Heat Waves, Droughts, and Preferences for Environmental Policy

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Abstract

Using data from a new household survey on environmental attitudes, behaviors, and policy preferences, we find that current weather conditions affect preferences for environmental regulation. Individuals who have recently experienced extreme weather (heat waves or droughts) are more likely to support laws to protect the environment. We find evidence that the channel through which weather conditions affect policy preference is via perceptions of the importance of the issue of global warming. Furthermore, environmentalists and individuals who consult more sources of news are less likely to have their attitudes towards global warming changed by current weather conditions. These findings suggest that communication and education that emphasizes consequences of climate change that are salient to the individual's circumstances may be the most effective in changing attitudes of those least likely to support pro-environment policy. In addition, the timing of policy introduction could influence its success.

Introduction

Attitudes towards global warming and environmental policy have shifted recently, with several studies finding a decline in concern for environmental issues over the last few years. For example, a 2009 Pew Research Center report shows a decline since January 2007 across party lines among those who see solid evidence of global warming. A recent survey by Gallup also shows the percentage of Americans responding that the seriousness of global warming has generally been exaggerated has steadily increased from a low of 30 percent in 2006 to 48 percent in 2010. Although some of the recent skepticism may be in reaction to "Climategate," these studies show that the decline in concern for environmental issues began before the November 2009 release of communications between a few climate scientists that fueled the criticism of global warming skeptics.

Over this same time period, although some areas of the U.S. have experienced summer heat waves and droughts, temperatures in the summer of 2008 and 2009 were relatively cool across the U.S., with average temperatures below a 20 year average in 37 of the 48 contiguous states in August 2008 and in 30 of the 48 contiguous states in August 2009. Media outlets have certainly made the connection of current weather conditions and climate change, especially when weather is hotter than average. An example is written by a *Seattle Times* business correspondent writing in response to the Pacific Northwest's record-breaking temperatures in August 2009:

> Seattle needs to pause from the "you can tell your grandkids about the great heatwave of '09," and take stock of potential climate-change effects here, including, for the sake of this blog's mission, the economic ones. For this may not be a twice-a-century event any longer. [1]

While there are likely a variety of factors that have influenced public opinion in the U.S., this paper investigates the role of weather conditions in affecting individual's preferences for

[1]Talton (2009).

environmental regulation as well as their general attitudes towards the importance of the issue of global warming. Using data from a new household survey on environmental attitudes, behaviors, and policy preferences, we find that current weather conditions do affect preferences for environmental regulation. Our empirical results support the conclusion that individuals who have recently experienced extreme weather (summer heat waves or droughts) are more likely to support laws to protect the environment even if it means restricting individual freedoms. We find evidence that the channel through which weather conditions affect policy preferences is via perceptions of the importance of the issue of global warming. Furthermore, individuals who consult more news sources and environmentalists are less likely to have their attitudes towards global warming changed by current weather conditions.

These findings have important policy implications. On the one hand, our results imply that some individuals will not become concerned about climate change until they begin to experience its effects, possibly *after* a time when relatively small changes in policy can be effective. On the other hand, because the effects of current weather conditions on attitudes towards global warming are strongest among those who may be less informed, our results also suggest that education and communication about climate change may have similar effects to experiencing severe weather. Furthermore, because our results emphasize the importance of experiencing extreme weather, they suggest that the way in which pro-environment messages are conveyed may be important in influencing people's preferences and actions. Specifically, messages that aim to help people experience vicariously the effects of climate change or to make the consequences salient to individual circumstances may be the most effective. Finally, they also suggest that the timing of communications and of policy initiatives affects public support for

them. Even when current conditions are transitory, they can create a greater sense of urgency regarding long-term policy issues.

Our work is related to the literature that examines support for environmental policy with a variety of methods. One way that some researchers have attempted to determine policy preferences is by examining outcomes on specific referendums. For example, Dubin, Kiewiet and Noussair (1992) use precinct-level voting data to show that individual demographic characteristics as well as political ideology influenced support for California ballot initiatives aimed at limiting economic development. In contrast, Kahn and Matsusaka (1997), although still focused on California initiatives, argue that income and price explain most of the variation in voting behavior and that political ideology does not play an important role in determining support for environmental goods.

Some recent work that analyzes voting on referendums in Switzerland corroborates the findings from the California referendums. For example, Halbheer, Niggli and Schmuzler (2006) analyze the characteristics of referendums on environmental policy that have been passed by the Swiss electorate, showing that endorsement by business associations and favorable economic conditions are associated with a greater likelihood of passage. Bornstein and Thalmann (2008) confirm the importance of economic conditions, using data from a survey conducted a few weeks after a Swiss referendum vote in which individuals were asked to explain their recent vote. Similar to the conclusions of previous researchers, they find an important role for perceptions of current economic conditions in determining support for environmental referendums.

Although these studies have the benefit of examining actual voting behavior rather than stated preferences, because they are necessarily examining voting on specific initiatives, their conclusions may be limited to those specific issues or locations. Others have examined

preferences for environmental policy via more broad-based surveys. Konisky, Milyo and Richardson (2008) examine responses to the 2007 Cooperative Congressional Election Study and find political ideology and partisan affiliation help to predict attitudes towards pollution and resource policies. Lee and Cameron (2008) find that individuals state that they are more willing to pay for climate change mitigation if they believe that the harm caused by climate change will be substantial, a finding that complements ours. Interestingly, Lee and Cameron (2008) use geographic characteristics that proxy for the vulnerability to climate change in their estimations (natural disasters, tornados recorded, hurricane zones, and temperatures). However, they use this data as a means of controlling for sample selection bias in a relatively low response rate mail survey and not as a direct determinant of policy preferences and attitudes as we do. Given the manner in which our sample was recruited and that its primary purpose was to elicit attitudes about the 2008 election and not environmental policy (explained more thoroughly below), we do not have the same concerns about sample selection as they do.

We extend the findings of this previous literature by demonstrating that current weather conditions are related to individuals' evaluations of the importance of the issue of global warming and that this importance is related to policy preferences. Individuals who believe that global warming is an important issue are more willing to support regulation that might restrict individual freedom. We also corroborate the broad findings of the previous work on support for environmental policy with a new nationally representative data source for the United States and, like previous authors, find support for the influence of political preference and ideology as well as income and education in determining attitudes towards environmental issues and policy.

Our results are consistent with the idea that experiencing extreme weather causes individuals to become more aware of the issue of global warming and increases their perception

of the risk of global warming. As such, they are related to previous work that examines how individuals update their estimates of risk of climate change. For example, Viscusi and Zeckhauser (2006) estimate median willingness to pay to avoid the risks of climate change and find that providing neutral information about the sources of climate change that makes the issue more salient or accessible increases the estimates of risk. In related work, Cameron (2005, 2005a) and Cai, Cameron, and Gerdes (2010) examine how individuals update their estimates of risk due to climate change and the effects of perceived risk on willingness to pay to mitigate those risks, showing that increased uncertainty about temperature increases, conflicting information, and being less informed about climate change all reduce an individual's willingness to pay for climate change mitigation.

Our conclusions are discussed in the following three sections. The next section describes the survey and the data used in our analysis. The third section presents the estimation results and the last section concludes by discussing the policy implications of our findings.

Data

Household Survey

The main data set used to address these questions is from an August 2009 nationally representative survey of U.S. citizens. It was implemented as an off-wave of the American National Election Studies (ANES) panel. The NSF-funded ANES panel has monthly observations for approximately 2,500 respondents in the U.S. between 2008 and 2009. The surveys are administered by Knowledge Networks, who recruited the panel via random digit dialing. The surveys are approximately 30 minutes in length and are completed on-line. Respondents were offered $10 per month to complete the monthly surveys and individuals who

did not have access to the Internet were offered a web appliance (MSN TV2 set-top box) and free access to the Internet during the time they remained in the ANES panel.

In several of the months, respondents are asked about attitudes relating to their political behavior and the 2008 election. In the remaining "off-wave" months, the ANES has made the panel available to other researchers for a fee. Therefore, in addition to having observations about environmental attitudes and behaviors, our data set can also be linked to an already rich data set from the ANES panel.

As we explain in more detail below, in our August 2009 survey we supplemented the ANES panel with 450 respondents who had also completed a nationally-representative survey of U.S. households conducted by Owen, Videras and Wu (forthcoming) in October 2007 using the Knowledge Networks web-enabled panel (also recruited via random digit dialing in a similar manner to the ANES panel).[2] We repeated eleven questions from the October 2007 survey in the August 2009 survey, allowing us to form a small panel.

The survey instrument for the August 2009 survey elicits responses about topics that can be categorized as follows: 32 specific pro-environment behaviors; 12 attitudes towards the environment and policies aimed at improving the environment; 109 questions about the extent and nature of social networks, including characteristics of the members of the network and the nature of the interactions; 22 questions about changes in life circumstances; and 10 questions about the influence of religion and religious affiliations on environmental behaviors and attitudes.[3]

[2] The Owen, Videras, and Wu (forthcoming) data are available at http://www.hamilton.edu/levitt/sustainable-development-research/environmental-survey-2007

[3] The survey instrument, descriptive statistics for the responses, and data are available for public viewing at the survey website: REMOVED TO PROTECT IDENTITY OF AUTHORS.

Overall, the data collected correspond to data in other large surveys. For example, results from the August 2009 survey indicate that only 14% of our sample recycles less often than several times a year and 17% contributed to an environmental organization in the last 12 months. In the third wave of the World Values Survey, 14% of the respondents from the U.S. indicate that they do not recycle and 25% say they have contributed to an environmental organization (time frame not specified).

Results from the small panel formed by combining the 2009 sample with the 450 October 2007 respondents also corroborate the findings of other studies mentioned in the introduction that attitudes have changed over this two year period. For example, in 2007, 39 percent of the respondents indicated that they did not consider themselves to be environmentalists. In 2009, however, that percentage increased to 55 percent.[4] Responses to a second question also suggest concern about the environment has waned: In 2007, 23 percent of respondents believed that it was "very likely" that climate change will affect them personally. That percentage was down to 17 percent in 2009. It is possible that the nationwide deterioration of economic circumstances caused individuals to place a lower priority on the environment. In fact, 21 percent of the respondents strongly disagreed with the statement "We worry too much about the future of the environment and not enough about prices and jobs today," in 2007. In 2009, only 9 percent of these same individuals strongly disagreed. (We explore the possible impact of the severe economic downturn during this time period in our robustness checks.) Importantly, we also find that attitudes towards environmental policy have changed. In 2007, 57 percent of the respondents supported laws to protect the environment. In 2009, the fraction of the same people that continued to support environmental protection laws was reduced to 48 percent.

[4] We use sampling weights in these calculations and in all specifications we report in this paper.

Two variables that will play a prominent role in the analysis are 1) the support for laws to protect the environment and 2) the importance of global warming as an issue to the respondent. Support for laws to protect the environment was asked in both August 2009 and October 2007, while the importance of global warming as an issue was only asked in the 2009 survey.

To construct the variable that represents support for laws to protect the environment, we use the response to the following question:

If you had to choose, which one of the following would be closest to your views?

a. *Government should let ordinary people decide for themselves how to protect the environment, even if it means they don't always do the right thing, or*

b. *Government should pass laws to make ordinary people protect the environment, even if it interferes with people's right to make their own decisions.*

Responses in which individuals selected the second option were coded as a 1 and responses in which individuals selected the first option were coded as a 0.

The importance of the issue of global warming was elicited from a question that asked respondents to indicate how important the issue of global warming was to them personally. Higher values of this variable indicate that the individual believed that global warming was more important; "Extremely important" responses to the global warming issue were coded as a 5 and "not at all important" were coded as a 1, with intermediate levels of importance being assigned a 2, 3, or 4.

Control variables in the estimation included the respondent's self-identification as an environmentalist, education, political party identification, household income, marital status, gender, and four regional dummy variables. Individuals identified themselves as either "definitely" an environmentalist, "somewhat" of an environmentalist or not an environmentalist. Political party identification is measured on a 7 point scale with 1 indicating a person who

identifies as a "Strong Republican" and a 7 indicating a person who identifies as a "Strong Democrat." [5]

Although the procedures used to recruit the sample indicate that this is a representative sample, the descriptive statistics in Table 1 are calculated using sampling weights. These statistics indicate that approximately 48 percent of the sample supports laws that protect the environment, but on average, respondents rate the issue of global warming as being slightly more than "somewhat important." Only six percent of the sample consider themselves to "definitely" be an environmentalist, but an additional 45 percent consider themselves to be "somewhat" of an environmentalist.

Comparing the mean estimates for several of the demographic characteristics to Census Bureau estimates suggest that the sample is slightly more educated and more likely to be married than the U.S. population as a whole. Thirty-nine percent of the respondents have a college degree compared to a 27 percent estimate by the Census Bureau while only 9 percent of our sample does not have a high school diploma (compared to 14 percent estimate by the Census Bureau). Nonetheless, the stated party affiliations of respondents are consistent with independent estimates.[6] These differences are likely due to the fact that the ANES sample contains only U.S. citizens and excludes U.S. residents who are unable to register to vote. Given our interest in understanding policy preferences, this slightly different sample should not alter the policy implications of our findings.

Additional Data

[5] We are unable to reject the restriction at the 10% level that the model is linear in the political preference rating so we use the party identification variable as a rating rather than a set of dummy variables.
[6] See, for example, Pew Research Center Publications (2008).

We supplement the survey data with data from the National Oceanic and Atmospheric Administration (NOAA) on average monthly temperatures by state and with data collected by the U.S. Postal Service on residential and business vacancies by census tract.

Important independent variables are related to the weather in the 48 contiguous states. These variables identify extreme weather in either August 2009 (the month the survey was completed) and in July 2009 (the previous month). To identify extreme weather, for each state, the average temperature for the month was divided by the twenty-year average for that state for that month to form a relative temperature.[7] A similar calculation was performed with the monthly precipitation. As mentioned earlier, the summer of 2009 was cool and dry in much of the U.S., however, some states experienced greater than typical average temperatures while others experienced significantly less rainfall. We identified states that had unusually hot weather as experiencing a "heat wave" in that month and states that were unusually dry as experiencing a "drought."[8] Because the summer was cool on average, we categorized states as experiencing a "heat wave" if they were in the 90th percentile or higher in relative average temperatures in our sample. In August, this translated into average temperatures at least one percent higher than normal for that month.

Although one percentage point may not seem dramatic, because these averages are over an entire month, this is a meaningful increase. In fact, in several of the states that we identified as experiencing a heat wave, temperature records were set. For example, according to records kept by NOAA and displayed on its web site, in Austin, Texas, a new record was set for the number of consecutive days in which the temperature exceeded 100 degrees in August 2009. In

[7]Our results are qualitatively similar if we use the difference between the average temperature for the month and the 20 year average instead of the ratio to determine the incidence of heat waves.

[8] Technically, of course, a drought is a much more serious and long term phenomenon. However, to aid our efforts to be concise, we employ the use of the term "drought" to refer to below average monthly rainfall.

Atlantic City, New Jersey the second hottest August ever recorded occurred; and on July 29, 2009, Seattle, Washington recorded an all-time high temperature of 105 degrees.

To identify a drought in a particular month, we used the bottom quartile of states (80 percent or less of the normal precipitation in August).[9] Given the potential for extreme weather to have cumulative psychological effects, we also created a second set of extreme weather variables that indicated that a state was in a drought in both July and August or was experiencing a heat wave in both July and August. Of course, there are fewer states that experienced extreme weather in both months.

Interestingly, because we used temperatures and precipitation relative to the average and not just absolute temperatures or precipitation, states that experienced extreme weather by this definition don't necessarily share other characteristics such as region or political affiliations of their residents. Specifically, the states that we identified as experiencing a heat wave in August are: Maine, New Jersey, Rhode Island, Texas, and Washington. The states that experienced a drought were: Arizona, California, Colorado, New Mexico, Nevada, Rhode Island, South Carolina, Texas, Utah, and Washington.[10] States that experienced a heat wave in both July and August are fewer, (Texas and Washington), while states that experienced a drought in both months were Arizona, California, Utah, and Washington.

[9] We are able to consider that a larger percentage of states are in a drought than a heat wave because the 2009 summer was cool and dry. Using a comparable 25 percent of the sample for defining a heat wave would require us to include states in our heat wave sample that were actually experiencing cooler than average temperatures. However, the bottom 25 percent of the distribution for precipitation experienced rainfall of only 80 percent of normal during August.

[10] We also examined unusually cool states during the summer of 2009, identifying those with atypically low temperatures (in the bottom 10 percent). However, these states were more geographically concentrated, causing concern that there is an unobserved common factor in these states that complicates the interpretation of the results and we do not report them in detail here. (They are available from the authors.) States with unusually cool temperatures in August 2009 were: Illinois, Kansas, Montana, North Dakota, Nebraska, and South Dakota.

Figure 1 shows graphs of the daily average and daily maximum temperature for the five states we identified as having a heat wave in August 2009. These graphs show that while four of the five states clearly experienced above average temperatures during the entire month, Washington state experienced above average temperatures primarily at the beginning of the month, but, as mentioned above, had record heat at the end of July.[11]

Analysis and Results

We are interested in the determinants of support for environmental policy. In particular, we estimate a probit model predicting support for environmental protection laws using individual characteristics and dummy variables indicating extreme weather in the respondent's state at the time of the survey. Specifically, we estimate

$$\text{Prob}(LAWS=1)=\Phi(\beta X + \gamma WEATHER+\theta REGION)$$

Where X is a vector of individual characteristics, *WEATHER* is a vector of dummy variables indicating extreme weather in the respondent's state, and *REGION* is a vector of dummy variables indicating region of the U.S. (North, South, Midwest and West). The individual characteristics that we include in X are: indicator variables for an individual's stated level of environmentalism, indicator variables for education level, party identification index, an index for household income, age, age-squared, gender, marital status and region of the country. We expect that individuals with stronger identification as environmentalists and as Democrats will be more likely to support environmental protection laws. In addition, other researchers have shown that demographic characteristics may also predict support for environmental policy with more educated, higher income, younger, and female respondents being more likely to express pro-

[11] In results available from the authors, we show that our results are robust to an alternative definition of August heat wave which does not include Washington state.

environment attitudes.[12] Finally, we control for region of the country because the weather variables of interest are geographically determined and support for environmental protection may vary by region. As explained above, we include a number of indicator variables that represent extreme heat, low precipitation, or cool temperatures during the survey period.

Table 2 presents the main results of this estimation, with each column of Table 2 using different combinations of the extreme weather measures.[13] Looking across all the columns of Table 2, we can first draw some conclusions about the control variables. As to be expected, stronger levels of environmentalism are associated with more support for environmental protection laws but lower levels of education correspond to less support. Those with strong affiliations with the Democratic Party are also more likely to express support for laws to protect the environment, while those without a high school diploma are less likely.[14] Although not reported in Table 2, the remaining demographic characteristics generally entered all specifications consistently and as expected. Women and individuals with higher household incomes were more likely to support environmental protection laws. Results for the regional indicators suggest that respondents living in the South or the Midwest are less likely to support environmental protection laws, even after controlling for political affiliation.

The bottom half of Table 2 presents the coefficients for the extreme weather dummies. These results show that the summer heat wave indicator enters positively and significantly in predicting support for environmental protection as does the dummy variable for an August drought. The remainder of the extreme weather dummies in Table 2 are all consistently positive,

[12] Cameron (2005a) suggests that men are more certain about their beliefs about climate change than women.
[13] Although we present some combinations of the extreme weather indicators in Table 2, we do not report an estimation in which they are all included simultaneously because several of the indicators are highly correlated. Nonetheless, if we do include all the extreme weather variables in one estimation, a Wald test rejects the hypothesis that all the coefficients on these extreme weather indicators are zero at the 1 percent level.
[14] The other education dummies in Table 2 are insignificant. When we remove the insignificant dummies so that we only compare the responses of those who don't have a high school diploma to everybody else, the dummy for no high school diploma becomes insignificant, but the remaining results are not materially affected.

but not all statistically significant. Although Table 2 presents the coefficients from the probit estimation, we note that the magnitudes of the estimated marginal effects are also quite large. For example, the marginal effects associated with the model in column 2 suggest that experiencing a heat wave in July and August increases the probability of supporting environmental protection laws by 11 percentage points.[15] Similarly, experiencing a drought in August (column 4) raises the probability of support by 9 percentage points. These are meaningful increases and suggest that the probability of successful introduction of pro-environment policy during times of extreme weather is significantly higher than when normal weather conditions prevail.

Of course, one potential issue with the interpretation of these results is the fact that the weather variables are measured at the state level. Although the specifications in Table 2 control for region of the country and a number of individual characteristics that should control for the predisposition to support environmental protection laws, (including stated level of environmentalism), it is still possible that there are unobservable individual characteristics that correlate with a state-level effect that are really driving the results. Fortunately, we are able to assess the importance of this potential problem by taking advantage of the small two-period panel data set that we are able to form that use some of the responses to our 2007 survey in which the question about support for environmental protection is repeated. The specifications in Table 3 replicate those in Table 2 using this small panel data set and add the respondent's support for environmental protection laws in October 2007 as an independent variable.[16] As to be expected, support for environmental protection in 2007 is a strong and significant predictor of support in 2009. In fact, of the remaining individual characteristics in the estimation, only stated

[15] These marginal effects are calculated holding all the other variables at their means.
[16] Note that because we are using a lagged value of support for laws as an independent variable, our two-period "panel" only allows cross-section estimation.

level of environmentalism and party identification are significant in predicting support for environmental protection laws once the previous level of support is considered. Results for the weather dummies reported in Table 3 are broadly consistent with those in Table 2. However, in the reduced sample, they are not all significant at the 10 percent level. Nonetheless, once the initial attitudes towards environmental protection are accounted for, respondents who live in states that experienced extreme heat in August (columns 5 and 6), were more likely to express support for laws to protect the environment in 2009. The small sample size used to produce these estimates allows us to corroborate the initial findings only weakly, they are suggestive that current weather may influence individual policy preferences.

Weather and attitudes towards global warming

Another way to examine the robustness of this initial finding is to seek evidence for a channel through which weather might logically affect policy preferences. In this case, especially given the stronger results for extreme temperatures, it is reasonable to argue that the channel through which current weather influences policy preferences is by affecting an individual's assessment of the issue of global warming. As mentioned earlier, survey respondents rated the importance of the issue of global warming. We use the responses to this question and estimate an ordered probit model that examines the impact of weather on an individual's assessment of the importance of the issue of global warming, after controlling for the same individual characteristics used in the earlier specifications. These results are reported in Table 4.

Unsurprisingly, environmentalism and party identification are strong predictors of the importance of global warming to the respondent. The only other demographic control that was consistently statistically significant in these specifications (not reported in Table 4) was gender: men were less likely to think that global warming was an important issue. The heat wave and

drought variables, however, continued to be statistically significant in ways that were broadly consistent with the earlier results. Individuals who lived in states that experienced a drought in August (column 1 of Table 4), a heat wave in August (column 2 of Table 4) or a heat wave in July and August (column 4 of Table 4) were all more likely to rate global warming as a more important issue.[17]

Thus far, we have presented evidence that extreme weather affects policy preferences and that this effect likely works through the weather's effects on attitudes towards global warming. If this is the channel through which weather affects policy preferences, once we control for attitudes towards global warming, the weather variables should no longer be significant. Although we do not report the detailed results here, we did confirm that none of the weather variables are significant predictors of support for environmental laws once we control for attitudes towards global warming, providing support for our reasoning.

Interactions of weather and media exposure

Taken together, these results suggest that current weather conditions affect attitudes towards global warming. Ironically, however, even the most pessimistic scientific analysis considers global warming to be a long-run phenomenon. Given that the current month's weather should not rationally affect a well-informed individual, we might expect that it might not affect all individuals in the same way. Especially if the weather serves as a shock that causes individuals to seek out more information and possibly update their beliefs, individuals who are less well informed may be more likely to be affected by current weather conditions. In this

[17] Given that weather is arguably an exogenous shock to individual attitudes towards global warming, it can be used as an instrument for these attitudes. However, Wald tests for exogeneity do not allow us to reject the null hypothesis of no endogeneity in the estimation of support for environmental regulation at the 10% significance level. Therefore, the instrumental variables approach is unwarranted. Nonetheless, in results available from the authors upon request, we show that attitudes towards global warming are strong predictors of support for environmental regulation when the extreme weather dummy variables are used as instruments.

section of the paper, we explore some interactions with individual media exposure to evaluate the evidence that the weather has a differential impact based on the nature of the information that an individual might have about global warming.

As mentioned in the introduction, several media reports on the unusual weather patterns in the summer of 2009 made connections between these weather patterns and the probability that global climate change would occur. We construct two variables that measure an individual's exposure to the news media from a question asked of about half of the ANES respondents in the first wave of the ANES conducted in January 2008. Individuals were asked how many days per week they received news from four sources: print, television, radio or the Internet. For each source, individuals responded from 0 to 7. We used these responses to create a variable called "Days News" which is the sum of the responses to the four questions. The minimum is zero and the maximum is 28. We also created a variable that indicates how many different types of news sources the respondent consults. This index called "News Variety" ranges from zero to four, with higher values indicating that the respondent regularly consults more different types of news. Interestingly, we do not find a significant relationship between total news exposure as captured by the number of days the respondent consults a news source and global warming attitudes, either with or without an interaction with weather.[18] However, we do find that there is a relationship between global warming attitudes and the variety of news sources that a respondent consults. These results are displayed in the first two columns of Table 5.

The results in column 1 of Table 5 suggest that individuals who consult a variety of news sources are less affected by the weather in forming their perceptions of risk from global warming than those that do not. One possible explanation for this result is that those who consult a greater

[18] This corresponds to a finding in Shanahan, Morgan, and Stenbjerre (1997) who find that television viewing is related to a general apprehension about the environment but is not related to specific threats to the environment.

variety of sources may be more sophisticated in obtaining information than those who do not. Thus, the fact that more sophisticated news gatherers are less affected by current weather conditions gives credibility to the finding that weather may be affecting the assessments of others. When we use heat wave in July and August as a measure of extreme weather (Column 2, Table 5) we find results consistent with those in column 1 that use August heat wave except that the interaction term between weather and news variety is not statistically significant. As we discuss later in more detail, a policy implication of this result is that information and education may substitute for experiencing extreme weather in forming attitudes about global warming. Therefore, while advocates of pro-environment policy should take advantage of public support generated by extreme weather, in its absence, communication and education may also be effective.

As further evidence of this mechanism, we also explored whether an individual's stated level of environmentalism interacts with the current weather conditions to produce more or less concern about global warming. If current weather conditions cause greater concern about global warming because they make individuals more aware of the problem or the consequences of the problem, we would expect that the least predisposed to concern by the environment would have the greatest reaction. We find evidence of this in columns 3 and 4 of Table 5 in the positive and significant coefficient of the interaction between heat waves and not being an environmentalist. In other words, while environmentalists are generally concerned about global warming, it is only those who do not consider themselves environmentalists that have attitudes that are affected by the weather.[19] Taken together, the results in Table 5 imply that experiencing extreme weather has the greatest impact on respondents who are less aware or knowledgeable about global

[19] Interestingly, those who do not consider themselves to be environmentalists consult about the same number of news sources each week (3.17) as those who do (3.22 for definite environmentalists, 3.29 for somewhat environmentalists).

warming to update their beliefs. This result emphasizes the policy implications mentioned earlier: communication strategies that help people understand better the effects of climate change, especially when individuals have experienced the effects personally, can be an effective way of increasing support for pro-environment policy.

Robustness check: economic conditions

Earlier we noted that one possible reason for the significance of state-level weather variables is that there is some unobserved state-level characteristic that is coincidentally correlated with extreme weather in the summer of 2009. Given the exogenous nature of weather and the fact that, at least for the heat wave states, there are no obvious similarities, it is difficult to identify such a characteristic. However, one potential candidate is economic conditions in the state which may relegate longer term environmental concerns to lower prominence. In fact, during the summer of 2009, the U.S. economy was in the midst of one of the worst economic downturns since the Great Depression. Furthermore, because this downturn was linked to a crash in the real estate market and a crisis in the mortgage markets, some areas of the country were hit harder than others and the impact could be localized. Therefore, it would be useful to determine if the results reported so far are affected by including a measure of the severity of local economic conditions.

Fortunately for us, there is a measure of how severely an area as small as a census tract was hit by the economic and financial crisis: the U.S. postal service tracks total addresses and vacancies (residential and business) and records them by census tract, enabling us to calculate a vacancy rate for each census tract. Because we are now focused on economic conditions and the possibility that the severity of the recession varies geographically, we also add a variable that indicates if a person is currently working. Unfortunately, we do not have access to census tracts

of the ANES respondents but can re-estimate the equations in Table 3 for those weather variables that were statistically significant (or border-line significant).

Table 6 contains those results. Column 1 of Table 6 first presents the results for the slightly changed specification that includes whether a person is working and the census tract vacancy rate. While employment status is not significant once we control for the original individual characteristics, vacancy rates do predict support for environmental regulation, with individuals from areas that have higher vacancy rates being more likely to support laws to protect the environment, even controlling for their 2007 stance. Importantly, the inclusion of this variable proxying for economic conditions does not compromise the significance of the August heat wave variable (column 2) and in column 3 of Table 6, the significance level of the August drought variable, though still not at 10%, actually increases from that reported in Table 3. Finally, in the last column of Table 7, we take advantage of another variable in our survey that measures whether individuals have fallen behind on their credit card payments in the last two years. Consistent with the positive sign on the vacancy rate, this variable also enters the estimation positively and significantly.

This result contrasts with findings in Kahn and Kotchen (2010) who argue that the recent recession has reduced concern for global warming and support for pro-environment policies. However, there are a number of differences in the two analyses. Importantly, our specifications in Table 6 take advantage of the fact that we observe an individual's support for environmental protection laws in October 2007, prior to the start of the Great Recession whereas Kahn and Kotchen are unable to control for prior individual beliefs in their data. Furthermore, our measure of support for laws to protect the environment is based on a survey question that elicits support for the environment, but also elicits support for laws that might restrict individual freedom. In

considering the interpretation of this result, it is important to note that in addition to vacancy rates, we also control for individual income and working status which might pick up the effects of the economic hardship that the respondent has experienced. Therefore, once we have controlled for individual economic circumstances, the additional information in the vacancy rate is really about the extent to which the financial crisis/recession affected the respondent's community.[20] It is possible that those who have witnessed the worst consequences of the financial crisis would be more likely to favor greater regulation in general because of the link that many made between irresponsible behavior of the private sector/lack of government oversight and the financial crisis. This finding also has interesting policy implications, suggesting that a downturn in the economy does not always have to lower the priority of pro-environment policy, if the effects of environmental problems are salient.

Of course, this is a speculative conclusion; further study on this issue is warranted. From the perspective of the main findings of this paper, however, the important point is that economic conditions are not an omitted state-level characteristic that is driving our results. Including measures of local and individual economic circumstances does not affect the magnitude or the significance of the effect of the heat wave variable.

Robustness check: alternative specifications

If experiencing extreme weather conditions is a proxy for risk perception, it is possible that individual socioeconomic characteristics would interact with the weather variables in producing preferences for policy. When we interact the heat wave variable with the

[20] In fact, when we regress the vacancy rate on all the other independent variables in the estimation and use the residuals from those specifications in place of the vacancy rate in the specifications reported in Table 6, we continue to obtain positive and statistically significant effects of the vacancy rate on support for laws to protect the environment.

socioeconomic controls in our estimation, we do not find consistent results for the interaction terms, but the results for the original weather variable in these more complex models are robust.

In addition, although our study was motivated by the idea that it is extreme weather conditions that cause individuals to update their beliefs about global warming and environmental policy, we also experimented with a linear specification for relative August temperatures. We find a positive and significant coefficient on the temperature variable (at the 10% level) consistent with our previous results. However, we continue to report results using a dummy variable for heat wave because that specification captures threshold effects and because it best fits the data.[21]

Falsification tests

Finally, the survey also asked respondents to rate the importance of the issue of education to them personally. As an additional check on our results, we use responses to this question to perform a falsification test. In other words, weather should not be related to the respondents' beliefs about the importance of education. When we attempt to estimate the importance of education using the same independent variables used in the specifications in Table 4, we do not find significant results for the weather dummy variables.[22] We also performed similar falsification tests using the news variety variable and obtained similar insignificant coefficients. As a final falsification test, we used weather in February and March to define two new heat wave variables based on the idea that a spring "heat wave" that occurred months before the survey wouldn't necessarily cause the same amount of concern about global warming as a summer heat

[21] The BIC for the model with the threshold effect is 7289, versus 7291 for the linear model.
[22] P-values on the weather coefficients in the falsification tests ranged from .98 to .13. Even in the case of the coefficient with the .13 p-value, the average marginal effect of this point estimate on the probability of rating education as an important issue was only 2 percentage points.

wave that occurs during the survey month. We found insignificant coefficients on these variables as well.

If we add the importance-of-education variable to the list of control variables in the global warming specification, it enters positively and significantly. However, it does not affect our original conclusions about the effect of weather on global warming attitudes. This positive correlation between the importance of education and global warming could reflect that both are important issues to similar people, or this result could be caused by an unobserved individual characteristic that causes some respondents to assign similar levels of importance to many social issues.

Discussion and Policy Implications

We have shown that exogenous occurrences of extreme weather can have a meaningful impact on individuals' perceptions about the importance of global warming and their support for environmental policy. While this conclusion about the effects of weather is new, previous literature has shown that exogenous events such as weather can influence policy choices in a variety of contexts. For example, in the economic development literature, rainfall shocks often play an important role in determining income. Miguel, Satyanath, and Sergenti (2004) use rainfall as an exogenous shock to economic growth to determine its effect on civil conflict in Africa. In a different vein, Acemoglu, Johnson and Robinson (2001) and Acemoglu and Robinson (2008) argue that climate and geography in colonial times influenced patterns of European settlement, which had long-run consequences for the development of political and economic institutions that endure today. Lis and Nickel (2009) advance different weather-related policy concerns, showing that extreme weather events put stress on government budgets. They argue that the anticipation of these expenses should influence current fiscal policy

decisions. Finally, Alexeev, Good, and Reuveny (2010) discuss the policy implications of increased immigration caused by extreme weather events.

While our work can be positioned in relation to other findings on the impact of climate and weather, a related policy implication of our results is the need to consider behavioral responses of individuals to meet policy goals as popularized by Thaler and Sunstein's *Nudge*.[23] These insights apply broadly to a wide range of policies attempting to change the behavior of individuals who may prioritize short-term satisfaction over long-term sustained benefit. For example, changes in laws that allow employers to set a default contribution rate to 401(K) plans above zero in order to increase long-term saving take advantage of insights from this research about inertia in individual savings decisions. Another example comes from policy intended to increase energy conservation. Allcott (2009), Ayers, Raseman and Shih (2009), and Shultz et al. (2007) show that providing information on energy bills that compares a household's energy consumption to that of peer households reduces energy consumption. Costa and Khan (2010) refine these conclusions by showing that the impact of this information varies by the political ideology of the household. This refinement is similar to our finding that not all individuals are affected equally by weather shocks. Overall, this research and ours suggest generally that effective policy should be informed by an understanding of all the forces that are affecting the decisions of individuals, regardless of the "rationality" of these factors.

That said, there are a number of specific policy implications that can be drawn from our work. The first relates to timing of policy. Policy makers who support environmental protection may want to introduce policy opportunistically when current events (e.g., heat waves, droughts, hurricanes) make the public more receptive. Furthermore, because these extreme weather events are likely to be temporary, policy introduced during these times should be geared

[23] Thaler and Sunstein (2009).

toward enacting long-term changes because public support is likely to wane (or may even be reversed) as weather conditions change. Finally, activists who wish to change public opinion about the importance of climate change may also want to consider opportunistically timing the use of limited advertising or educational resources. Our results suggest that those who are least likely to believe that climate change is an important issue may be most receptive to education about climate change when they have recently experienced extreme weather. In such circumstances, limited educational resources would be most effectively used following extreme weather events.

There are also implications for the nature of the education and communication. We show that having recent experience with extreme weather is associated with greater concern for global warming. This suggests that communication that portrays the effects of global warming as personal as possible or that aims to have people experience vicariously some of the effects of climate change will be the most effective. For example, appealing to broad interests for the public good and the welfare of future generations will not be as effective a communication strategy as one that uses a visceral message that appeals to personal or local concerns. An example of this kind of salient communication about consequences of actions comes from Wellington, New Zealand in which signs at intersections that read "Stop, Look, Live" are more effective in preventing pedestrian accidents than the more traditional "Look Right" warnings.[24] Similarly, our work suggests that advocates for environmental policy should be as specific as possible in communicating the personal consequences of global warming.

In support of this policy implication, Lowenstein (2000) argues for the importance of visceral factors in determining human behavior, arguing that emotional factors play a dominant role in decision-making. In addition, studies of advertising aimed at improving health outcomes

[24] Thaler and Sunstein (2011).

show that advertisements that use visceral cues are very effective. Amos and Spears (2010) examine weight loss advertising and Terry-McElrath et al. (2005) provide similar evidence about the effectiveness of visceral advertising in a youth anti-smoking campaign.

In sum, while our study is related to perceptions about global warming, our conclusions are related to other important policy issues that require individuals to trade-off short-term costs for long-term benefit such as health, energy usage, and even financial decisions. Of course, there are limitations to our findings. Importantly, our results are based on individual responses to a survey, not on actual votes. Stated preferences for policy that are influenced by current weather conditions may not follow individuals into the voting booth. However, these initial results do suggest further research on how individual, perhaps idiosyncratic, experiences affect support and votes for environmental policy.

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Figure 1

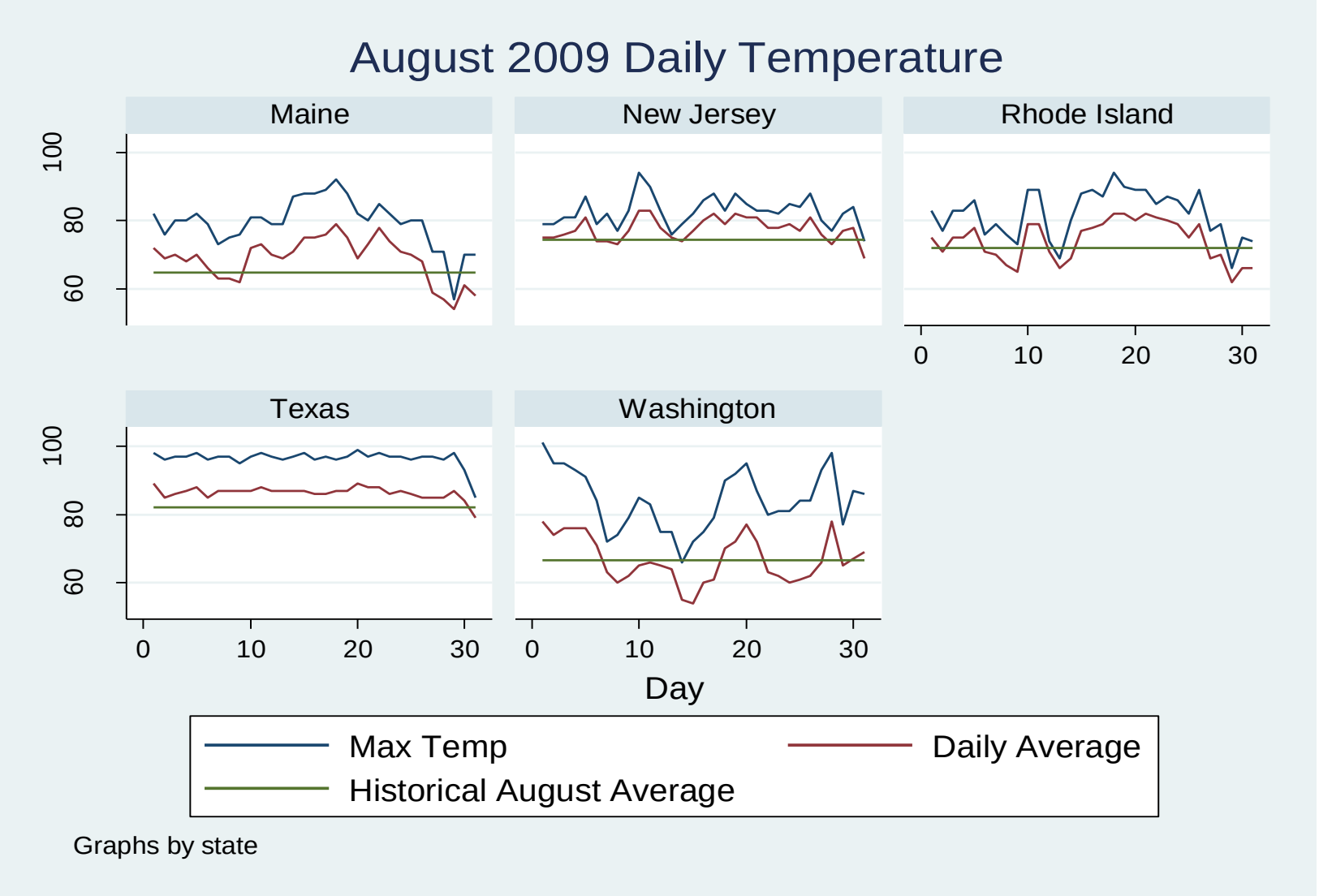
August 2009 Daily Temperature
Maine
New Jersey
Rhode Island
Texas
Washington
100
80
60
0
10
20
30
Day
Max Temp
Daily Average
Historical August Average
Graphs by state

Table 1: Descriptive Statistics

Variable	Mean	Minimum	Maximum
Policy variables			
Support for laws	0.48	0	1
Importance of global warming	3.24	1	5
Definitely environmentalist	0.06	0	1
Somewhat environmentalist	0.45	0	1
Individual Characteristics			
Age	48.15	18	98
No HS diploma	0.09	0	1
HS diploma	0.3	0	1
Some College	0.23	0	1
College degree	0.39	0	1
Male	0.48	0	1
Married	0.66	0	1
Household income index	12.01	1	19
Party ID	4.21	1	7
Region identifier			
Northeast	0.19	0	1
Midwest	0.25	0	1
South	0.35	0	1
Weather variables (state level)			
August heat wave	0.13	0	1
August and July heat wave	0.09	0	1
August drought	0.27	0	1
August and July drought	0.15	0	1
Media exposure			
Days News	14.63	0	28
News Variety	3.18	0	4

Means calculated using sampling weights. For all variables except *Days News* and *Days Internet News*, 2,473 observations used. For Days News and News Variety, 1,180 observations used.

Table 2: Support for laws to protect the environment (Probit Coefficients)

	(1)	(2)	(3)	(4)	(5)	(6)
Definitely environmentalist	1.1310**	1.1498**	1.1505**	1.1480**	1.1431**	1.1502**
	(7.50)	(7.67)	(7.64)	(7.68)	(7.63)	(7.69)
Somewhat environmentalist	0.4229**	0.4235**	0.4235**	0.4259**	0.4237**	0.4255**
	(5.57)	(5.59)	(5.60)	(5.62)	(5.58)	(5.62)
No HS diploma	-0.2971*	-0.2932*	-0.2890*	-0.2919*	-0.2994*	-0.2927*
	(1.70)	(1.67)	(1.65)	(1.67)	(1.69)	(1.66)
HS diploma	-0.1332	-0.1379	-0.1385	-0.1361	-0.1308	-0.1346
	(1.38)	(1.43)	(1.44)	(1.42)	(1.36)	(1.40)
Some college	-0.1141	-0.1221	-0.1185	-0.1204	-0.1181	-0.1198
	(1.38)	(1.48)	(1.44)	(1.46)	(1.44)	(1.46)
Party ID	0.1921**	0.1945**	0.1941**	0.1932**	0.1941**	0.1938**
	(11.61)	(11.84)	(11.83)	(11.71)	(11.80)	(11.79)
Drought in July and August	0.1969		0.1505			
	(1.29)		(0.98)			
Heat wave in July and August		0.2813**	0.2652*			
		(2.02)	(1.89)			
August drought				0.2322*		0.1791
				(1.89)		(1.20)
August heat wave					0.1759	0.0816
					(1.45)	(0.56)
Other controls[a]	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2487	2487	2487	2487	2487	2487

[a]All specifications use sampling weights and include controls for household income, age, age squared and dummy variables for sample, region, gender, and marital status.
Robust z statistics in parentheses. * significant at 10%; ** significant at 5%

Table 3: Support for laws to protect environment, controlling for prior support (Probit Coefficients)

	(1)	(2)	(3)	(4)	(5)	(6)
Support in 2007	0.9041**	0.9482**	0.9436**	0.9353**	0.9553**	0.9565**
	(5.07)	(5.32)	(5.28)	(5.26)	(5.31)	(5.31)
Definitely environmentalist	1.1156**	1.1469**	1.1407**	1.1437**	1.1928**	1.1925**
	(3.36)	(3.45)	(3.44)	(3.48)	(3.55)	(3.56)
Somewhat environmentalist	0.4646**	0.4465**	0.4548**	0.4534**	0.4630**	0.4620**
	(2.53)	(2.48)	(2.51)	(2.52)	(2.56)	(2.56)
No HS diploma	0.1681	0.1769	0.1856	0.1523	0.2374	0.2331
	(0.47)	(0.49)	(0.51)	(0.43)	(0.66)	(0.65)
HS diploma	-0.1882	-0.2238	-0.2148	-0.2501	-0.2143	-0.2209
	(0.73)	(0.88)	(0.84)	(0.98)	(0.83)	(0.86)
Some college	-0.0527	-0.0645	-0.0541	-0.0876	-0.0482	-0.0523
	(0.22)	(0.27)	(0.22)	(0.36)	(0.20)	(0.21)
Party ID	0.1367**	0.1387**	0.1392**	0.1410**	0.1431**	0.1434**
	(3.09)	(3.17)	(3.18)	(3.23)	(3.28)	(3.30)
Drought in July and August	-0.1916		-0.3031			
	(0.59)		(0.88)			
Heat wave in July and August		0.4661	0.5118			
		(1.36)	(1.48)			
August drought				0.4499		0.0589
				(1.50)		(0.17)
August heat wave					0.6566**	0.6302*
					(2.28)	(1.91)
Other controls[a]	Yes	Yes	Yes	Yes	Yes	Yes
Observations	405	405	405	405	405	405

[a]All specifications use sampling weights and include controls for household income, age, age squared and dummy variables for region, gender, and marital status.
Robust z statistics in parentheses. * significant at 10%; ** significant at 5%

Table 4: Importance of Global Warming Issue (Order Probit Coefficients)

	(1)	(2)	(3)	(4)
Definitely environmentalist	0.6120**	0.6095**	0.5980**	0.6082**
	(4.22)	(4.20)	(4.14)	(4.20)
Somewhat environmentalist	0.3308**	0.3273**	0.3282**	0.3277**
	(5.62)	(5.57)	(5.58)	(5.58)
Party ID	0.1269**	0.1276**	0.1260**	0.1274**
	(9.73)	(9.78)	(9.71)	(9.72)
August drought	0.2059**			
	(2.19)			
August heat wave		0.1741**		
		(2.01)		
Drought in July and August			0.1417	
			(0.98)	
Heat wave in July and August				0.1824*
				(1.92)
Other controls[a]	Yes	Yes	Yes	Yes
Observations	2514	2514	2514	2514

[a]All specifications use sampling weights and include controls for household income, age, age squared and dummy variables for sample, region, gender, educational attainment, and marital status.
Robust z statistics in parentheses. * significant at10%; ** significant at 5%

Table 5: Importance of Global Warming: Interactions with Media Exposure and Level of Environmentalism (Ordered Probit Coefficients)

	(1)	(2)	(3)	(4)
Definitely environmentalist	0.999***	0.994***	0.635***	0.627***
	(5.47)	(5.47)	(4.14)	(4.17)
Somewhat environmentalist	0.637***	0.632***	0.358***	0.342***
	(7.01)	(6.93)	(5.70)	(5.53)
August heat wave	1.116***			
	(2.59)			
News variety	0.079	0.056		
	(1.51)	(1.07)		
News variety * August heat wave	-0.222*			
	(1.79)			
July and August heat wave		0.829**		
		(2.00)		
News variety * July and August heat wave		-0.141		
		(1.19)		
Definitely environmentalist*August heat wave			0.027	
			(0.07)	
Somewhat environmentalist*August heat wave			0.0534	
			(0.46)	
Not environmentalist*August heat wave			0.293**	
			(2.33)	
Definitely environmentalist*July and August heat wave				-0.093
				(0.24)
Somewhat environmentalist*July and August heat wave				0.106
				(0.87)
Not environmentalist*July and August heat wave				0.264*
				(1.90)
Other controls[a]	Yes	Yes	Yes	Yes
Observations	1121	1121	2514	2514

[a]All specifications use sampling weights and include controls for household income, age, age squared, party identification, and dummy variables for sample, region, gender, educational attainment, and marital status.

Robust z statistics in parentheses. * significant at 10%; ** significant at 5%

Table 6: Support for laws to protect environment, controlling for prior support and economic conditions (Probit Coefficients)

	(1)	(2)	(3)	(4)
Support in 2007	0.8980**	1.0174**	0.9981**	0.9778**
	(5.02)	(5.56)	(5.53)	(5.37)
Definitely environmentalist	1.0991**	1.2228**	1.1706**	1.4008**
	(3.42)	(3.66)	(3.59)	(3.82)
Somewhat environmentalist	0.4667**	0.5096**	0.5007**	0.5260**
	(2.61)	(2.83)	(2.79)	(2.94)
Party ID	0.1303**	0.1350**	0.1331**	0.1319**
	(3.02)	(3.08)	(3.05)	(2.98)
Currently working	0.1943	0.131	0.117	0.0815
	(0.95)	(0.61)	(0.56)	(0.38)
Vacancy Rate	4.3394**	5.0421**	5.0575**	5.1616**
	(2.03)	(2.39)	(2.34)	(2.45)
August heat wave		0.6690**		0.6425**
		(2.42)		(2.33)
August drought			0.4711	
			(1.61)	
Fell behind in payments				0.5338*
				(1.92)
Other controls[a]	Yes	Yes	Yes	Yes
Observations	415	405	405	404

[a]All specifications use sampling weights and include controls for household income, age, age squared, and dummy variables for region, gender, educational attainment, and marital status.
Robust z statistics in parentheses. * significant at 10%; ** significant at 5%