomial Regression

As previously noted, we utilize regression analysis to test the impact of factors affecting benefits and costs on the number of partnerships formed after 1990 and the range of partnership activities observed in each watershed. The discrete and nonnegative properties of the dependent variables suggest using an event count procedure to model the process underlying partnership formation. The expected value of event count models is reported as an incidence rate of events over space or time; in this case, the expected number of partnerships or number of activities in a watershed. The standard Poisson event count model assumes that the conditional variance of the count distribution is equal to the expected value, which means that the incidence rate is constant within each watershed (King 1989). However, in our watershed population the variance of the partnership count (.75) exceeds the mean (.32), which suggests our data violates Poisson assumptions (King 1989; Long 1997). Technically, this condition is referred to as overdispersion, and means that there are more watersheds with higher numbers of partnerships and more with zero partnerships than would be predicted by a Poisson process (Long 1997).

There are two possible sources for the overdispersion observed in our data. First, observing zero partnerships in a watershed could mean that there is no niche for partnerships because the benefits are too low, or that benefits are present but transaction costs are too high (i.e., the niche exists, but is not filled). Second, the idiosyncratic attributes of watershed action arenas makes it likely that there are unmeasured sources of heterogeneity that are not captured by the independent variables in our dataset (Cameron and Trivedi 1998; King 1989).

To account for these two sources of overdispersion, we use a zero-inflated negative binomial regression model (ZINB), which estimates the probability of seeing a particular number of partnerships by combining a logit distribution with a negative binomial distribution (Cameron and Trivedi 1998; Greene 1994, 2000; Lambert 1992; Long 1997).[2] The logit equation accounts for the first possible source of overdispersion by predicting the probability of seeing a watershed with no opportunities for partnerships, since the benefits are just not present in these watersheds. The negative binomial equation predicts the expected number (including zero) of watershed partnerships where opportunities exist and takes into account the second source of overdispersion (heterogeneity) by introducing a Gamma-distributed error term into the conditional mean of the standard Poisson distribution. Formally:

$$\Pr(y_i = 0 \mid \mathbf{x}_i, \mathbf{z}_i) = \psi_i + (1-\psi_i) f(\mathbf{x}_i\beta)$$
$$\Pr(y_i > 0 \mid \mathbf{x}_i, \mathbf{z}_i) = (1-\psi_i) f(\mathbf{x}_i\beta)$$
where
$$\psi_i = G(\mathbf{z}_i\gamma)$$

For ZINB, f(.) is the probability density function for the negative binomial distribution and G(.) is the cumulative logistic distribution.

The logit equation contains the factors affecting the benefits of watershed partnerships, since these determine whether or not a niche exists. The negative binomial equation contains the transaction cost indicators since these determine how many partnerships will develop in watersheds with favorable niches. In short, the existence of a problem (e.g., environmental degradation) is necessary for the appearance of a solution (e.g., watershed partnership, as predicted by the logit equation), and the size of transaction costs will determine the subsequent scope of the solution (as predicted by the negative binomial equation).

This ZINB model passes two tests that indicate it is appropriate for our data. First, the alpha parameters are significant in all models, indicating the presence of unobserved heterogeneity within each watershed as one source of overdispersion. This reconfirms the appropriateness of the negative binomial model as opposed to the Poisson model for the count portion of the distribution. Second, the Vuong tests are significant in all models, indicating the appropriateness of the ZINB model relative to a single negative binomial model including all vari-

[2] Technically speaking, the term overdispersion refers to a situation where the conditional variance of the event count exceeds the conditional expected value. The negative binomial model achieves this condition by adding a random error term to the expected value of the distribution. However, zero inflated models create overdispersion even when a Poisson process is used to generate the event count. For example, the conditional variance of a zero-inflated Poisson (ZIP) model is: $\mathrm{Var}(y_i \mid \mathbf{x}_i, \mathbf{z}_i) = \mu_i(1-\psi_i)(1+\mu_i\psi_i)$, where μ_i is the expected value of the count model. Hence, any zero-inflated model leads to overdispersion, and the overdispersion of the ZINB model is greater than for the ZIP model.

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ables *without* the extra zero-generating process of the logit model.

As an extra precaution, we estimated two additional models to ensure robustness across alternative specifications: (1) a single-equation negative binomial model that includes all independent variables, and (2) an "inclusive" ZINB model that includes all significant benefits and cost factors from the presented ZINB model in both equations (i.e., logit and negative binomial). Greene (2000, 892; Table 19.19) cautions that a comparison of the ZINB and a single-equation negative binomial model in terms of the difference between the mean predicted probability for each count and the observed count may contradict the Vuong criteria, as is true for our model.[3] The inconclusive test is not a problem in our case since all models provide almost identical substantive conclusions. Consequently, we present the model that better reflects our theory and reference the other models only when discussing variables that behaved differently in the alternative estimation. Thus, except as noted in the text, the significant coefficients reported in the next section are significant in all three models we tested—the reported ZINB model, a single-equation negative binomial model without zero-inflation, and the inclusive ZINB model including all variables in the negative binomial and logit portions of the model.

As a final precaution, we include three variables that directly control for spatial autocorrelation, prior institutional development, and watershed size. First, to deal with spatial autocorrelation across upstream and downstream watersheds, the prior neighbors variable counts the number of watershed partnerships that existed prior to 1990 at the six-digit watershed level, which is the next largest level above the eight-digit HUCs in the USGS hierarchy. Second, to deal with temporal effects and excluded variables as well as to account for the informational advantages of having a model elsewhere in the watershed, the prior partnerships variable includes a count of the number of pre-1990 partnerships, which have been excluded from the dependent variable count. Third, to control for the size of the watershed, we enter the watershed area in 100 square mile units in both stages of the estimation.

Estimation results are presented in Table 2. Column 1 lists the variables in our model. The parameter estimates for the fully specified model of the partnership count are presented in column 2. To test the robustness of these estimates, the restricted models in columns 3 and 4 include only the significant explanatory variables from the fully specified model.[4] The coefficients for the logit (benefits) equation are presented in the upper portion of the table, and those for the negative binomial (transaction costs) equation in the lower portion. Notice that because the logit model is predicting the probability of zero partnerships and the expected number of partnerships is a product of both the logit and negative binomial portions of the model, negative logit coefficients *increase* the probability of partnerships and positive logit coefficients *decrease* the probability. The negative binomial coefficients are interpreted as usual, with positive (negative) coefficients increasing (decreasing) the number of partnerships or activities.

To compare the magnitude of effects, Table 3 reports the predicted change in the incidence rates of partnerships and number of activities due to a one standard deviation increase from the mean of the significant independent variables in the restricted models (columns 3 and 4 of Table 2), holding all other independent variables constant at their mean level. To avoid confusion, remember that positive changes in variables with negative coefficients in the logit model lead to positive changes in the probability of partnerships appearing. Although these discrete changes appear small, they should be judged relative to the partnership incidence rate (.38) and the activities incidence rate (.92) holding all independent variables at their means. The percentages in parentheses in Table 3 provide this relative measure. For example, the .07 increase attributed to federal aid represents a 19 percent increase in the partnership incidence rate holding all independent variables at their means. To simplify presentation, we report that federal aid increases the partnership incidence rate by 19 percent and do not repeat that this represents the change associated with a one standard deviation increase from the mean in federal aid. The discussion will focus on the restricted model results for partnership rates in Table 2 and the associated percentage changes reported in Table 3. We discuss the activities count results when they show important differences from the partnership count.

Results

Creating the Partnership Niche

The results of the logit analysis at the top of Table 2 strongly confirm the importance of *problem severity* in creating the niche that partnerships fill. Adverse eco-

[3]For example, the observed proportion of zero counts in our data is .75, while the mean predicted probability of zero counts is .80 for our reported ZINB model, .77 for the inclusive ZINB model, and .75 for single-equation negative binomial regression. The discrepancy between the predicted values of the models becomes smaller when looking at higher counts.

[4]Population density was also dropped to reduce multicollinearity problems.

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TABLE 2 Zero-Inflated Negative Binomial Models for Watershed Partnerships

	***Full Model for Partnerships* (N=1617)**	***Restricted Model for Partnerships* (N=1685)**	***Restricted Model for Activities* (N=1685)**
Features of Watersheds Affecting Benefits: Logit Model			
Problem Severity			
Adverse Ecosystem Conditions	–.11 (.03)**	–.10 (.02)**	–.03 (.01)**
Agricultural Runoff	–.89 (.30)**	–1.05 (.27)**	–.73 (.11)**
Urban Runoff	–.78 (.31)**	–.75 (.28)**	–.07 (.02)**
Population Density	1.36 (.62)*	—	—
Active NPDES Permits	–.02 (.01)*	–.013 (.01)**	–.001 (.0005)*
Institutional Opportunities			
Integrated Agency	–.03 (.53)	—	—
Ecosystem Management	.25 (.34)	—	—
Wetlands Legislation	–.03 (.34)	—	—
NPDES Primacy Time	.02 (.02)	—	—
NPDES Enforcement	3.58 (1.99)^	4.11 (1.84)*	1.49 (.81)^
Water Debt	.012 (.01)^	.01 (.005)*	<.001 (.002)
Political Incentives			
Agriculture	.03 (.01)*	.04 (.01)**	.04 (.01)**
Mining	.02 (.03)	—	—
Farm Concentration	–.01 (.02)	—	—
Watershed Area (Control)	–.45 (.28)	–.43 (.27)	–.28 (.12)*
Constant	2.80 (.83)**	2.95 (.74)**	2.63 (.37)**
Features of Watersheds Affecting Transaction Costs: Negative Binomial Model			
Institutional Support			
Prior Partnerships	.37 (.09)**	.39 (.09)**	.30 (.10)**
Prior Neighbors	.02 (.03)	.03 (.03)	.05 (.03)
Federal Aid	.03 (.01)**	.03 (.01)**	.02 (.01)*
State Aid	.01 (.004)**	.01 (.003)**	.01 (.004)**
Local Aid	–.003 (.02)	—	—
LCV 1993-94	.003 (.002)	—	—
Public Water/Sewer	<.000 (.003)	—	—
Characteristics of Actors			
Per Capita Income	.12 (.03)**	.11 (.02)**	.05 (.02)
High Education/Occupation	–.01 (.03)	—	—
Black	–.02 (.01)**	–.01 (.004)**	–.01 (.008)*
Hispanic	–.02 (.01)*	–.03 (.01)**	–.01 (.01)
State Natives	.002 (.004)	—	—
Watershed Area (Control)	.34 (.10)**	.32 (.10)**	.24 (.10)**
Constant	–3.37 (.61)**	–3.08 (.43)**	–.02 (.47)**
Model Fit			
Log Likelihood	–1143.34	–1179.76	–1898.23
Log Likelihood χ^2 (d.f.)	103.24 (13 d.f.)**	117.08 (8 d.f.)**	57.85 (8 d.f.)**
McFadden's Pseudo-R^2	.12	.12	.07
Alpha	.35 (.11)**	.38 (.11)**	.91 (.15)
Vuong Test	5.63	6.94	8.17
N	1617	1685	1685

Notes: Reported estimates are coefficients for the ZINB model. Alpha is the parameter governing the variance of the incidence rate in the negative binomial model. McFadden's Pseudo-R^2 is computed according to Long (1997). Two-tailed hypothesis tests: ^p<.10, *p<.05, **p<.01

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TABLE 3 Discrete Change in Rate of Partnership Formation and Activities for Standard Deviation Change in Independent Variables

Independent Variables	*Discrete Changes in Partnership Rate*	*Discrete Changes in Activities Rate*
Features of Watersheds Affecting Benefits		
Problem Severity		
Adverse Ecosystem Conditions	.04 (10%)	.17 (18%)
Agricultural Runoff	.04 (11%)	.42 (45%)
Urban Runoff	.08 (22%)	.21 (23%)
Active NPDES Permits	.08 (21%)	.13 (14%)
Institutional Opportunities		
NPDES Enforcement	−.03 (9%)	−.11 (11%)
Water Debt	−.03 (9%)	−.03 (3%)
Political Incentives		
Agriculture (Farming, Forestry, Fishing)	−.04 (10%)	−.32 (34%)
Features of Watersheds Affecting Transaction Costs		
Institutional Support		
Prior Partnerships	.05 (13%)	.09 (10%)
Federal Aid	.07 (19%)	.14 (15%)
State Aid	.10 (26%)	.19 (20%)
Characteristics of Actors		
Per Capita Income	.14 (37%)	.15 (16%)
Black	−.06 (15%)	−.12 (13%)
Hispanic	−.12 (31%)	−.17 (19%)

Note: Cell entries are discrete changes in the expected value of the ZINB distribution for a one standard deviation increase from the mean of each independent variable holding all other variables at their sample means, with parentheses indicating percent increase/decrease from incidence rate holding all variables at their means. Values calculated from coefficient estimates of the restricted partnership and activities count models in Table 4, column 3 and 4.

system conditions, urban and agricultural runoff[5], population density, and NPDES permits are all highly significant in all equations, confirming the responsiveness of partnerships to increasing scarcity of ecosystem resources. An increase in the problem severity variables increases the probability of partnerships between 10 percent and 22 percent (Table 3). Reflecting the comparative advantage of partnerships for addressing nonpoint source pollution, urban runoff has the strongest influence (among the problem severity indicators) on both dependent variables, while agricultural runoff has the strongest influence on the activities count.

Two of the six variables measuring *institutional opportunities* play a significant role in influencing the niche for partnerships. A dollar increase in per capita debt for water infrastructure increases the partnership incidence rate by 9 percent. Local governments focused on infrastructure appear to respond to the financial incentives offered by partnerships. Indeed, expenditures on local water infrastructure have traditionally been one of the most popular facets of environmental policy in the eyes of local government.

An increase in enforcement efforts by NPDES agencies significantly reduces the niche for partnerships by 9 percent (Table 3), although the differences between these results and those from the other models estimated suggest the relationship between partnerships and regulatory agencies is undoubtedly more complex. In the unrestricted ZINB model that includes this variable in both equations, it is significant in the count portion of the model, but actually increases rather than decreases the number of partnerships. Given these opposite effects in the two stages of the model, enforcement is understandably insignificant in the negative binomial model without

[5] As a precautionary note, the alternative ZINB model that includes the agricultural runoff variable in both equations is significant and in the right direction in the count equation of the model, but insignificant in the logit equation. Thus, all three models we tested indicate that agricultural runoff has a significant impact on partnerships, but the models do not provide a clear answer to whether the impact is more important in determining the opportunity for partnership development or the number of partnerships to be developed. The variable probably reflects both benefits and transaction costs and is best conceptualized as an indicator of the net benefits of partnerships.

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zero-inflation. At the very least, these differences require caution in our conclusions and reiterate the need for further research in this unexplored area. However, the results also illustrate an interesting theoretical possibility. The existence of active command-and-control institutions may indeed reduce the initial benefits of watershed partnerships, as indicated in Table 2. Once the partnership process is in motion, however, active regulatory agencies may perceive partnerships as a useful tool not only for increasing the social pressures to comply with permit requirements, but also for solving environmental problems that were previously beyond the reach of command-and-control policies. An active partnership and active regulatory agency may well complement each other.

On the other hand, none of the indicators of state environmental policies significantly hinders the formation and development of partnerships. While innovative state policies might reduce the need for partnerships, the lack of effects suggests that they, or the political climate that produces them, may also stimulate more partnerships. For example, active state programs such as Florida's ecosystem management program and California's Natural Communities Conservation Planning are specifically designed to publicize the benefits and encourage the organization of ecosystem management teams (Wheeler 1996). Further research is needed to disentangle these two possibilities.

Among *political incentives*, the significant impact of the size of the agricultural sector confirms the contractual perspective hypothesis: opposition from dominant agricultural interests decreases the partnership incidence rate by 10 percent and decreases the activity rate by a much larger 34 percent (Table 3). The resistance of agricultural communities is not surprising given the importance of agricultural runoff for stimulating partnership formation. These results, combined with the insignificant impact of the alternative farm concentration variable, are inconsistent with the capture theory hypothesis that dominant agricultural interests create partnerships to avoid regulatory controls.[6] The percentage of mineworkers does not affect the incidence rate, indicating that agriculture is the most widespread extractive industry affecting watershed partnerships.

Overcoming Transaction Costs

Results from the negative binomial equation confirm that *institutional support* as well as *characteristics of actors* have significant effects on the number of partnerships that form in favorable niches. The institutional support provided by prior partnerships significantly enhances the number (13 percent) and activity level (10 percent) of post-1990 partnerships, confirming the importance of prior institutional patterns in the evolution of collective-action institutions (North 1990). However, the prior-neighbors variable was not significant, suggesting that previous partnerships have little of the spillover effects that have been found in state-level policy diffusion studies. Existing partnerships within a watershed provide models and establish relationships that later partnerships can follow, but these may be too dependent on local factors to help neighboring partnerships.

Money provides critical institutional support to collective-action problems. Transfer payments from the state and the federal government to local governments within the watershed significantly increase the number and activities of partnerships, although local transfer payments do not. State transfers (26 percent) have a much stronger effect than federal transfer payments (19 percent) on partnership numbers—if money matters, then more money may matter more, since per capita transfers from states are almost ten times the size of federal aid (Table 1).

Neither the ideological persuasion of Congressional representatives as measured by LCV nor the percentage of public water/sewer users had significant impacts on partnerships. In sum, institutional support appears to be specialized—prior partnerships and money help, but neighboring partnerships, pro-environmental attitudes, and potentially complementary institutions do not.

Two characteristics of actors have the expected strong, significant effect on partnerships. An increase in per capita income increases the partnership incidence rate by 37 percent, the largest effect in the model. The indicator of high educational/occupational status is not significant in Table 2 due in part to the high correlation ($r= .59$) with income, but is positive and significant in models that exclude per capita income. Both income and education/occupational status provide the human resources for reducing transaction costs, although income appears to be a better indicator. Conversely, an increase in the percentage of blacks and Hispanics in the watershed communities decreases the partnership incidence rate by 15 percent and 31 percent, respectively. More resources clearly improve the possibility of collective action, while the heterogeneity and low resource levels associated with minority populations have the opposite effect. On the other hand, the percentage of state natives does not have significant effects on partnerships. To the extent our coarse measure of population stability does not adequately capture the concept of a "sense of place," this hypothesis requires further research.

[6]We checked two alternative measures of concentration: the percent of farms over 1000 acres and the number of agricultural workers per farm. Neither significantly affected the partnership incidence rate.

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Overall, inspecting the relative magnitude of the effects (Table 3) for both benefits and transaction costs reveals two main themes. First, the relatively large effects of the runoff indicators and the negative effect of NPDES enforcement activities suggest the benefits of partnerships are primarily related to their comparative advantage for addressing the "unfinished business" of environmental policy, where command-and-control institutions are not appropriate for the problem (nonpoint pollution) or because they are ineffective in implementation.

Second, the large effects of monetary resources like per capita income and intergovernmental transfers suggest that having the resources necessary to overcome transaction costs is a key to the supply of new institutions. This finding reflects the common observation among partnership participants of a positive correlation between funding and partnership success (Kenney et al. 2000; Yaffee et al. 1996). High socioeconomic status as measured by per capita income or education/occupation provides the transaction resources necessary to negotiate new agreements and is correlated with the human and social capital inherent in educational and occupational advancement. Lower levels of human and social capital may prevent minority populations from developing the ability to overcome transaction costs in resisting environmental harms under both the status quo and the partnership agreements. One normative implication of this research is that the development of watershed partnerships exhibits the same problems of environmental justice associated with command-and-control approaches—benefits accrue primarily to those who are already better off.

Conclusion

Let us return then to our opening question: why is the policy process moving toward cooperative, decentralized institutions, and what factors make these solutions viable? We have argued that partnerships emerge because of their comparative advantage over command-and-control institutions in responding to the increasingly acute, unresolved problems of local natural resource management. The disillusionment with state and federal alternatives among both environmental and economic interests has provided a niche for the emergence of decentralized institutions that encourage cooperation among divergent interests. We have shown that both the mounting environmental problems in watersheds and the weakness of existing institutions to manage those problems increase the emergence of watershed partnerships.

However, since common interests do not necessarily lead to common action (Olson 1965), partnerships will not emerge automatically in response to potential benefits. We show that partnerships increase most rapidly in number and activities in homogenous watersheds with the stocks of human, social, and financial capital (from internal or external sources) necessary to overcome the transaction costs of building new institutions.

From a broad political science perspective, the growth of cooperative institutions provide a research site for analyzing alternatives to federal command-and-control agencies that evolve to resolve collective-action problems and for testing key propositions derived from the contractual approach to the study of politics. From the policy perspective, the factors affecting the growth of watershed partnerships suggest advantages and disadvantages inherent in cooperative institutions. Partnerships are more likely to emerge in watersheds facing dispersed pollution problems that are difficult to solve with command-and-control policies, particularly where the agricultural community is not too strong to resist new environmental policies. However, watershed partnerships are not globally efficient solutions to *all* environmental collective-action problems, only those well suited to the cooperative governing style of partnerships. Partnerships are complements and not substitutes for existing command-and-control policies, which have lower transaction costs for more traditional water quality concerns like point-source pollution. In short, even if partnerships are effective in improving environmental outcomes, as many experts claim, they do not provide a magic bullet for solving all environmental problems.

While the environmental impact of watershed partnerships awaits empirical verification, if partnerships do prove effective in managing conflicts over local resources and providing more conservation at less cost, they may become a valued and permanent part of the American mélange of political institutions. But unlike the constitutionally based authority of other political institutions, the reliance on cooperation is likely to guarantee a short life for partnerships that cannot produce positive outcomes and clear benefits for all major participants. For example, agricultural interests might try to use partnerships to undermine attempts to impose new regulations, and they are likely to be less willing to voluntarily implement best management practices if the threat of state and federal regulations is not present. Similarly, environmental and recreational groups might continue to press for more stringent state and federal regulations and tougher enforcement to enhance gains obtained from the partnership agreements. To the extent competing advocacy coalitions revert to the mutually

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harmful behavior of past regulatory battles, partnership solutions to collective-action problems are self-limiting.

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Appendix
List of Variables

This list is organized by the factors influencing benefits and transaction costs in Table 1. The five main sources of data (and acronyms used to identify them in the following list) are the 1997 dataset of watershed partnerships assembled by the Conservation Technology Information Center (CTIC), EPA's *Index of Watershed Indicators* (IWI), the *1990 Census of Population* (Census), the *1992 Census of Government Finance: Counties* (1992 CGFC), and EPA's *NPDES Permit Compliance System* (PCS).[7] The first two data sources use the eight-digit watershed as the basic data unit. For the remaining data sets, we convert data from other geographic units into the watershed equivalent by using MABLE, a widely used geographic correspondence engine created by the U.S. Census Bureau specifically for such conversions.[8] Signs in parentheses indicate expected direction of influence on incidence rate of watershed partnerships.

Dependent Variables: Watershed Partnerships and Activities

Partnerships: A count of the number of post-1990 partnerships registered in the watershed on the CTIC dataset as of mid-1997. (Pre-1990 partnerships are used as an independent variable.) The partnership count excludes partnerships that report education as their only activity, in order to address the argument that education partnerships are not as important as others. Furthermore, regional projects that cover more than one watershed are "assigned" to each watershed, so the count of projects by watershed is actually higher than the total number of individual projects identified by CTIC. Unreported analyses show that neither the inclusion of regional projects nor the exclusion of education-only projects changes the sign or significance of any reported coefficients.

CTIC initially identified partnerships through interviews with federal and state officials followed up by extensive interviews with identified partnerships. Partnerships are also added via Internet self-nominations, extensive searches using state and Federal agency contacts, and annual inquiries of known partnerships about other candidates. To insure the quality of the database (CTIC, personal communication), CTIC screens out those candidates that are not engaged in partnership activities. For example, environmental interest groups are purposely excluded because they represent stakeholders, not partnerships. Not surprisingly, Sabatier (2000) demonstrates that concentrated efforts in limited geographic areas can locate additional partnerships not in the CTIC database. Because resource limitations are the main reason for the undercounting, we expect that the undercounting is random and hence will increase standard errors but otherwise not bias our results. Our research sacrifices the accuracy affordable in regional data for the generalizability provided in a national database. Both levels of study are important to provide robust analyses.

Activities: A sum of the number of activities listed for each partnership in the watershed, following the same restrictions as for *Partnerships*.

Features of Watersheds Affecting Benefits

Problem Severity

Adverse Ecosystem Conditions (+): A composite index created by EPA to measure the objective environmental conditions in a watershed. The index includes data on meeting designated use standards (i.e., fishable, drinkable, swimmable—these components receive the greatest weight in the overall indicator), fish and wildlife consumption advisories, indicators of source water condition for drinking water systems, contaminated sediments data from sampling stations, ambient water quality (cadmium, copper, lead, mercury), and a wetland loss index. Higher numbers represent increasing environmental problems. Source: IWI

Agricultural Runoff (+): A composite index created by EPA that consists of three components: a nitrogen runoff potential, sediment delivery to rivers and streams, and pesticide leaching/runoff. Source: IWI

Urban Runoff (+): Percent of land area per watershed that has greater than 25 percent imperviousness. Impervious-

[7]For additional information on the IWI, see http://www.epa.gov/iwi/. The data in this paper is based on the October 1998 release of the IWI. We utilized EPA's Integrated Data for Enforcement Analysis (IDEA) system to gather the PCS enforcement data. See http://es.eps.gov/oeca/idea for more information on IDEA and the PCS.

[8]Using the 1990 United States Census population count as a weighting variable, MABLE calculates the percentage of a particular geographic area (the source geographic unit) that falls into a watershed (the target geographic unit). For example, given a single county (or census block group) that crosses two watershed boundaries, MABLE will produce a weighting variable that represents the proportion of the county population that falls into each HUC. Information from each source unit is then multiplied by the corresponding weight, and then aggregated at the watershed level to produce an overall watershed characterization. For further information on MABLE, see the Census internet site http://www.oseda.missouri.edu/plue/geocorr/htmls/geocorr3.html.

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ness reflects land development that replaces absorbent soils with pavement and cement. Source: IWI

Population Density (+): EPA calculation of population density measured in 1000s of people per square mile. High population density reflects intensive use of ecosystem services. Source: IWI

Active NPDES Permits (+): Average number of active NPDES permits per watershed from 1990 to 1996. Source: PCS

Institutional Opportunities

Integrated Agency (–): Dummy variable for states that have integrated pollution control and natural resource functions into one agency. Source: Author Internet search, *Guide to State Environmental Program* (Bureau of National Affairs 1994).

Ecosystem Management (–): Dummy variable for states that have an ecosystem management program. Source: Author Internet search.

Wetlands Program (–): 1991–1992 Green Index (Hall and Kerr 1991) indicator of states that have laws protecting inland or freshwater wetlands.

NPDES Primacy Time (+): Number of years after 1972 Clean Water Act was passed before state clean water program receives primacy, or EPA authorization to administer the National Pollution Discharge Elimination System (NPDES) point source permitting program. States without primacy receive maximum value. Source: EPA

NPDES Enforcement (–): Mean number of enforcement actions per active discharge permit between 1990–1996. Source: PCS

Water Debt (+): Total per capita debt for water utilities, measured in dollars. Source: 1992 CGFC

Political Incentives

Agriculture (– for contract hypothesis, + for rent-seeking hypothesis): Percentage of employed people over sixteen in the ecosystem in agricultural occupations, including farming, forestry, and fisheries. Source: 1990 Census

Mining (– for contract hypothesis, + for rent-seeking hypothesis): Percentage of employed people over sixteen working in the mining industry. Source: 1990 Census

Farm Concentration (+ for rent-seeking hypothesis): Percentage of farms with annual sales greater than $200,000 in 1992. This measure is less subject to regional differences in the size of farms than the alternative available measure of farms over 1,000 acres, although there is no difference in our analyses from using either of these concentration measures. Source: 1992 Census of Agriculture.

Features of Watersheds Affecting Transaction Costs

Institutional Support

Prior Partnerships (+): number of pre-1990 partnerships that exist in a given watershed, as determined by the date of inception reported in the CTIC data set. The pre-1990 partnerships are not counted in the dependent variable.

Prior Neighbors (+): number of ecosystem partnerships that existed prior to 1990 in the six-digit accounting unit (the next highest level in the USGS hierarchy) that contains the eight-digit watershed. There are 352 six-digit accounting units ranging from 125 square miles to 47,100 square miles.

Federal Aid (+): Percent of per capita county revenue from Federal sources. Source: 1992 CGFC

State Aid (+): Percent of per capita county revenue from State sources. Source: 1992 CGFC

Local Aid (+): Percent of per capita county revenue from local intergovernmental transfers. Source: 1992 CGFC

LCV 1993-1994 (+): A continuous [0,100] scale that measures the mean environmental activism of all 103rd Congress members representing any portion of the watershed, using the League of Conservation Voter scores on important environmental legislation. 100 equals maximum environmental support.

Public Water/Sewer (+): Index that averages two measures: (1) Percentage of total households using public sewerage, and (2) Percentage of total households using centralized public or private drinking water supply systems (as opposed to individual wells). Alpha= .88. Source: 1990 Census

Characteristics of Actors

Per Capita Income (+): Per capita income, measured in thousands of dollars. Source: 1990 Census

High Education/Occupation (+): The census categories of education, professional occupations, and finance sector occupations are highly correlated. We average the percentage in each category in the watershed. Education is represented as the percentage of people over twenty-five with graduate or professional degrees. Professional occupation is the percentage of employed people over sixteen in the watershed with executive, administrative, managerial, professional specialty occupations, and related support occupations. Finance occupations are the percentage of people over sixteen in the watershed working in finance industries. Alpha = .69. Source: 1990 Census

Black (–): Percentage of population who are black. Source: 1990 Census

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Hispanic (−): Percentage of population who are Hispanic. Source: 1990 Census

State Natives (+): Percentage of population born in state of residence. Note that this does not measure within-state mobility. Source: 1990 Census

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