Informing the Debate

Determinants of Complex Policy:

Understanding the role of science in public policy

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A key puzzle in the study of politics is the collective process by which policy decisions are made. This process is seldom simple or straightforward in part because the issues facing policy makers and citizens are multifaceted. Of course, the degree and source of this complexity varies dramatically across policy arenas. Although some policy disputes are rooted in underlying conflicts and ambiguities of values; the policy process is often driven by what appear to be questions of information or fact. Debates occur about both the underlying nature of an alleged "problem" as well as the likely impact of a proposed policy. Nowhere is the role of facts and information more prominent than environmental policy. The existence of an environmental threat is generally framed in language of scientific risk and the design of policies embedded in the language of science.

Although there is an enormous extant literature on the social and political impact of science and technology, there is remarkably little direct research on how scientific information actually diffuses into the policy process. The value of understanding the process is clear to anyone interested in fostering either better policy or better science. This report the preferences for three topical policy issues held by a random sample of residents in the state of Michigan. These include: climate change, directional oil drilling (specifically with respect to potential drilling under the Great Lakes) and efforts to control Asian carp. These cases provide an interesting range of environmental issues including physical (directional drilling), chemical (climate change) and biological (Asian carp). While these issues are obviously quite diverse they nevertheless share some important attributes. Each issue:

- Has high political salience and visibility in the State of Michigan.
- Carries significant economic implications
- Involves significant questions of science and technology as well as political preference
- Represents an issue that Michigan policy makers will need to confront in the next decade

Table 1 presents the specific text used to measure public opinion on each of these issues.

Table 1:
Policy Issue Questions and Allowable Responses

Climate Change	There has been much debate in recent years about global climate change and its causes and effects. Do you think there is: (1) Strong scientific evidence that the earth's climate is changing (2) Some scientific evidence (3) Little or no scientific evidence that the earth's climate is changing?
	Is global climate change (1) A direct result of human activity (2) A result of both human activity and naturally occurring changes in the environment (3) A direct result of naturally occurring changes in the environment?
Asian Carp	There has also been debate about the possible effects Asian Carp may have on the Great Lakes eco-system. Do Asian Carp represent (1) A serious threat (2) Somewhat of a threat (3) Little or no threat to the Great Lakes and its eco-system?
	Should preventing Asian Carp from reaching the Great Lakes be a high priority, a moderate priority, or a low priority for state and federal authorities? (1) a high priority (2) a moderate priority (3) a low priority for state and federal authorities?
Oil Drilling in Lake Michigan	Geologists are confident that there are significant oil reserves under Lake Michigan. Which of the following best describes your position on drilling for oil under the Great Lakes? (1) Drilling for oil poses little or no risks to the Great Lakes (2) There some risks associated with drilling for oil, but probably worth the risks (3) Drilling under the Great Lakes poses significant risks
	It has been proposed to use directional drilling, where the oilrig is located on-shore and the well is drilled at an angle to reach the oil, instead of using off-shore oil rigs which drill a vertical well. Do you think on-shore directional drilling is (1) Much safer (2) Somewhat safer (3) Not at all safer than off-shore vertical drilling

These issues present two interesting characteristics that make them particularly useful for studying the link

between scientific information and policy preferences. First, there exists a broad scientific consensus about each issue. Thus, few scientists doubt the existence of climate change; most see directional drilling as carrying less environmental risks than "standard" off-shore drilling, and the introduction of Asian carp into he Great Lakes is generally regarded as a significant ecological threat.[1] In contrast to this scientific consensus, these issues often divide citizens and policy makers. Conservatives are most likely to be skeptical of the science that underlies claims about climate change. Those on the left are thought more likely to reject claims about the safety and desirability of directional oil drilling. The controversy over Asian carp (at least within the state of Michigan) seems relatively free of ideological connotations.[2] This report not only considers the variance within citizen preferences, but will examine those factors associated with this variance. Of particular interest are possible explanations for individual preferences that are inconsistent with scientific consensus.

The Nature of Scientific Information

Numerous scholars have noted a general limitation of science in policy formation given the lack of certainly in scientific findings (Mickwitz 2003). Jasanoff (1987) focuses on how decision-making in the policy process constrains the use of scientists and scientific knowledge in environmental and public health arenas. The higher the uncertainty of science, the more important political factors become. Jasanoff also points out the significance of explaining the scientific reasoning behind policy decisions to the public. The public is not always well informed on issues, particularly when those issues are highly technical. It is noted that scientists are often brought in at the beginning of the decision-making process. Interestingly, it is the political actors rather than the scientists who must explain and interpret technical data to a policy audience.

There is no question that science does not extinguish political controversy (Jasanoff 1996; Sarewitz 2004). It is equally clear that scientific research is itself influenced by the political decision-making process (Haller and Gerrie 2007). Sarewitz (2004) argues that politics exacerbates scientific uncertainty, even when a

[1]This is not to suggest, of course, that there is a similar body of evidence that points to an appropriate policy response.
[2]This variation is of particular importance in understanding any particular issue (such as climate change) since it is essentially to "control" for any prior partisan or ideological bias among citizens and policy makers if one is to understand political decision making.

great deal of scientific information is available. Sarewitz goes so far as to say that new scientific knowledge only strengthens the debate over environmental issues. For example, Kraft and Vig (1997) note that environmental legislation passed in the 1970's was passed largely in the absence of significant empirical evidence for many of the claims put forth by those supporting the legislation. They assert that a political consensus around values and beliefs led to passage rather than new scientific information. Oreskes (2004) argues that the goal of science is not to prove or disprove, but to build consensus through a great deal of research. The use of science in creating environmental policy includes an unreasonable standard of proof. Despite controversies over science this does not preclude action by the policy community. For example, Alario (2000) finds that sustainable planning in Chicago was implemented even while a debate over the science underpinning the plan continued.

Some observers argue that the impact of science on policy is further constrained by the dependence of science on the economic elites. Lambright (1985) argues that such elites typically fund science and thus the scientific information utilized in public policy will be constrained by the interested that supported it. Blissett (1972) interviewed scientists from various institutions to get a broader understanding of how science is conducted and to what extent scientists interact with policy communities. He found that scientists largely prefer a system where their work is outside of government supervision. However, the fact that scientists are quite often dependent on funding by businesses or government ultimately has an impact on scientific autonomy. Tisdell (1981) developed case studies of policy priorities of several countries. He argues that when government funded science is typically applied to primary policy goals.

Studies concerning the interaction between scientists and various institutions of government are not abundant though there are exceptions. Schooler (1971) notes the strong ties between scientists and the executive branch, but finds a more ad hoc relationship between scientists and Congress, the states, and cities. Rich (1981) notes the importance of norms and attitudes when it comes to the interaction between the research community and policy makers. The notion of scientific uncertainty clearly emerges here. Rich argues that the use of knowledge is highly dependent on whether the decision makers and scientists are under similar cultural norms. He adds to this framework by including an analysis of bureaucratic decision-making. How the bureaucracy operates has an important impact on how information is utilized and disseminated. The flow of informa-

tion can be hindered or expanded depending on how staff and gatekeepers in the bureaucracy translate information.

Farrell et al. (2001) note the importance of credibility, legitimacy and relevance when it comes to how scientific experts are involved in policy decisions. These three aspects are very dependent on the context of the policy. Farrell et al. (2005) create a set of contextual characteristics that will change how scientists and policy makers or stakeholders interact. Among those characteristics are key components including the goal, capacity, treatment of uncertainty and framing of the policy. Universities can also have tight bonds with policy communities. For example, Shapely and Roy (1985) identify a close working relationship between the agricultural industry and universities; however, the authors tend to leave out a discussion of the relationship between governments, industries and universities.

The Public and Scientific Information

It is well recognized that the public often lacks significant substantive knowledge about political issues. In addition, findings show that individuals can only have so much understanding of the world around them because of a limited capacity to do so (Simon 1947, 1983). Public opinion research argues that citizens hold very low levels of political sophistication (Campbell et al. 1960; Converse 1964). On average citizens do not pay particular attention to politics and do not have strong opinions on most issues. Technical issues in particular can be confusing to the public and may generate inconsistent attitudes. Through a long-term panel study Miller (2004) has shown a relatively low level of scientific literacy in the United States. Other scholars have identified gender differences in the perception of science, with men having more favorable attitudes. One possible source of this difference lies in the lower level of scientific knowledge among women (Hayes and Tariq 2000).

The direct link between scientific information and policy preferences is unclear. Doble (1995) examines the ability of the public to form reasonable opinions on highly technical issues. He conducted an experiment using two complex issues: global warming and disposal of solid waste. Respondents are surveyed before and after receiving information about the topics. Their policy preferences were then compared to those scien-

tists working in a related field. Results indicate that after individuals are briefly educated about these complex policies their views are very similar to the views of scientists. While this provides evidence that the public is capable of assimilating technical information, it is not clear what independent impact such information might have on policy preferences.

Public opinion research has made clear that core values are an important organizing structure (Feldman 1988; Goren 2001, 2004). This leads to questions over which values are tapped in the case of highly technical or "scientized" issues. Gamble and Kassardjian (2008) find a set of values that individuals rely on when considering biotechnology including: general health of society, conservation, and ethics. An important consideration involving scientific information and knowledge is that knowledge appears to merely reinforce pre-existing values and beliefs (Collingridge and Reeve 1986; Nelkin 1975, 1979). If an individual is predisposed to believe in climate change new scientific findings will only reinforce this belief. In addition, if their value system leads them to dispute climate change they will continue to find science that calls into question the reality of global warming. Individuals can use facts to reconcile their beliefs (Schon and Rein 1994). Ludwig et al. (2001) note the strong relationship between facts and values and conclude that science cannot be removed from the broader cultural context.

Leiserowitz et al (2006) examine values that lead to attitudes in favor of sustainability. They find that values associated with a shared responsibility and equity lend themselves to favorable attitudes around sustainability issues. Individualism, on the other hand, can lead to consumerism, which tends to have negative consequences for sustainability.

Despite, the possibility that the public at large is ill informed on scientific issues several authors argue for their participation in science policy. Through a series of essays and case studies on nuclear policy and biomedical policy, Peterson (1984) argues for citizen involvement in these policy areas. He agrees that public participation can hamper or delay policies and projects, though Peterson argues the importance of democratic decision-making overrides this concern. Eden (1996) argues that environmental policy needs a built-in component for public education. He contends that environmental policy will ultimately be unsuccessful without public participation and understanding.

Debates surrounding options in environmental policy have become increasingly complex and can often be difficult for both the public and policy maker to understand. For instance, climate change can be viewed through a multitude of perspectives (Sarewitz 2004). Scientific information is being utilized to implement public policy in a variety of ways, though this complexity makes it easy for critics to find areas of so-called scientific uncertainty. Technical problems like climate change, stem-cell research, brownfield policy and other areas that concern information provided by the scientific community can be challenging to explain and create policy around. Bradshaw and Borchers (2000) note the different characterizations of scientific uncertainty for lay individuals and policy makers as compared to the scientific community. As noted above, the former are seeking certainty, while the latter are looking for consensus building. Collingridge and Reeve (1986) make the argument that the policy process' use of science can be harmful to both policymakers and scientists. The scientific method yields conclusions that are not absolute. Politicians often attempt to utilize science as an absolute to push forward their ideas. Ultimately debates over technicalities present in scientific research occur and science becomes politicized. Harman et al (1998) writes from the perspective of the environmental and social scientist, arguing that there will be difficulty in separating science and ethics. It is not always clear where the line is drawn when bringing uncertain scientific knowledge into the context of policy formulation and implementation. Pielke (2004) argues that science has become politicized. For instance scientists are becoming increasingly concerned with obtaining certain political outcomes and less concerned with scientific learning.

Science and Environmental Policy

Scholars have identified the prominence of scientific information in developing policy to address environmental problems (see Fisher 2000; Hannigan 1995). One can see science utilized in the agenda setting process. For example, when the federal government passed policy regarding the depletion of the ozone layer science was what brought the policy to the governmental agenda in the first place (Mickwitz 2003).

Tunistra (2008) provides an international case for how scientists and policy makers work together on two programs: the United Nations Economic Commission for Europe Convention on Long Range Transboundary Air Pollution (UN ECE LRTAP) and EU Clean Air for Europe Programme (CAFE). The author points out

the difficulty of pinpointing a precise role for scientists and policy makers in the process. Through a series of interviews conducted with scientific experts, stakeholders, and political figures the authors find that scientists are hired to work directly with policymakers. Tunistra also finds that issues of uncertainty within the scientific community play a significant role in policy formation. Similarly, Gusfield (1975) indicates that scientific information has played an important role in drug policy formation.

Weible et al (2004) are interested in how science was utilized in the policy planning to establish protected marine areas in California. The authors discuss the different approaches by the National Research Council in integrating scientific findings and experts into policy. Initially the council espoused a linear approach whereby scientists would conduct research that was then presented to stakeholders. This has since changed to a more interactive approach, with stakeholders brought into the process at multiple junctures to insure that needs and concerns are being addressed. Through their case studies the authors find that when it came to the Marine Life Protection Act scientists were directly involved in the process from the beginning with little to no citizen input. After a plan was created it was presented to the citizenry and was received with outrage. In a second attempt the scientists worked in conjunction with stakeholders including citizens, government officials, and interest groups, resulting in a more successful policy attempt.

Brunner et al. (2005) discusses the concept of adaptive governance (AG). AG examines collaborative decision-making and argues for community-based initiatives to solve collective action problems. Scientists, the public, and community officials work together in concert through the formulation and implementation of public policy. Brunner's has generated several case studies including issues with endangered species, watershed programs, forestry concerns at the national stage, among others, to demonstrate how these community based initiatives work. The collaborative nature is again successful in these policy areas.

Science and Policy: Citizen Response in Michigan

While the literature on the link between policy and science describes a complex and indirect relationship, the popular view, at least for environmental policy, is much more straightforward. Citizens in Michigan were asked if "we could do a better job protecting the environment if scientists had a greater role in the design

and implementation of environmental programs." An overwhelming majority of respondents (over 83%) either strongly agreed or somewhat agreed with this statement. The clear implication here is that citizens would favor a science-based approach to the design and implementation of environmental policy.

Table 2
Should Scientist have Greater Role in Environmental Policy?

QUESTION: WE COULD DO A BETTER JOB PROTECTING THE ENVIRONMENT IF SCIENTISTS HAD A GREATER ROLE IN THE DESIGN AND IMPLEMENTATION OF ENVIRONMENTAL PROGRAMS.			
	N	Percentage	Cumulative Percentage
Strongly Agree	326	34.7	34.7
Somewhat Agree	455	48.4	83.1
Neither Agree Or Disagree	12	1.3	84.4
Somewhat Disagree	88	9.3	93.8
Strongly Disagree	59	6.2	100.0

Citizen responses also reveal that environmental policy remains a highly salient issue. Citizens were asked whether "protecting the natural environment should be a high government priority." As shown in Table 3 almost 92% of all respondents expressed some measure of

Table 3
Should Protecting The Natural Environment Should Be A High Government Priority?

QUESTION: PROTECTING THE NATURAL ENVIRONMENT SHOULD BE A HIGH GOVERNMENT PRIORITY.			
	N	Percentage	Cumulative Percentage
Strongly Agree	583	61.7	61.7
Somewhat Agree	283	30.0	91.7
Somewhat Disagree	36	3.8	95.5
Strongly Disagree	42	4.5	100.0

agreement with this statement. Taken together Table 2 and Table 3 predicts that where scientific consensus on environmental issues exists, public opinion should support strong public action framed within that consensus.

Experience suggests, however, that such a straightforward link will seldom exist. Indeed, Table 4 shows that the apparent unambiguous commitment to public efforts to protect the environment is, in fact, severely constrained by other values. Full 92% of all respondents express some

Table 4
Should efforts To Protect The Environment Must Be Balanced With Economic Impact?

QUESTION: EFFORTS TO PROTECT THE ENVIRONMENT MUST BE BALANCED WITH ECONOMIC IMPACT			
	FREQUENCY	VALID PERCENT	CUMULATIVE PERCENT
Strongly Agree	431	45.8	45.8
Somewhat Agree	435	46.2	92.1
Neither Agree Or Disagree	13	1.4	93.5
Somewhat Disagree	42	4.5	97.9
Strongly Disagree	20	2.1	100.0

agreement with the view that efforts to protect the environment must be balanced with economic impact.[3]

Response Overview

Table 4 provides an overview of citizen response on each of the three issues examined in the State of the State Survey.

[3]Note that this represents a interesting change in Michigan public opinion. In a State of the State Survey (SOSS 23) conducted in the spring of 2001, over 64% of all respondents endorsed the view that "Protecting the environment is so important that the requirements and standards should be as high as possible." Less than 36% of respondents agreed that issues of cost should be taken into account when framing environmental policy.

Table 4
Citizen Response on Policy Issue Questions

Scientific Evidence Of Climate Change?		Is Climate Change Result Of Human Activity?	
Strong	36%	Human Activity	20%
Some	45%	Human Activity and Natural Forces	68%
Little	19%	Natural Forces	12%
Asian Carp Effects On Eco-System		Priority Of Stopping Asian Carp	
Serious Threat	58%	High	69%
Somewhat of Threat	34%	Medium	25%
Little threat	8%	Low	6%
Oil Drilling Under Great Lakes?		On-Shore vs. Off-shore Drilling	
Little or No Risk	4%	Much Safer	14%
Some Risk-But Worth It	46%	Somewhat Safer	46%
Too Much Risk	49%	No Safer	49%

Table 4 reveals widespread citizen agreement with existing scientific consensus on the issues of climate change and Asian carp. Thus, 81% of respondents agreed that there is at least some evidence for climate change, and 88% agreed that at least some climate change was due to human activity. There was an even broader consensus about the environmental threat of Asian carp. Here 58% of the population saw Asian carp as a serious threat, and 92% saw carp as at least somewhat of threat. Sixty-nine percent of the respondents gave a high priority to controlling carp, and 94% saw it at least as a medium priority. The public was a good deal more skeptical about directional drilling than one might expect based on current scientific and technical literature. Forty-nine percent of the population indicated that the risk of onshore directional drilling was no safer than traditional offshore drilling. Moreover, 49% of the population held the drilling for oil under the Great Lakes involved an unacceptable level of ecological risk.

Policy Preference Coherence

The data in Table 4 show that popular opinion often diverges from scientific consensus. This is particularly true on the question of oil directional drilling and possible drilling under the Great Lakes. An obvious question is whether some individuals have a general tendency to reject scientific consensus, or whether such rejection varies with specific substantive issues. The issue of individual level consistency with scientific consensus is examined from two perspectives. First, responses for same policy area are examined to see if individuals are consistent within defined areas. Second, responses across the three issue areas are examined to see if individuals are consistent across the three issue areas.

Table 5 reports a simple correlation matrix for individual responses to each policy question.

Table 5
Correlation Matrix for Individual Responses to Policy Questions

	ASIAN CARP EFFECTS ON ECO-SYSTEM	PRIORITY OF STOPPING ASIAN CARP	OIL DRILLING UNDER GREAT LAKES	ON-SHORE VS. OFF-SHORE DRILLING	SCIENTIFIC EVIDENCE OF CLIMATE CHANGE	CLIMATE CHANGE AND HUMAN ACTIVITY
ASIAN CARP EFFECTS ON ECO-SYSTEM	1 (N=886)	.648** (N=815)	-.165** (N-873)	.209** (N=704)	.269** (N=871)	.051 (N=683)
PRIORITY OF STOPPING ASIAN CARP		1	.086* (N=804)	.091* (N=653)	.109** (N=801	-.052 (N=656)
OIL DRILLING UNDER GREAT LAKES			1	.215** (N=741)	-.387** (N=914)	-.164** (N=725)
ON-SHORE VS. OFF-SHORE DRILLING				1	-.054 (N=731)	-.157** (N=595)
SCIENTIFIC EVIDENCE OF CLIMATE CHANGE					1	.241** (M=733)
CLIMATE CHANGE AND HUMAN ACTIVITY						1

** Significant at .01 level

The analysis presented in Table 5 reveal a relatively high degree of consistency within policy areas. The Asian carp questions have the highest positive association (.65), while the oil drilling and climate change questions have a somewhat smaller (but statistically significant) positive association (.22 and .24 respectively). The pattern between issue areas is much less clear. Overall, measured associations are small and inconsistent.

A factor analysis of the six questions was undertaken to better assess whether there was some consistent structure to the question responses. The results of this analysis are presented in Table 6.

Table 6
Rotated Component Matrix For Citizen Response on Policy Issue Questions [a]

ROTATED COMPONENT MATRIX[a]		
	COMPONENT	
	1	2
Scientific Evidence Of Climate Change	.560	-.468
Climate Change And Human Activity	.080	-.640
Asian Carp Effects On Eco-System	.883	.077
Priority Of Stopping Asian Carp	.888	.124
Oil Drilling Under Great Lakes	.029	.701
On-Shore Vs. Off-Shore Drilling	.146	.672
Extraction Method: Principal Component Analysis. Rotation Method: Varimax With Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

The factor analysis suggests that there was, indeed, an underlying structure to the responses and identified two principal dimensions within the response data. The first dimension is largely defined by responses to the questions about Asian carp and whether there was scientific evidence to support the claim of ongoing climate change. The questions about climate change and oil drilling clustered on the second. Note, however, that the climate change questions were negatively associated with the derived component. These findings are consistent with the intuitive criterion used to select the policy areas. Opinions about climate change and drilling for oil under Lake Michigan are negatively related, while public opinion about Asian carp is relatively independent of the more ideologically driven issues.

Determinants of Public Opinion

There is clearly significant public disagreement with "established" scientific views in each of the policy areas examined. The interesting question thus becomes what factors (other than established scientific opinion) drive public opinion. The analysis begins with a review of three broad factors often tied to policy preferences: individual political and/or ideological values, levels of education and various demographic characteristics. Table 7 summarizes the specific indicators used for each factor.

Table 7
Possible Explanations for Policy Responses

Factors	Indicators	Possible Values
Political Factors	Party identification	(1) Strong Republican (2) Not Strong Republican (3) Lean Republican (4) Neither (5) Lean Democrat (6) Not Strong Democrat (7) Strong Democrat
	Political ideology	(1) Very Conservative (2) Somewhat Conservative (3) Lean Conservative (4) Middle (5) Lean Liberal (6) Somewhat Liberal (7) Very Liberal
Education	Years of education	(1) Less than High School (2) High School (3) Some College (4) College or more
	Have taken science course in college?	(0) No (1) Yes

Table 7
Possible Explanations for Policy Responses (cont'd)

Factors	Indicators	Possible Values
Demographic	Income	(1) Less than $10,000 (2) $10,000-19,999 (3) $20,000-29,999 (4) $30,000-39,999 (5) $40,000-49,999 (6) $50,000-59,999 (7) $60,000-69,999 (8) $70,000-89,999 (9) $90,000-99,999 (10) $100,000-149,999 (11) $150,000 or More
	Race	Percent White
	Place of residence	(1) Rural (2) Small town, city or village (3) Suburb (4) City
	Gender	Percent Male

Political Variables

Conventional wisdom (as well as a good deal of social science research) argues that political variables are important predictors of policy. Table 8 provides an overview of the relationship between political ideology and policy preferences. As noted above, political ideology is measured on a seven-point scale ranging from very conservative to very liberal. Table 8 reports the mean ideology score for respondents choosing each possible policy preference, and whether a simple analysis of variance finds the differences across the mean ideology scores were likely to have occurred by chance. The data strongly supports the view that ideology is

strongly linked to policy preferences. First, all the differences in ideology scores are significant at the .01 level with the single exception of whether Asian Carp "represent a serious threat" That difference is significant at the .05 level. More interesting however, is the consistency of the observe differences. Liberals are more likely to see Asian carp as a greater ecological threat, see on-shore direction oil drilling as

Table 8
Political Ideology and Policy Preferences

Ideology 1=Very Conservative 7=Very Liberal	Do Asian carp represent*		
	A Serious Threat	Somewhat of a Threat	Little or No Threat
	3.44	3.85	2.66
	Stopping Asian Carp from reaching the great lakes should be a**		
	High Priority	Moderate Priority	Low Priority
	3.40	3.71	5.11
	On-shore directional drilling is**		
	Much Safer	Somewhat Safer	Not At All Safer
	2.84	3.80	3.85
	Drilling for oil under the great lakes**		
	Little Or No Risks	Some Risks – But Worth The Risks	Significant Risks
	1.65	2.86	4.33
	About global climate change**		
	Strong Scientific Evidence	Some Scientific Evidence	Little Or No Scientific Evidence
	4.27	3.48	2.37
	Is global climate change**		
	Direct Result Of Human Activity	Both Human Activity And Naturally Occurring Changes	Direct Result Of Naturally Occurring Changes
	4.59	3.71	3.02

* Difference of means test by analysis of variance show differences significant at .05 level of significance.
**Difference of means test by analysis of variance show differences significant at .01 level of significance.

no safer than traditional offshore drilling, perceive more significant dangers in drilling under the Great Lakes, agree that there is strong scientific evidence for climate change, and agree that climate change is the result of

human activity. The only apparent exception to this pattern is that liberal respondents assign a lower priority to stopping Asian carp from reaching the Great Lakes than do more conservative respondents.

Table 9 reports the mean party identification score for each policy preference. Once again observed differences are statistically significant. Differences between how Republicans and Democrats respond to the question of whether directional on-shore drilling is safer than off-shore drilling

Table 9
Party identification and Policy Preference

Party Identification 1=Strong Republican 7=Strong Democrat	Do Asian Carp represent**		
	A Serious Threat	Somewhat Of A Threat	Little Or No Threat
	4.31	3.99	5.40
	Stopping Asian Carp from reaching the Great Lakes should be a**		
	High Priority	Moderate Priority	Low Priority
	4.23	3.86	4.99
	On-Shore directional drilling is*		
	Much Safer	Somewhat Safer	Not At All Safer
	4.36	4.13	4.87
	Drilling for oil under the Great Lakes**		
	Little Or No Risks	Some Risks – But Worth The Risks	Significant Risks
	3.31	3.63	5.03
	About global climate change**		
	Strong Scientific Evidence	Some Scientific Evidence	Little Or No Scientific Evidence
	5.06	4.04	3.52
	Is global climate change**		
	Direct Result Of Human Activity	Both Human Activity And Naturally Occurring Changes	Direct Result Of Naturally Occurring Changes
	4.95	4.47	3.94

* Difference of means test by analysis of variance show differences significant at .05 level of significance.
**Difference of means test by analysis of variance show differences significant at .01 level of significance.

are statistically different at the .05 level. All other responses are significant at the .01 level. As with ideology, there is consistency between party identification and policy preferences. Those who see Asian carp as a

serious issue and as a high policy priority are more Republican. This is also true for those who see on-shore directional drilling safer than off-shore drilling and that there is little or no risk in drilling for oil under the Great Lakes. In contrast, those who believe that there is strong evidence of climate change, and that this change is the direct result of human behavior tend to be supported by Democrats.4

Education Variables

Table 10

Education and Policy Preferences

	Do Asian Carp Represent**		
Education 1= Less than High School 4= More than College Degree	A Serious Threat	Somewhat Of A Threat	Little Or No Threat
	3.1181	2.9725	2.0980
	Stopping Asian Carp from reaching the Great Lakes should be a**		
	High Priority	Moderate Priority	Low Priority
	3.0847	3.1242	2.5562
	On-shore directional drilling is		
	Much Safer	Somewhat Safer	Not At All Safer
	2.9648	2.8919	3.1121
	Drilling for oil under the Great Lakes**		
	Little Or No Risks	Some Risks – But Worth The Risks	Significant Risks
	2.3621	3.0635	2.9924
	About global climate change**		
	Strong Scientific Evidence	Some Scientific Evi-dence	Little Or No Scientific Evidence
	3.1369	2.9824	2.8036
	Is global climate change*		
	Direct Result Of Human Activity	Both Human Activity And Naturally Occurring Changes	Direct Result Of Naturally Occurring Changes
	3.0918	3.0696	3.0251

* Difference of means test by analysis of variance show differences significant at .05 level of significance.
**Difference of means test by analysis of variance show differences significant at .01 level of significance.

[4] Note that for both questions about Asian carp and the question comparing the relative safety of onshore directional drilling and offshore drilling, the immediate response was the "most Republican' set of respondents.

Table 10 reports the relationship of education to policy preferences. The differences across groups across groups are statistically significant in all cases, except as to whether on-shore directional drilling is safer than traditional offshore . Those seeing Asian carp as a serious ecological issue and a high policy priority have the highest average education. Those seeing the greatest risks for drilling under Great Lakes had the highest education. Those claiming strong scientific evidence for climate change had relatively high education levels. However, differences among those who disagreed about the relation between human activity and climate change were quite small.

Table 11

Science Class and Policy preferences

Percent Reporting Science Class in College	Do Asian Carp Represent**		
	A Serious Threat	Somewhat of a Threat	Little or No Threat
	0.5417	0.4523	0.1595
	Stopping Asian Carp from reaching the great lakes should be a		
	High Priority	Moderate Priority	Low Priority
	0.4921	0.5766	0.4089
	On-shore directional drilling is**		
	Much Safer	Somewhat Safer	Not At All Safer
	.5033	.4155	.5823
	Drilling for oil under the great lakes**		
	Little Or No Risks	Some Risks – But Worth The Risks	Significant Risks
	.3633	.4772	.5003
	About global climate change		
	Strong Scientific Evidence	Some Scientific Evidence	Little Or No Scientific Evidence
	.4814	.5159	.4311
	Is global climate change		
	Direct Result Of Human Activity	Both Human Activity And Naturally Occurring Changes	Direct Result Of Naturally Occurring Changes
	.5780	.4963	.4469

Table 11 reports the association between whether a respondent ever had a college level science class and policy preferences.[5] The strongest association between experience of a science class and policy preference is

[5] Note that for all respondents that report not attending any college where included in this analysis and were coded as having not attended any college level science class. While this coding is certainly technically correct, it could confuse the possible link between taking a science class and policy preferences for those attending college.

around the issue of Asian carp. Those respondents agreeing that Asian carp represented a serious ecological threat had the highest proportion of those with a science class experience. Interestingly, there was no significant difference between groups as to whether stopping Asian carp should be a policy priority. There are statistically significance differences between groups about the relative safety of directional versus traditional offshore drilling, and whether it is safe to drill under the Great Lakes. There were no statistical differences in science class experience for either climate change question.

Economic/demographic Variables

Tables 12-15 explore a number of social-demographic factors that may be related to policy preferences. Table 15 considers the association between income and policy preferences. The differences in mean scores across the policy positions are all significant at the .01 level. In most cases income is positively associated with scientific consensus. The single exception is that those who indicate climate change is due to both human and naturally occurring phenomena have the highest average income.

Table 12

Income and Policy Preferences

	Do Asian Carp represent**		
INCOME LEVELS 1= LOWEST 11=HIGHEST	A Serious Threat	Somewhat Of A Threat	Little Or No Threat
	6.5783	6.0566	2.9570
	Stopping Asian Carp from reaching the Great Lakes should be a**		
	High Priority	Moderate Priority	Low Priority
	6.4901	6.5487	4.7239
	On-shore directional drilling is**		
	Much Safer	Somewhat Safer	Not At All Safer
	6.5312	5.8599	5.8320
	Drilling for oil under the Great Lakes**		
	Little Or No Risks	Some Risks – But Worth The Risks	Significant Risks
	7.3392	6.2845	5.9809
	About global climate change**		
	Strong Scientific Evidence	Some Scientific Evidence	Little Or No Scientific Evidence
	6.2944	6.1320	5.9040
	Is global climate change**		
	Direct Result Of Human Activity	Both Human Activity And Naturally Occurring Changes	Direct Result Of Naturally Occurring Changes
	6.0215	6.3664	5.7401

* Difference of means test by analysis of variance show differences significant at .05 level of significance.
**Difference of means test by analysis of variance show differences significant at .01 level of significance.

Table 13 presents the relationship between race and policy preferences. Once again

Table 13

- Difference of means test by analysis of variance show differences significant at .05 level of significance.

	Do Asian Carp represent**		
Percent White	A Serious Threat	Somewhat Of A Threat	Little Or No Threat
	90%	95%	18%
	Stopping Asian Carp from reaching the Great Lakes should be a**		
	High Priority	Moderate Priority	Low Priority
	91%	96%	96%
	On-shore directional drilling is**		
	Much Safer	Somewhat Safer	Not At All Safer
	91%	90%	82%
	Drilling for oil under the Great Lakes**		
	Little Or No Risks	Some Risks – But Worth The Risks	Significant Risks
	58%	88%	87%
	About global climate change*		
	Strong Scientific Evidence	Some Scientific Evidence	Little Or No Scientific Evidence
	85%	93%	74%
	Is global climate change*		
	Direct Result Of Human Activity	Both Human Activity And Naturally Occurring Changes	Direct Result Of Naturally Occurring Changes
	88%	92%	76%

- **Difference of means test by analysis of variance show differences significant at .01 level of significance.

the racial makeup of respondents choosing specific policy preferences is statistical significant (for the carp questions and on-shore versus off-shore drilling question the difference is significant at the .01 level: otherwise the difference is significant at the .05 level). Race seems to be associated with number interesting variations. Perhaps most dramatic is the question which asks whether Asian carp represent a serious threat to the environment. Ninety percent of respondents indicating carp are a serious threat are white and 95% 0of those seeing carp as somewhat of a threat are white. However, only 18% of those who saw carp as little or no threat were white. Somewhat surprisingly the differences in the racial proportions of those ranking the importance of stopping Asian carp from reaching the Great Lakes was much smaller. Note, however, that this shift is best explained the relatively low response rate by nonwhite respondents to the priority question rather than what might seem to be

an inconstant response pattern for the carp questions. White respondents see significantly greater risks in on-shore directional drilling and efforts to drill under the Great Lakes than nonwhites. Finally whites seem more willing to accept that there is strong scientific evidence to support the notion of climate change, and that such change is, at least in part, the result of human activity.

Table 14 shows the relationship between policy preferences and the type of community in

Table 14

Residence and Policy Preference

Place Of Residence 1=Rural 4=Urban	DO ASIAN CARP REPRESENT**		
	A Serious Threat	Somewhat Of A Threat	Little Or No Threat
	2.05	2.12	3.48
	Stopping Asian Carp from reaching the Great Lakes should be a**		
	High Priority	Moderate Priority	Low Priority
	2.06	2.00	2.46
	On-Shore Directional Drilling is**		
	Much Safer	Somewhat Safer	Not At All Safer
	1.91	2.08	2.34
	Drilling for oil under the Great Lakes		
	Little Or No Risks	Some Risks – But Worth The Risks	Significant Risks
	2.64	2.17	2.15
	About global climate change*		
	Strong Scientific Evidence	Some Scientific Evidence	Little Or No Scientific Evidence
	2.22	1.97	2.61
	Is global climate change**		
	Direct Result Of Human Activity	Both Human Activity And Naturally Occurring Changes	Direct Result Of Naturally Occurring Changes
	2.40	1.97	2.21

- Difference of means test by analysis of variance show differences significant at .05 level of significance.
- **Difference of means test by analysis of variance show differences significant at .01 level of significance.

in which the respondent resides. Differences in residence are significant for the carp and climate questions as well as whether on-shore directional drilling is safer than off-shore drilling. All of these differences are significant at the .01 level except for the question concerning the level of scientific evidence for climate change which is significant at the .015 level. Respondents who indicated Asian carp were a significant concern and should be a

high policy priority reported living in a more rural setting than those who expressed less concern about Asian carp. Those reporting that on-shore directional drilling is safer than off-shore drilling also report more rural residences. Those who see strong evidence for climate change, and that such change is the result of human activity report more rural residences.

Table 15 presents the relationship between gender and policy preferences.

Table 15

Gender and Policy Preferences

	DO ASIAN CARP REPRESENT**		
Percent Male	A Serious Threat	Somewhat Of A Threat	Little Or No Threat
	57%	37%	66%
	Stopping Asian Carp from reaching the Great Lakes should be a**		
	High Priority	Moderate Priority	Low Priority
	54%	39%	50%
	On-Shore Directional Drilling is**		
	Much Safer	Somewhat Safer	Not At All Safer
	86%	53%	46%
	Drilling for oil under the Great Lakes		
	Little Or No Risks	Some Risks – But Worth The Risks	Significant Risks
	49%	56%	46%
	About global climate change*		
	Strong Scientific Evidence	Some Scientific Evidence	Little Or No Scientific Evidence
	50%	50%	505
	Is global climate change**		
	Direct Result Of Human Activity	Both Human Activity And Naturally Occurring Changes	Direct Result Of Naturally Occurring Changes
	49%	46%	60%

* Difference of means test by analysis of variance show differences significant at .05 level of significance.
**Difference of means test by analysis of variance show differences significant at .01 level of significance.

Gender differences questions about Asian carp and oil drilling, but not for climate change. The pattern of these gender differences is unclear. Those seeing Asian carp as somewhat of a environmental challenge have greater proportion of women. Males dominate both extreme categories, although this dominance is clearest among those see little or no threat from Asian carp. Males overwhelmingly dominate the group that sees on-shore directional drilling as safer than off-shore drilling. Males dominate the group of respondents who

support on-shore directional, seeing little or some risks to the effort.

Overview

Table 16 summarizes the link between science based policy preferences and each of the explanatory variables discussed above.[6]

Table 16
Summary Explanatory Variables for Policy preferences Consistent with Scientific Consensus

	ASIAN CARP		DRILLING		CLIMATE	
	A Serious Threat?	High Priority?	Much Safer?	Little or No Risk?	Scientific Evidence?	Human Activity?
Ideology		Conservative	Conservative	Conservative	Liberal	Liberal
Party				Republican	Democratic	Democratic
Education	Highest			Lowest	Highest	Highest
Science Class	Yes		No	No		
Income	Highest		Highest	Highest	Highest	
Percent White		Lowest	Highest	Lowest		
Residence	Rural		Rural			Urban
Percent Male		Highest	Highest			

The table reports cases in which the highest or lowest mean score for a given explanatory variable aligned with scientific consensus. For example, respondents indicating that Asian carp should be a high priority were more conservative than either of the other two possible response groups. Similarly, those respondents claiming that there was a broad base of scientific evidence for climate change had the highest mean income of the three response groups. On the other hand, those identifying Asian carp as a serious ecological threat were neither the most liberal or most conservative response group.

[6] A complete breakdown of category rankings is provided in Appendix I.

As expected, ideology is a strong predictor of policy preferences. For five of the six policy questions, ideology is associated with the science based policy response. Interestingly, however, the direction of this association is not consistent across issue areas. Those identifying Asian carp as high priority, on-shore drilling directional drilling as safer than off-shore drilling, and drilling under the Great Lakes as safe were the most conservative respondent group. Those agreeing that there was a sound scientific basis for climate change and that climate change was heavily impacted by human activity were the most liberal respondent group. Education and income were associated with scientific consensus in four policy questions. The highest income group sees Asian carp as a high threat, onshore drilling directional drilling as safer than offshore drilling, drilling under the Great Lakes as safe, and agree that there is a strong base of scientific evidence for climate change. The highest education group sees Asian carp as a high threat; a sound scientific basis for climate change and that climate change was heavily impacted by human activity. The lowest education group agreed with the view that drilling under the Great Lakes as safe. The overall impact of taking a science course is modest. Those declaring Asian carp to be a significant ecological threat had the highest proportion of respondents with a science course experience. However, those who saw directional drilling and drilling for oil under the Great Lakes actually reported less experience with college science classes. It is particularly noteworthy that science classes seem to have no impact on attitudes toward climate change.

It is somewhat surprising that political party less often was less often associated with the policy response. The respondent group that perceived drilling under the Great Lakes as safe was the most Republican respondent group. Those agreeing that there was a sound scientific basis for climate change and that climate change was heavily impacted by human activity were the most Democratic of respondent groups.

Summary Model

Table 17 presents a summary model for each issue preference. The table presents

Table 17
Summary Model Coefficients

	ASIAN CARP		DRILLING		CLIMATE	
	A Serious Threat?	High Priority?	Much Safer?	Little or No Risk?	Scientific Evidence?	Human Activity?
Ideology	.018	.015**	.118*	.392**	-.338**	-.178**
Party	-.089*	.014	-.031	.162**	-.172**	-.060
	.001					
Education	-.112	.038**	.009	-.113*	-.175**	.051
Science Class	-.177*	.057**	.074	.036	.115**	-.075
Income	-.161**	.009**	-.054	-.031	-.087*	.041
Percent White	-.099**	.089**	-.086	.063	.036	-.185**
Percent Male	.197**	.045**	-.190**	-.060	.046	.000
Residence	-.257**	.026**	.121**	-.089*	.198**	-.112*
R^2	.25	.15	.09	.26	.24	.08

** Significant at .01 level
* Significant at .01 level

a set of standardized linear regression coefficients estimated for each policy response. Perhaps the most obvious feature of the models reported in Table 17 is their relatively low explanatory power. Overall variance explained ranged from a high of 27% (Should there be drilling under the Great Lakes) to a low of 9% (Whether directional onshore direction drilling is safer than traditional offshore drilling) and (9%) whether climate change is primarily due to human activity. Obviously there remain critically important factors driving public opinion that are not captures in this analysis. Nevertheless, Table 17 does reveal some interesting patterns. First is the obvious importance of political ideology as a predictor of policy preferences. The ideology coefficient has the greatest explanatory power for four of the six policy questions. As noted in Table 16, the impact

of ideology is contingent on the specific issue. Thus, conservative respondents are more likely to express agreement with scientific consensus than more liberal respondents. The opposite is true for questions on climate change. The question as to whether Asian carp is a serious threat to the ecology of the Great Lakes is the only policy question for which the ideology coefficient is not statistically significantly significant. Interestingly, however, the question of whether respondents see Asian carp as a policy priority is associated with ideology.

Two somewhat surprising results can be derived from Table 17. First is the consistent association between respondent's place of residence and policy preferences. There is a clear association between the size of a community in which a respondent lives and expressed policy preference. As with ideology this association is not always consistent with scientific consensus, but it is consistently significant across all policy questions. These resident effects are strongest for the two Asian carp questions. A second surprising finding is the relatively modest impact of education n policy preferences. Although the education coefficient is statistically significant for four of the six policy questions, the size of the coefficients relative to other external variables are modest. Moreover, the sign of the coefficients are not always consistent scientific consensus. Specifically there is a modest negative correction between education and the view that it is safe to drill under the Great lakes. Education is also negatively associated with the view that climate change is the result of human activity.

The other demographic variables that have been considered show an inconsistent and generally modest association with policy preferences. However, it does appear that these variables have relatively greater predictive power for Asian carp that seems clearly to be the least politicized issue of the three issues examined here. In the case of Asian carp, all of the demographic variables are statistically significant. For the issue of oil drilling and climate change, the coefficients are smaller and reach levels of statistical significance in only about half of the cases.

Policy Implications

There can be little doubt that no simple linear relationship between scientific information and citizen policy preferences exists. This is due in part, of course, to the fact that scientific research often fails to present clear guidelines for policy. However, even where there exists a relatively strong consensus within the scientific community concerning an environmental policy issue, the link between science and public opinion remains complex and indirect. Even though survey respondents strongly endorse the view that environmental policy would be better if scientists had more to do with the design and implementation of policy, substantial numbers of respondents reject scientific conventions on the issue of Asian carp, directional oil drilling under the Great Lakes and climate change. Indeed, for of these policy issues, a majority of respondents explicitly rejected the scientific consensus.

As expected, political ideology plays an fundamental role in expressed policy preferences. The degree to which respondents identified themselves as conservatives or liberals was perhaps the most consistent predictor of policy preferences. However, this relationship is itself quite complex. Although political ideology divides citizens as to preferred policy options, there is no straightforward link between ideology and willingness to accept scientific consensus on environmental questions. Sometimes liberals are more likely to embrace the science consensus, other times conservatives. The implication is that the nature of specific policy issues interacts with the core values that define ideology and it is the nature of this interaction rather than ideology itself that drives policy preferences. The analytic puzzle thus becomes one of "unpacking" relevant core values and attributes of policy to better understand this interaction.

One striking result of this study is the relative weak association between education and the acceptance of scientific consensus. For three of the six policy questions, overall education had no statistically significant association with policy position.[7] Moreover, one of the significant associations had a sign in the opposite direction than one would expect (i.e., more education is associated with a policy position that is in opposition to the general scientific consensus). The explanatory power of taking a college level science course had even less

[7] This refers to the multivariate model described in Table 17.

impact on policy preferences. Here again, coefficients were typically small, not statistically significant and occasionally in the "wrong" direction.

The most consistent demographic variable associated with policy preferences was size of the community in which the respondent lived. This finding supports a common view that local political cultures do exist, and that they have a real world impact on how citizens see the world. As with political ideology, however, residence does not exhibit a linear relationship with scientific consensus. Sometimes rural residents chose preferences most consistent with science consensus, other times urban residents do so.

What implications do these findings have for those who would hope that citizen's policy preferences would be more consistent with existing science? First, it should be noted that a number of relatively straightforward strategies that are popular with educators are unlikely to be effective.

These include:

- More Information: It is clear that ideology and other factors tend to "screen out" or otherwise inhibit the impact of information that is counter to existing values and perceptions.
- More education: A number of social and political critics argue that more education is a key to both public understanding and public acceptance scientific information. Once again, it seems clear that that ideology and other factors inhibit the impact of information that is counter to existing values and perceptions.
- Increased science education: Like education in general, there is little evidence that college level science education directly increases the likelihood that citizen preferences will be more consistent with existing scientific consensus.

The current (as well as potential) impact of scientific information is best understood in terms of the way in which that information is provided by political elites. For example, in the public discourse surrounding environmental policy, citizens are often presented a policy frame in which one must choose between conservation goals and economic benefits. The interaction of this dichotomy with individual ideological core value is often relatively straightforward. Certainly when environmental policy is presented in such terms, one would expect that public divisions would be driven by core values not science.

It is important to recognize, however, that the literature on issue framing suggests that not all policy goals need to be promoted as representing mutually exclusive values. Circumstances do arise where policy goals can be seen as converging. Such "collaborative issue framing" may create extensive and powerful coalitions for proactive environmental policy. The clear implication of the analysis presented in this report is that for science to play a greater role in the creation and implementation of environmental policy, decision makers (and perhaps scientists themselves) will need to promote issue frames that emphasize complementary (or at least non-exclusionary) goals and outcomes. Further research is essential to understand the capacity of the general public in accepting these frames and incorporating them into their view of public policy.

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APPENDIX I

Summary of Relationships Between External Factors and Asian Carp

	A Serious Threat	Somewhat of a Threat	Little or No Threat
Ideology		Most Conservative	Most Liberal
Party		Most Republican	Most Democratic
Education	Highest		Least
Income	Highest		Least
Percent White		Highest	Least
Percent Male		Lowest	Highest
Residence	Most Rural		Least Urban
	High Priority	Moderate Priority	Low Priority
Ideology	Most Conservative		Most Liberal
Party		Most Republican	Most Democratic
Education		Highest	Lowest
Income		Highest	Lowest
Percent White	Least		Highest
Percent Male	Highest	Least	
Residence		Most Rural	Most Urban

Summary of Relationships Between External Factors and Offshore Drilling

	Much Safer	Somewhat Safer	Not at all Safer
Ideology	Most Conservative		Most Liberal
Party		Most Republican	Most Democratic
Education		Least	Highest
Income	Highest		Least
Percent White	Highest		Least
Percent Male	Highest		Least
Residence	Most Rural		Most Urban
	Little or No Risk	Some Risk- But Worth Risk	Significant Risks
Ideology	Most Conservative		Most Liberal
Party	Most Republican		Most Democratic
Education	Least	Highest	
Income	Highest		Least
Percent White	Lowest	Highest	
Percent Male		Highest	Least
Residence	-	-	-

Summary of Relationships Between External Factors and Climate Change

	Strong Scientific Evidence	Some Scientific Evidence	Little or no Scientific Evidence
Ideology	Most Liberal		Most Conservative
Party	Most Democratic		Most Republican
Education	Highest		Least
Income	Highest		Least
Percent White		Highest	Least
Percent Male	-	-	-
Residence		Most Rural	Most urban
	Direct Result of Human Activity	Both Human Activity and Naturally Occurring Change	Direct Result of Naturally Occurring Change
Ideology	Most Liberal		Most Conservative
Party	Most Democratic		Most Republican
Education	Highest		Least
Income		Highest	Least
Percent White		Highest	Least
Percent Male	-	-	-
Residence	Most urban	Most Rural	

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