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# The Science-Natural Resource Policy Relationship: How Aspects of Diffusion Theory Explain Data Selection for Making Biodiversity Management Decisions

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*This study extends a previous project which examined the salience of neo-institutional theory in explaining how data are selected for use in making and implementing biodiversity management decisions. Our prior findings prompted us to examine the selection of data from federal, state or local, and nongovernmental sources using aspects of diffusion theory. We argue that diffusion theory also possesses explanatory value regarding the identification and selection of data within a natural resource agency. We empirically test our theory by analyzing original data collected from a 2007 survey of U.S. Fish and Wildlife Service field offices. We find that drivers of diffusion identified by previous research are explanatory of how data are selected. Specifically, perceptions of other field offices' data selection procedures and collaboration with interest or advocacy groups aid in explaining field office data selection. The results enhance our understanding of the science-natural resource policy relationship.*

**Keywords:** Environmental Policy, Biodiversity Management, Best Available Science, Diffusion Theory, Interest Groups, Advocacy, Science, Natural Resource Policy, U.S. Fish and Wildlife Service.

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*Este estudio expande la investigación de un proyecto anterior que examinó la importancia de la teoría neoinstitucional para explicar cómo se seleccionan los datos para tomar e implementar decisiones de manejo de biodiversidad. Nuestros hallazgos previos nos llevaron a utilizar aspectos de la teoría de la difusión para examinar la selección de datos tanto, de los distintos niveles de gobierno, como de fuentes nogubernamentales. Argumentamos que la teoría de la difusión también posee valor explicativo para la identificación y selección de datos dentro de una agencia de recursos naturales. Ponemos a prueba nuestra teoría mediante el análisis de datos originales de una encuesta de las oficinas de campo del Servicio Estadounidense de Peces y Vida Salvaje publicada en el 2007. Encontramos que los motores de la difusión identificados en nuestra investigación previa son importantes para explicar cómo seleccionar datos útiles para la hechura de decisiones del manejo de la biodiversidad. Los resultados amplian nuestra comprensión de la relacion entre la ciencia y las politicas de recursos naturales.*

Science is undeniably intertwined with natural resource policy. Federal policy directives aim to strengthen science-policy ties, particularly with regard to the use of *best available science* (see Institute for Regulatory Science 2013) in making and implementing policy. The Endangered Species Act of 1973 requires consultation of the "best scientific and commercial data available" when making threatened or endangered species designations (U.S. Senate 1973). The National Standard Two of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 offers a similar mandate in requiring that conservation and management efforts rely on "the best scientific information available" (U.S. House 2006). On the agency level, the U.S. Environmental Protection Agency (EPA) stresses the use of *best available science* in implementing the Clean Water Act of 1972 (US EPA 1997, cited by Sullivan *et al*. 2006, 460). However, the *best available science* standard faces continual scrutiny (see McBride 2009), is often described as poorly defined and ambiguous (Bisbal 2002; Meyer 1998; Mills *et al*. 2009; Ryder *et al*. 2010; Sullivan *et al*. 2006), and a disconnect exists between the ideal use of science in making and implementing natural resource policy and our understanding of the science-policy relationship.

Further complicating the science-natural resource policy relationship is the voluminous amount of data and information available to natural resource professionals. Biologists, analysts, and managers working within federal and state natural resource agencies have their choice of various datasets, reports, and tools with which to arrive at a ground-level implementation decision related to a particular policy directive. Prior to its January 15, 2012 termination,[1] the National Biological Information Infrastructure (NBII) served as a "broad, collaborative program to provide increased access to data and information on the nation's biological resources" (UC Davis 2012). NBII, overseen by the U.S. Geological Survey (USGS), provided a database which linked biological data, information, and decision-support tools provided by federal, state, and local natural resource agencies and nongovernmental organizations for use in making biodiversity management decisions. Most federal and state natural resource agencies were NBII partners, as were many environmentally focused nongovernmental organizations. Even if browsing has been made less convenient with the termination of NBII, those same sources of biological information remain available to natural resource professionals as they implement policy directives and make ground-level biodiversity management decisions. Thus a compelling question arises. Given the ambiguity of the *best available science* standard and the plethora of data available to biologists and other natural resource professionals, how are data identified for use in making biodiversity management decisions?

This article is an extension of our earlier research that empirically tested the explanatory value of neo-institutional theory in describing how data are selected for use in making biodiversity management decisions (Gerlach, Williams, and Forcina 2012).[2] In the previous study, we found that data selection among U.S.

[1] The FY 2012 federal budget mandated the termination of NBII (USGS 2011).

[2] The average citizen identifies *biodiversity* as species richness or the number of species in a system (Simberloff 1999). For the purposes of this article, we employ the USFWS definition of *biodiversity*: "the variety of life and its processes, including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur" (USFWS 2012). Thus a *biodiversity management decision* is any decision made which protects,

Fish and Wildlife Service (USFWS) field offices can be explained by the neo-institutional tenets of normative isomorphism[3] and path dependency.[4] The normative isomorphism component of those findings led us to believe that certain aspects of diffusion theory may also be salient in explaining data selection for use in making biodiversity management decisions. Specifically, normative isomorphism refers to the adoption of actions based on perceptions of what has been deemed successful by others within a particular community. This phenomenon exists at the core of diffusion theory (Berry and Berry 1999). However, diffusion theory expands on the idea by also accounting for the pursuit of competitive advantage and response to advocacy in adopting a particular innovation (Berry and Berry 1999; Daley 2007; Martin 2001; Mintrom and Vergari 1998; Sapat 2004). Therefore, the current study expands upon the previous research by empirically testing aspects of diffusion theory as explanatory factors of data selection.[5] This line of research offers theoretical and practical contributions to our understanding of the science-natural resource policy relationship. From a theoretical perspective, the current study tests tenets of diffusion theory in a new realm, the natural resource policy process, which adds to our understanding of diffusion and the process of human decision making. Practically, this study provides a greater understanding of how and why data are selected for use in making biodiversity management decisions. Rather than a blind reliance on the standard of *best available science*, an objective study of data selection can only aid in our understanding of how science affects natural resource policy.

Though this study examines data selection among USFWS field offices, the results of our research are of value on a global scale. Habitat and biodiversity management problems are similar globally to what we witness in the United States. Wetland management is a crucial issue in South America (Junk 2013), Australia (Finlayson *et al.* 2013), and Russia (Robarts, Zhulidov, and Pavlov 2013) just as it is in the United States. Concern for climate change and global warming exists globally as well, as various mitigation efforts are under way, and much research is devoted to scenario modeling and planning (Betts *et al.* 2011; Hulme and Dessai 2008; Moss *et al.* 2010). Some advocate for increased

preserves, and promotes this variety of life. These decisions are typically made as part of the implementation of a specific policy directive, but are also made by biologists, analysts, and managers as stand-alone, ground-level management decisions which are scientifically supported and necessary.

[3] *Normative isomorphism* refers to a homogeneity which exists among organizations as a result of the perception that established decision-making practices have been sanctioned by other successful decision-making entities within a particular community (Meyer and Scott 1992).

[4] *Path dependency* is the phenomenon of adherence to institutionalized methods of action which makes undergoing change too costly for an organization (Pierson 2000).

[5] We use the same dataset in the current study as we did in the previous one, though we test a different set of hypotheses using a different set of independent variables that specifically measure aspects of diffusion theory. See the “Methods” section of this article.

science-policy integration through environmental impact assessment (Portman *et al.* 2012), while others advocate for increased public engagement in environmental decision-making processes (Tsouvalis and Waterton 2012). Regardless of the approach, science is at the forefront of environmental and natural resource policy making on every continent. Though governmental institutions differ, the selection of data for use in making and implementing natural resource policy decisions is not unique to the United States. Therefore, we feel that the results of this research are of value to international comparative scholars in the field of resource policy and management, as well as of relevance to practitioners in areas of the world outside the United States.

The remainder of the manuscript proceeds as follows. First, we review briefly how data are typically used to make biodiversity management decisions. Second, we present an alternative means by which to understand data selection for use in making biodiversity management decisions through the lens of diffusion theory. Next, we detail the methods used in the empirical analysis of our theory. Finally, we present the results of our data analysis followed by a discussion of those results and a brief conclusion.

## Using Science to Make Biodiversity Management Decisions

Environmental law scholar Fred Bosselman (2004, 366) states, "that the environmental and scientific issues implicated by the word 'biodiversity' are very important, and should be considered in decision-making, but that the word biodiversity alone lacks the precision needed for a workable legal standard." Indeed, there are many facets to biodiversity and the task of managing for it. In the area of fisheries management, the "best scientific information available" mandate of the National Standard Two of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (U.S. House 2006) services as a policy directive related to the role of science in informing management decisions. However, a means by which "best scientific information" is identified is not presented in the National Standard Two (Vellucci 2007). Though Sullivan and others (2006) offer a tremendous guide for identifying *best available science*, Vellucci (2007, 282) asserts, "[t]o comply with this requirement, fishery managers must determine what constitutes the 'best available science.' " Thus data used in making biodiversity management decisions related to fisheries is often selected at the implementation, or agency, level.

Congressional legislation related to managing for biodiversity is somewhat limited, with the Endangered Species Act of 1973 arguably being the most famous of all congressional acts on the issue. While policy directives flow from the Endangered Species Act, a tremendous amount of autonomy exists among natural resource professionals related to the implementation of those directives. For example, the standard of *best available science* is endorsed in the Endangered Species Act (U.S. Senate 1973). However, the identification of what constitutes *best available science* is often a ground-level implementation decision in the area of threatened or endangered species protection.

In making everyday biodiversity management decisions related to species, habitat, and ecosystem level management, USFWS biologists and analysts often serve their managers as scientific advocates.[6] These biologists, analysts, and managers realize the importance of selecting reliable data when making such decisions, and they take the task seriously. While *best available science* is the common standard by which these data are selected, we argue there is more to the understanding of data selection. Ultimately, *best available science* is a political construct that aims for the objective reliance upon sound science in making environmental and natural resource policy decisions. We believe a thorough understanding of the science-policy relationship includes explaining *how* data are selected to inform decisions, a recipe which is missing from most *best available science* directives (Ryder *et al.* 2010; Sullivan *et al.* 2006; Vellucci 2007). As an extension of our previous research, we believe aspects of diffusion theory deserve careful consideration as explanatory mechanisms related to data selection for making biodiversity management decisions.

## Diffusion Theory and Data Selection Practices

In a previous study, we empirically tested the salience of select tenets of neo-institutional theory in explaining data selection. We found that normative isomorphism and path dependency are viable theories for explaining this phenomenon. However, we perceive enough similarities in normative isomorphism and certain aspects of diffusion theory to warrant empirically testing the latter as well. For example, normative isomorphism occurs as a result of the perception that established decision-making practices have been sanctioned by other successful decision-making entities within a particular organizational community (Meyer and Scott 1992). Berry and Berry (1999) found that adoption occurs based on three motives, one of which is copying what has been successful elsewhere. After empirically confirming the value of normative isomorphism in explaining data selection for use in making biodiversity management decisions, the next logical step is to test the aspects of diffusion theory that share some of the same principles.

Everett M. Rogers' (1962) classic book, *Diffusion of Innovations*, is widely regarded as the seminal work on diffusion theory. Rogers (1962, 5) defines *diffusion* as "the process by which an innovation is communicated through certain channels over time among members of a social system." Rogers (1962, 12) defines an *innovation* as an "idea, practice, or object that is perceived as new by an individual or other unit of adoption." Diffusion of innovations requires

[6] Roanoke-Tar-Neuse-Cape Fear Biologists Committee (led by Wendy Stanton), interviewed by John Gerlach, Pocosin Lakes National Wildlife Refuge, Columbia, NC, August 22, 2005.

four elements: (1) innovation; (2) communication system; (3) social system; and (4) time (Rogers 1962).

A common theme among diffusion literature is research conducted on state adoption of innovative federal programs or policies. Sapat (2004) suggests that four factors affect state adoption of national innovations: (1) severity of the policy issue; (2) importance of the institutional factors involved; (3) interest group roles; and (4) contextual factors. Sapat (2004) asserts that agencies adopt innovations that deal with problems created within their realm of expertise. States are also more likely to adopt innovative policy initiatives if all stakeholders are included in the policy process (Sapat 2004). Berry and Berry (1999) add that states will adopt policy initiatives based on three motives: (1) copying what has been a success elsewhere; (2) seeking competitive advantage; and (3) responding to citizen pressure.

A federal natural resource agency provides an ideal laboratory within which to study aspects of diffusion theory as it pertains to the natural resource policy process. With specific regard to data selection practices, Rogers' (1962) four required elements are satisfied: (1) a particular data source serves as the innovation; (2) field office interaction with other field offices, natural resource agencies, or outside entities serves as a communication system; (3) the natural resource community serves as a social system; and (4) time is an element of any policy process. The structure of the USFWS is a primary reason the agency is a logical setting for this research. Much USFWS work is done in field offices across the nation (USFWS 2012). These field offices include 551 National Wildlife Refuges, 70 National Fish Hatcheries, 65 fishery resource offices, 86 ecological services field stations, and thousands of small wetlands and other management lands (USFWS 2012). Service biologists are expected to play an integral role in the natural resource policy-making process by making policy and implementation recommendations based on biological information selected for use by the field office (personal communication, August 22, 2005). Thus, due to the presence of Rogers' (1962) elements of diffusion and the critical role the USFWS plays in managing for biodiversity and implementing legislation such as the Endangered Species Act, the agency provides a tremendous venue for studying aspects of diffusion and their influence on the science-natural resource policy relationship.

### The Influence of Surrounding Field Offices

Diffusion theory literature offers significant insight into the impact of surrounding organizations on organizational decision making. Research shows that state governments are heavily influenced in policy adoption processes by the actions of surrounding states (Daley 2007; Grossback, Nicholson-Crotty, and Peterson 2004). Daley and Garand (2005) assert that states are precisely in tune with the pressures indirectly applied by the successes or failures of surrounding states to either implement or scrap similar policies. Elazar (1972) suggests that state policy makers see nearby states as experimental laboratories for policies, viewing neighboring states as a critical source of information in overcoming the obstacle of policy uncertainty. Clemens (1998) agrees, having found that reform-minded administrators often use states as "experiment stations."

We argue the same general approach is taken by USFWS field offices when selecting data for use in making biodiversity management decisions. We assert that service field offices copy data selection practices which have been proven successful in other field offices within the agency, a very similar approach to Berry and Berry's (1999) explanation of state-to-state policy adoptions. USFWS field offices may even treat others as data selection laboratories, waiting to assess the value of biodiversity management decisions made using particular data sources before selecting those sources themselves. Of course, these data selection practices may well be based more on perception than reality. Therefore, we test the following hypothesis to determine the influence of other field offices on USFWS field office data selection.

> Hypothesis 1: Field office data selection is positively associated with the perceived source of data other field offices are using for making their own biodiversity management decisions.

**The Influence of Advocacy on Data Selection**

Research on the role of interest groups in the diffusion of innovations indicates a positive relationship between advocacy and adoption (Daley 2007; Martin 2001; Mintrom and Vergari 1998; Sapat 2004). It is difficult to find an aspect of government or public administration today that is devoid of interest or advocacy groups. The question of how much policy influence an interest group is capable of exerting is often at the forefront of policy-making processes. Nicholson-Crotty and Nicholson-Crotty (2004) find that advocacy groups with significant access to decision makers can affect policy rather easily. Martin (2001) found the diffusion of municipal ordinances to be aided significantly by interest groups. Mere association with interest groups and various policy networks has been shown to allow policy entrepreneurs the opportunity to determine how and when to best present their ideas and impact policy (Mintrom and Vergari 1998).

Such advocacy is no stranger to the science-natural resource policy relationship. Ground-level natural resource policy and implementation decisions are often reached through collaborative efforts (Brunner *et al.* 2005; Thomas 2003). These collaborations open windows of opportunity for external data producers to influence the policy and implementation process. Natural resource agencies and their field offices are often willing to enter these collaborations. Collaborative efforts allow an agency or field office to share data and other resources thus reducing operating costs (Thomas 2003). These arrangements also encourage community-based initiatives designed to solve natural resource problems at the local level (Brunner *et al.* 2005).

We argue that diffusion and adoption influences pertaining to advocacy play a significant role in the natural resource policy process, particularly during the data selection phase. There are many sources of biological information available to policy makers. NBII surpassed the 100 partners benchmark in 2004, with the number of separate visitors to the NBII website surpassing three million in 2010 (USGS 2011). Those visitors downloaded an average of one terabyte of data monthly (USGS 2011). Many NBII partners continue to produce biological data in the absence of the program. Their data marketing efforts are noticeable and often impactful among biologists, analysts, and managers (personal communication, August 22, 2005). Mohr (1969) argues the likelihood of adoption of an innovation increases with higher levels of organizational motivation. Given the voluminous amount of data available to USFWS field offices and evidence of data marketing and motivating efforts within the natural resource community (Lackey 2007; Scott *et al.* 2007), we hypothesize that marketing efforts and collaboration with suppliers of biological information influence the data selection practices of USFWS field offices. This practice is consistent with the diffusion theory tenet of advocacy influencing adoption, which has been empirically confirmed in other public policy areas and within different levels of government (Daley 2007; Martin 2001; Mintrom and Vergari 1998; Nicholson-Crotty and Nicholson-Crotty 2004; Sapat 2004). We aim to replicate these results within a natural resource policy venue by examining the following two hypotheses.

> Hypothesis 2: Data marketing efforts are positively associated with the selection of a particular data source for use in making biodiversity management decisions.[7]

> Hypothesis 3: Collaboration with a nongovernmental data producer (interest or advocacy group) is positively associated with the selection of nongovernmental data for use in making biodiversity management decisions.[8]

Theoretically, the selection of data for use in making biodiversity management decisions is partially shaped by the influence of external factors, or other adopters. These other adopters may be other USFWS field offices or external data producers collaborating with, or marketing data to, the field office. While diffusion theory has traditionally been studied within the context of the adoption of innovative policies, we believe certain aspects of the theory are salient in explaining data selection. We empirically test our hypotheses using an original survey of USFWS field offices.

[7] We test hypothesis two using all three dependent variables. In addition to typical interest or advocacy groups, federal, and state/local agencies have also been reported to market data products to USFWS field offices.

[8] We test hypothesis three using only the *nongovernmental data frequency of use* dependent variable. We do so because collaboration with an interest or advocacy group on policy issues typically implies working with nongovernmental entities. We aspire to determine the influence of this collaboration on the selection of nongovernmental data.

## Methods

Data were collected through an original web-based survey of 557 USFWS field offices conducted in 2007. The 557 targeted field offices were painstakingly selected via a thorough review of the USFWS agency website, opinions of wildlife and fisheries biologists, and the recommendations of agency administrators. Field offices were selected for inclusion in the study if they qualified as offices that make ground-level biodiversity management decisions. This criterion excluded law enforcement field offices and most upper-level management offices. Surveyed field offices include national wildlife refuges, national fish hatcheries, and ecological services stations. Each field office in our sample received instructions that one employee, preferably a biologist, should answer and return the survey on behalf of the entire office.

Survey response rate in this study was 36.6 percent. Some 204 of 557 USFWS field offices completed the survey. Our response rate was significantly aided by the endorsement of the then-Science Advisor to the USFWS Director. Of the 204 responses spread across all eight regions of the USFWS, 9 percent came from Region 1 (Pacific), 11 percent Region 2 (Southwest), 17 percent Region 3 (Great Lakes-Big Rivers), 25 percent Region 4 (Southeast), 16 percent Region 5 (Northeast), 14 percent Region 6 (Mountain-Prairie), 3 percent Region 7 (Alaska), and 5 percent Region 8 (California-Nevada). Survey response was not significantly different from what would be expected based on the actual distribution of surveyed field offices by region.[9]

### Variables and Measures

We used the same survey instrument in the current study as was employed in our previous research.[10] The survey was constructed based on consultation with USFWS professionals, review of the NBII database, and a modest pilot study. The pilot study asked 55 faculty members within the College of Natural Resources at North Carolina State University to comment on variable measures and survey flow. The purpose of the pilot study was to assure face and content validity. Data were collected on three dependent variables and seven independent variables for use in this study. We also employed control variables to account for regional differences in USFWS field office decision making.

*Dependent variables*. Data selection was measured by asking participants to rate the frequency with which they use federal, state or local, and nongovernmental data sources.[11] We asked the question, "When selecting

[9] A chi-square goodness of fit test confirmed that no significant difference existed (p = .56).

[10] See Gerlach, Williams, and Forcina (2012).

[11] The federal, state or local, and nongovernmental categories were chosen based on natural groupings of NBII partners. Prior to NBII termination, the program included partners identified as governmental organizations, nonprofits, and private sector entities (Kutner and Giles 2006).

data, how frequently does your field office use the following data sources in making biodiversity management decisions?" Participants were given a seven-point scale (1 = never, 2 = rarely, 3 = annually, 4 = quarterly, 5 = monthly, 6 = weekly, 7 = daily) and asked for one response per data source. This survey item measured our data selection dependent variables *federal data frequency of use, state or local data frequency of use*, and *nongovernmental data frequency of use*. We also collected data for the importance level participants attach to each data source. However, there was very little variance in the responses for each data source. An initial review of the data provided us with the confidence that frequency of use reflects actual data selection more accurately than perception of importance. Importance levels appear biased upward, which makes intuitive sense. USFWS professionals may attach greater importance to federal data, even if they do not use it as often as other sources.

The dependent variables contain a wealth of information regarding the frequency of data usage. One alternative to test our hypotheses is to estimate traditional ordinary least squares models; unfortunately, this would require making assumptions that the intervals between adjacent categories (i.e., "Weekly" and "Daily") are equal, which might lead to misleading results (Long 1997). A more appropriate alternative for our purposes is an ordered logit, which estimates the probability that the USFWS field office chooses any of the mutually exclusive categories of data usage. This approach takes advantage of the considerable variation in the dependent variables without making unreasonable assumptions. Nevertheless, there are very few field offices that choose "Never" when discussing the frequency of use of that data source (federal: 1.8 percent, state/local: 1.8 percent, nongovernmental: 2.2 percent). Since the lack of variation at lower levels would make it extremely difficult to retrieve accurate estimates of those outcomes, we transform the original measure so that Never and Rarely are in one category and Annually and Quarterly are in another category. This maintains the value of ordered responses while still allowing us to explain the more frequent uses of data, which is of greater theoretical importance for this project.

*Independent variables*. To test our three hypotheses, we measured the perceived source of data used by other field offices for making biodiversity management decisions, marketing efforts of data suppliers, and collaboration with nongovernmental data producers. The perceived source of data used by other field offices variable (*other field office data source*) was measured by the following survey question.

- "The adoption of data is important in making biodiversity management decisions. When your field office is adopting data, how influential is the following?"

Participants were asked to rate "data sources used by other U.S. Fish and Wildlife Service field offices" on a 10-point scale where 1 = Unimportant and

10 = Important. These data were used to test hypothesis one related to the influence of other field offices on data selection practices.

To study the potential effects of data marketing on data selection, we used the independent variables *federal agency data marketing efforts, state or local agency data marketing efforts*, and *nongovernmental data marketing efforts*. These variables were measured by asking participants to rate the frequency with which federal, state or local, and nongovernmental agencies/organizations market data to their field office. The following survey item was administered.

- "In general, how frequently do the following market their data products to your field office?"

Participants were asked to answer for each data source using a six-point scale (1 = never, 2 = rarely, 3 = annually, 4 = quarterly, 5 = monthly, 6 = weekly). A category for daily was not presented, as daily marketing efforts are extremely rare or even unrealistic.

Our third hypothesis was tested using independent variables related to frequency of collaboration with nongovernmental data producers (*confer w/ nonprofit organizations, confer w/ private sector businesses*, and *confer w/ academic institutions*) as a measure of interest or advocacy group pressures. Frequency of collaboration with each nongovernmental entity was assessed by the following question.

- "How often does your field office confer with the following when making biodiversity management decisions?"

In keeping with a similar pattern as our previous assessments of frequency, participants were asked to respond for nonprofit organizations, private sector businesses, and academic institutions using a seven-point scale (1 = never, 2 = rarely, 3 = annually, 4 = quarterly, 5 = monthly, 6 = weekly, 7 = daily). These variables measure the intensity of working relationships between field offices and nongovernmental data producers/suppliers.

*Controlling for region*. Some regional differences among USFWS field offices exist in the types of ground-level policy or implementation decisions with which they are faced and the species and habitats they are charged with managing. To account for the potential influence of these regional differences on data selection when making biodiversity management decisions, we assessed *Service region* via the following survey item.

- "To which region of the U.S. Fish and Wildlife Service does your field office belong?"

Respondents were asked to select from the eight regions of the agency (Pacific, Southwest, Great Lakes-Big Rivers, Southeast, Northeast, Mountain-Prairie, Alaska, California-Nevada). Region names are set by the USFWS. To control for the possibility that some regions use data sources in a manner unexplained

**Table 1. Summary Statistics**

| | Min. | Max. | Mean | Std. Dev. |
|---|---|---|---|---|
| Data frequency of use: Federal | 0 | 4 | 2.20 | 1.25 |
| Data frequency of use: S/L | 0 | 4 | 1.85 | 1.17 |
| Data frequency of use: NG | 0 | 4 | 1.6 | 1.17 |
| Other field office data source | 1 | 10 | 7.83 | 2.03 |
| Data marketing efforts: Federal | 1 | 6 | 2.83 | 1.48 |
| Data marketing efforts: S/L | 1 | 6 | 2.37 | 1.18 |
| Data marketing efforts: NG | 1 | 6 | 2.55 | 1.31 |
| Confer W/ Nonprofit Organizations | 1 | 7 | 3.26 | 1.44 |
| Confer W/ Private Sector Businesses | 1 | 7 | 2.79 | 1.50 |
| Confer W/ Academic Institutions | 1 | 5 | 3.98 | 1.30 |

by our model, we estimate each ordered logit with dichotomous variables representing each region (California-Nevada serves as the reference category).

We provide the summary statistics for all these variables in Table 1.

## Statistical Analysis and Results

Our theory suggests that data selection in making natural resource policy can be explained by a number of tenets related to diffusion theory. To control for the possibility that different regions will exhibit different levels of usage frequency due to varying patterns of diffusion, we estimated ordered logit models with regional fixed effects. We present the ordered logit estimation results for the three models of frequency of data usage in Table 2.

None of the regional fixed effects coefficients are statistically significant at conventional levels. This may seem unexpected given that diffusion patterns at the subregional level may cause the field offices within a region to use a specific data source more or less often than other regions. However, these insignificant coefficients are reassuring in that they suggest that there are no regional patterns of data usage that are unexplained by our model.

The first hypothesis states that field offices that perceive other field offices to be influential in their data selection practices are more likely to mirror the practices of others across data sources. The expectation here is that the coefficient for *other field office data source* will be positive in all three of the models for different data sources. The results are consistent with our first hypothesis, as the coefficient is positive and statistically significant (at the 95 percent confidence level or higher) for each of the three data sources. This indicates that considering the data sources used by other USFWS field offices as more important makes a field office more likely to frequently choose a particular data source in their biodiversity management decisions. Since the effects are nonlinear, it is often difficult to assess the true substantive impact of a variable

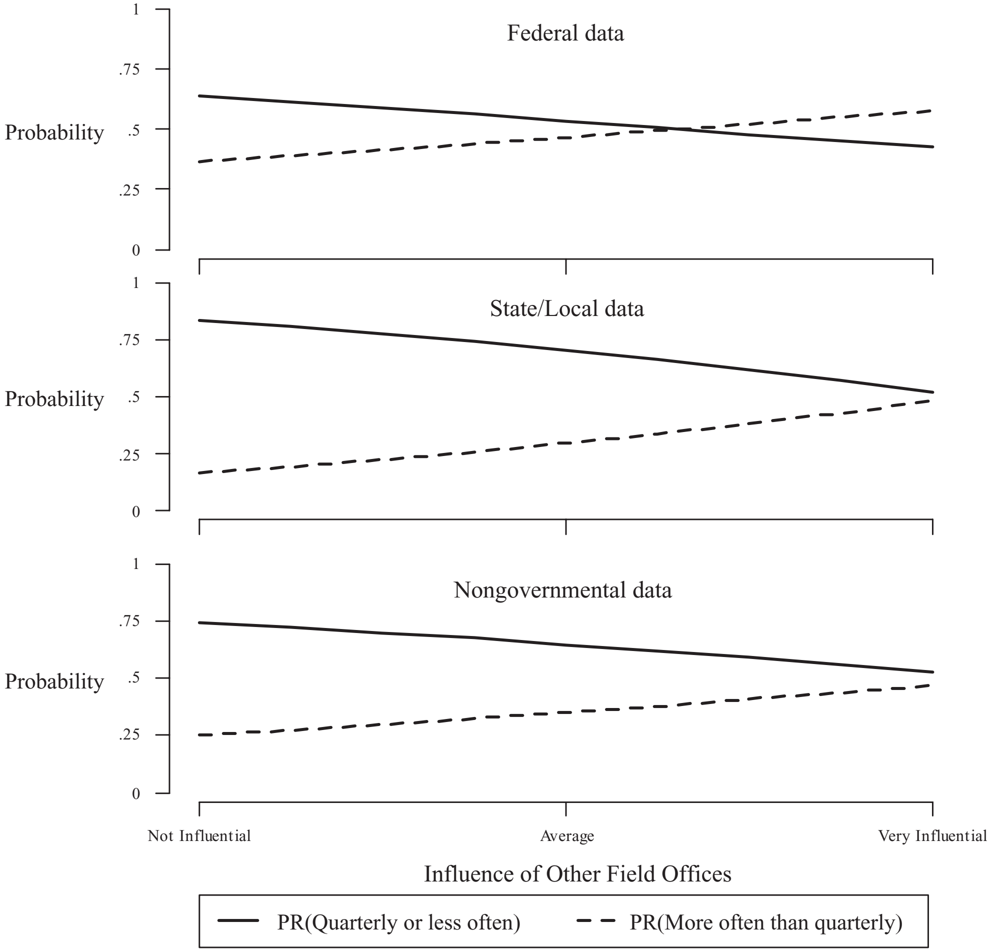
**Table 2. Ordered Logit Results for Frequency of Data Usage for Federal, State/Local and Nongovernmental Data**

| | Federal | State/Local | Nongov't |
|---|---|---|---|
| Other Field Office Data Source | .12** | .21*** | .13** |
| | (.07) | (.07) | (.07) |
| Data Marketing Efforts: Federal | .06 | | |
| | (.09) | | |
| Data Marketing Efforts: S/L | | .25** | |
| | | (.11) | |
| Data Marketing Efforts: NG | | | −.11 |
| | | | (.12) |
| Confer W/ Nonprofit Organizations | | | .47*** |
| | | | (.13) |
| Confer W/ Private Sector Businesses | | | .16 |
| | | | (.12) |
| Confer W/ Academic Institutions | | | .55*** |
| | | | (.15) |
| Pacific | 1.00 | 1.05 | .77 |
| | (.62) | (.66) | (.65) |
| Southwest | .72 | .22 | .44 |
| | (.61) | (.64) | (.62) |
| Great Lakes-Big Rivers | .81 | .83 | .48 |
| | (.58) | (.62) | (.59) |
| Southeast | .47 | .43 | .08 |
| | (.57) | (.61) | (.59) |
| Northeast | .38 | 1.07 | .22 |
| | (.59) | (.63) | (.61) |
| Mountain-Prairie | −.13 | .15 | −.14 |
| | (.63) | (.67) | (.63) |
| Alaska | −.06 | .41 | −.78 |
| | (.79) | (.78) | (.86) |
| $\tau_1$ | −1.04 | .31 | 3.07 |
| | (.76) | (.76) | (.86) |
| $\tau_2$ | 1.03 | 2.83 | 5.33 |
| | (.75) | (.79) | (.92) |
| $\tau_3$ | 1.83 | 3.83 | 6.68 |
| | (.75) | (.81) | (.96) |
| $\tau_4$ | 3.03 | 5.11 | 8.52 |
| | (.77) | (.83) | (1.03) |
| Observations | 189 | 190 | 185 |
| Log Likelihood | −283.7 | −266.7 | −233.9 |
| Pseudo-$R^2$ | .02 | .04 | .16 |

*Notes*: *** p-value < .01, ** p-value < .05, * p-value < .1. Standard errors in parentheses.

on the outcome of interest simply by examining the coefficients. Instead, we present Figure 1, which shows how the cumulative probability of using that data source quarterly or less often (solid line) or more often than quarterly (dashed line) changes as one varies the influence of other field offices.

**Figure 1.**
**Probability of Choosing Each Data Source More or Less Often than Quarterly across Values of *Other Field Office Data Source***




If one considers other field offices as noninfluential (far-left side of the horizontal axis), then that office is much more likely to rarely choose to use a particular data source. It is important to note that the biggest difference between these two values occurs with state/local data, where the probability of using state/local data quarterly or less often is .85, and the probability of more frequent usage is .15. As a field office considers other field offices more influential (a move along the horizontal axis), then that office becomes much more willing to frequently use each of the three data sources. In the Federal model, if a field office considers other field offices as very influential, then the probability of frequently using federal data exceeds the probability of rarely using federal data. This figure provides clear evidence in favor of the first hypothesis, as it appears as though field offices copy the data selection procedures of other field offices that have been proven successful.

Our next hypothesis is that direct marketing efforts will encourage the use of specific data sources. To measure this aspect of diffusion, we asked participants to answer how frequently the data source was marketed to their field office, with values ranging from 1 (never) to 6 (weekly). Our expectation is that the data source-specific *Data Marketing Efforts* variable will be positive and statistically significant in each model, indicating that marketing efforts encourage the frequent use of that data source. We find inconsistent evidence in favor of this hypothesis, as the coefficient for *Data Marketing Efforts* is statistically significant only in the state/local model. This would suggest that marketing efforts are more influential in encouraging the use of state/local data sources than either federal or nongovernmental. Substantively, the effects of marketing efforts on the frequency of state/local data usage are quite large when we consider the change in probabilities of selecting the various frequency outcomes. For example, increasing the *Data Marketing Efforts (state or local agency)* variable from 1 (never) to 6 (weekly) decreases the probability of rarely or never using state/local data by .11, and increases the probability of using state/local data daily by .10.[12]

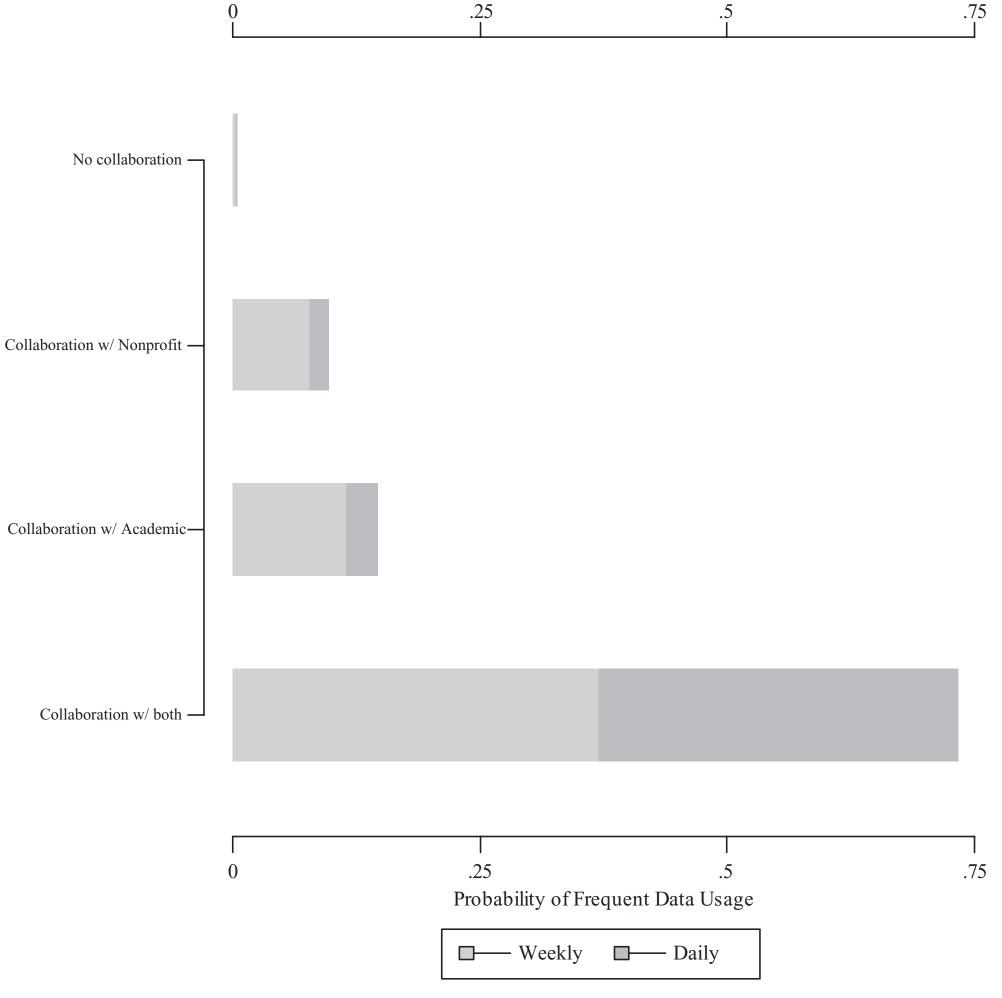
Our final hypothesis addresses an aspect of diffusion that is specific to the usage of nongovernmental data. We hypothesized that collaborating with a nongovernmental data producer (an interest or advocacy group) would be positively associated with using nongovernmental data in biodiversity management decisions. We measure the frequency of collaboration with three nongovernmental data producers: nonprofit organizations, private sector businesses, and academic institutions.

The results in the final column of Table 2 suggest that collaboration with these nongovernmental entities is an important determinant in the frequency of nongovernmental data usage. In fact, according to the pseudo-$R^2$, our explanatory model (with the inclusion of the collaboration variables) explains the variation in frequency of nongovernmental data usage better than the other two models. More specifically, frequently collaborating with nonprofit organizations and academic institutions (though not private sector businesses) makes field offices more likely to frequently use nongovernmental data sources. To better illustrate the substantive effects of data collaboration, we present Figure 2.

Figure 2 presents the probability of using nongovernmental data sources weekly (light gray shade) and daily (dark gray shade) for four different scenarios

[12] These differences are statistically significant at the 95 percent confidence level: [–.28, .01] and [.01, .27].

**Figure 2.**
**The Effects of Collaboration with Interest or Advocacy Groups on the Frequency of Nongovernmental Data Usage by U.S. Fish and Wildlife Service Field Offices**




of collaboration efforts.[13] The first scenario represents a case where the field office never confers with either nonprofit or academic institutions when making biodiversity management decisions. Understandably, the probability of using nongovernmental data on a weekly or daily basis is quite small (.003 and .0006, respectively). Frequently collaborating with only nonprofit organizations

[13] The other explanatory variables are held at their modes, and the region is set as the excluded category (California-Nevada).

increases the probability of frequently using those data sources (.08 and .02, respectively), as does collaborating with only academic institutions (.12 and .03, respectively). The scenario where a driver of diffusion (Daley 2007; Martin 2001; Mintrom and Vergari 1998; Sapat 2004) has by far the largest substantive impact is when the field office frequently collaborates with both nonprofit and academic institutions. In this scenario, the probability of frequently using nongovernmental data—either weekly or daily—skyrockets to .37 and .36, respectively. This would suggest that conferring with these other two sources substantially increases the willingness for field offices to use nongovernmental data.

## Discussion

In our previous study, we found the neo-institutional tenet of normative isomorphism to be explanatory of data selection practices among USFWS field offices (Gerlach, Williams, and Forcina 2012). Our prior research proved that field offices select data for use in making biodiversity management decisions, in part, based on their desires to use natural resource community-sanctioned data sources. Data selection practices are also explained by the neo-institutional phenomenon of path dependency (Gerlach, Williams, and Forcina 2012). Substantively, this finding means that USFWS field offices are likely to continue selecting data sources which have served their needs in making past biodiversity management decisions. The results of our current study offer additional insight into understanding how field offices select data, a core component of the science-natural resource policy relationship.

Aspects of diffusion theory explain data selection as well. Based on the work of Daley (2007), Grossback, Nicholson-Crotty, and Peterson (2004), and Daley and Garand (2005), we expected to find that other USFWS field offices exert influence on the data selection process of a particular office. Our empirical analysis confirmed this hypothesis. We also expected to find that data marketing efforts of outside entities and collaboration with nongovernmental data producers influence data selection among USFWS field offices. While empirical support for the influence of data marketing efforts was limited, collaboration with nongovernmental data producers is influential in the process, particularly with regard to selecting data from nongovernmental sources. This result supports previous findings by Daley (2007), Martin (2001), Mintrom and Vergari (1998), and Sapat (2004) that interest or advocacy groups play a significant role in adoption of an innovation, or, in the case of our research, a data source.

Our findings indicate that data selection for use in making biodiversity management decisions is reliant on the social construction of which data sources are deemed acceptable by others. The standard of *best available science*, which seeks to accomplish the objective use of the best-known scientific and biological information to inform policy and implementation decisions, is ambiguous

(Bisbal 2002; Meyer 1998; Mills *et al.* 2009; Ryder *et al.* 2010; Sullivan *et al.* 2006). It thus appears that USFWS field offices seek exogenous assistance in selecting data. Perhaps this is the mechanism by which field offices identify what they *perceive* to be "best available" science and information. Aspects of diffusion theory tell us much about this process. We know that field offices are influenced by the data preferences of offices around them, and they give considerable credence to the data of nongovernmental producers with which they collaborate in the biodiversity management process. This social construction of which data are deemed acceptable and useful comes as no surprise. These findings are consistent with an abundance of research conducted on the sociology of science, which contends the social construction of acceptable science involves a formulation, verification, and perception process which struggles for objectivity given the subjective nature of humanity (Astley 1985; Latour and Woolgar 1979; Ziman 2000). This theory exists in direct contrast to any objective identification of *best available science*, which is why data selection is more accurately explained by tenets of neo-institutional theory and the aspects of diffusion theory examined in this study. The current findings have theoretical, practical, and potentially global implications with regard to the selection of data for making and implementing biodiversity management decisions.

**Theoretical Implications**

The primary theoretical contribution of this study relates to our understanding of the science-natural resource policy relationship. While the particular role of science and the scientist in the environmental and natural resource policy process is debated (Lackey 2007; Meine and Meffe 1996; Noss 2007; Scott *et al.* 2007; Shrader-Frechette 1996), the *value* of science to the process is not questioned. Rather, politicians and policy makers have paid considerable attention to molding and mandating the use of science in making and implementing policy, as evidenced by policy directives such as the *best available science* standard. We argue that a crucial first step to better understanding the science-natural resource policy relationship lies in explaining how science and biological information are identified and selected as worthy of informing the policy process.

Diffusion theory appears to have explanatory power with regard to data selection. While the current research is not a traditional diffusion of innovations study as set forth by scholars such as Jack Walker (1969), there is value in initially examining how *aspects* of diffusion theory are salient in describing the data selection process. Two key aspects of diffusion theory, the influence of surrounding entities and the effects of advocacy on the adoption of an innovation, provide an alternative lens through which we may view the data selection process. Through this lens, we see that the data selection process cannot be fully understood without considering the various influences of outside entities on data selection. Those outside entities may be other natural resource agency offices, nongovernmental collaborators, or both. This study empirically confirms that a political construct such as *best available science* is insufficient to our understanding of how data are selected in reality. Rather, a deeper examination of accepted theory, such as aspects of diffusion, offers considerable insight into our understanding of the science-natural resource policy relationship.

A secondary theoretical implication of this study is the further empirical confirmation of the merits of diffusion theory, its various tenets, and its far-reaching application in the realm of public policy. While diffusion theory has been proven quite valuable for understanding the public policy process on multiple fronts (Berry and Berry 1999; Daley 2007; Daley and Garand 2005; Elazar 1972; Grossback, Nicholson-Crotty, and Peterson 2004; Martin 2001; Mintrom and Vergari 1998; Rogers 1962; Sapat 2004; Walker 1969), the current study offers a look at diffusion of innovations in a different policy realm, the natural resource policy process. Karl Popper (1959) defined a scientific truth as one that can be regularly reproduced. By establishing the value of diffusion theory in explaining data selection for making and implementing biodiversity management decisions, this study provides another empirical confirmation of the salience of the theory advanced by Everett Rogers (1962) over 50 years ago.

**Practical Implications**

From a practical standpoint, the results of our study offer two potentially helpful insights. First, in proving that USFWS field office data selection is influenced by surrounding offices and nongovernmental collaborators, we show that field offices seek external assistance in identifying optimal, or even *best available*, data for adoption into their biodiversity management processes. While this can serve as a mechanism by which data are brought to the attention of field offices—data that may go otherwise undiscovered. Relying too heavily on the influence of outside entities can be problematic. For instance, selecting data which are not as well aligned with the localized nature of a particular biodiversity management decision as another data source may cause a field office to overlook data which are more appropriate to the situation. A hallmark of the USFWS is its presence in virtually every corner of the United States and its territories. The agency operates local field offices, in part, because biodiversity management is a task that is inherently different in various areas of our geographically diverse nation. A recommendation to natural resource professionals may be to remain vigilant in allowing surrounding field offices and nongovernmental collaborators to inform data selection practices without driving the process past data which are more appropriate and perhaps *best available* to the localized biodiversity management problem.

A second practical implication of our work is closely tied to the first. Reliance upon the influence of outside entities can potentially lead to overusing these field offices and nongovernmental data producers as means of lowering information costs. Anthony Downs (1957) suggested that individuals attempt to reduce information costs by relying on others to process information for them. With regard to USFWS field office data selection, a Downsian approach may lead to an inappropriately heavy reliance upon others to inform the office which data are best for their particular biodiversity management decisions, a determination that should ultimately rest with the individual field office or natural resource professional. Herbert Simon (1947) warned that humans have a tendency to *satisfice*, or make decisions based only on the information that is readily available at the time without accounting for outcome probabilities, historical assessments, and so on. A practical recommendation of our work is that natural resource professionals steer clear of a Downsian approach or the urge to satisfice when making data selection decisions. The input of outside entities, while valuable, may work best in determining optimal science when it is considered alongside many other factors unique to the particular biodiversity management issue being addressed. In essence, *best available science* may not merely be what is popular elsewhere.

**Global Implications**

Without making any leaps that our data are not prepared to support, we would be remiss if we failed to point out the potential for cross-national implications of the current research. Environmental issues are being addressed all over the world on various levels of government. In particular, climate change is a pressing issue which relies upon the use of sound science for making and implementing mitigation policy. On the international level, the Intergovernmental Panel on Climate Change continues to produce data that are used by various levels of government around the world to inform climate policy (Ravindranath 2010). The results of our research are not exclusively applicable to U.S. natural resource agencies. Rather, on issues such as climate change and more localized environmental and natural resource problems, the identification and application of reliable science to the policy-making and implementation process is imperative. While some environmental issues differ as a result of geography, many issues are similar globally to ones faced in the United States. For example, the management of wetlands is critical in South America (Junk 2013), Australia (Finlayson *et al*. 2013), and Russia (Robarts, Zhulidov, and Pavlov 2013). Therefore, the selection of appropriate data for use in addressing these problems is quite important, and aspects of diffusion theory provide an avenue by which we might better understand data selection practices cross-nationally.

Regardless of governmental structure or environmental or natural resource policy issue, the lessons of the current study apply. Portman and others (2012) examined the performance of eight countries on mechanisms of integrated coastal zone management, including environmental impact assessment. This is a global process discussed often in the United States in relation to various environmental issues. As some of the same mechanisms for environmental management that are used in the United States are being employed globally, the process by which data are selected to inform these management and implementation decisions is equally important around the world. Aspects of diffusion theory may provide a lens by which to more fully examine the global science-policy relationship. However, further research is necessary to link the lessons of the current study to international environmental and natural resource management.

## Conclusion

While the current study offers additional insight into the science-natural resource policy relationship, it is not without limitations. However, three main limitations of the current study can easily be tied to areas for future research. First, data limitations prevented a full-scale diffusion study as outlined by Walker (1969). A future study might examine the diffusion of a particular data source or set through USFWS field office channels, accounting for all aspects of diffusion theory including the ones addressed in this article. Second, our study examined data *sources* (federal, state or local, nongovernmental) as categorized by natural NBII groupings. Future research might examine the diffusion of datasets, which provides a more focused exploration of how data are used to inform biodiversity management decisions. While data source selection can provide initial insight into how aspects of diffusion theory affect the science-natural resource policy relationship, studying the selection of specific datasets may allow for more telling results as USFWS field offices may use multiple datasets from the same source. Finally, this area of research is ripe for comparative exploration cross-nationally. Data limitations prevent us from making any broad comparisons between how data are selected in the United States versus other nations, but we do believe the results of the current study potentially apply outside U.S. borders. A future study might compare data selection drivers cross-nationally and test the salience of diffusion theory in explaining the phenomenon globally.

In spite of some limitations, the results of the current study offer a significant contribution to the current literature on natural resource governance and administration and its practice. This study empirically confirms the salience of aspects of diffusion theory in explaining how data are selected for use in making and implementing biodiversity management decisions. Given the abundance of literature devoted to understanding and defining policy directives such as the standard of *best available science* (Bisbal 2002; Meyer 1998; Mills *et al*. 2009; Ryder *et al*. 2010; Sullivan *et al*. 2006), we are pleased to add to the literature an alternative view of *how* data are selected and science is used in making biodiversity management decisions. While additional research is warranted to fully understand data selection, aspects of diffusion theory should not be ignored in describing the nature of the science-natural resource policy relationship.

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