

ISSN 0199-0039, Volume 32, Number 1



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The effects of gender on climate change knowledge and concern in the American public

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Published online: 5 June 2010
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Abstract This study tests theoretical arguments about gender differences in scientific knowledge and environmental concern using 8 years of Gallup data on climate change knowledge and concern in the US general public. Contrary to expectations from scientific literacy research, women convey greater assessed scientific knowledge of climate change than do men. Consistent with much existing sociology of science research, women underestimate their climate change knowledge more than do men. Also, women express slightly greater concern about climate change than do men, and this gender divide is not accounted for by differences in key values and beliefs or in the social roles that men and women differentially perform in society. Modest yet enduring gender differences on climate change knowledge and concern within the US general public suggest several avenues for future research, which are explored in the conclusion.

Keywords Gender · Climate change · Knowledge · Concern

Introduction

For several decades, sociologists of science and environmental sociologists have been investigating gender dynamics in scientific knowledge and environmental concern, respectively. The upshot is a mix of both robust patterns and inconclusive results. Largely independent of these efforts is a burgeoning, multidisciplinary literature examining public opinion on global warming, an important science-based environmental issue rife with political conflict and moral concerns. To date, no work

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on global warming public opinion systematically analyzes in much theoretical depth how gender relates to global warming beliefs and attitudes. Rather, studies typically include gender as a statistical control in multivariate models and then only discuss the performance of this variable in passing—often with little or no theoretical discussion. This current study attempts to remedy this situation.

Global warming, or climate change,¹ is the most expansive global environmental problem facing humanity and arguably is the most serious environmental challenge to the Western experience of modernity—e.g., economic growth, industrial capitalism, technological development, and material prosperity. As such, climate change is a theoretically and empirically interesting case for examining gender dynamics. The scientific basis and dangerousness of this problem urge integration of insights from previous gender work in sociology of science and environmental sociology.

To this end, I employ theoretical insights from relevant literatures on gendered experiences with science and on gender differences in environmental concern to examine gender dynamics in climate change public opinion. This analysis provides an opportunity to adjudicate among competing environmental concern hypotheses, while also improving our understanding of the American public's beliefs and attitudes about this impending global environmental problem. Two questions guide this study. First, how, if at all, do men and women differ in their climate change knowledge and in their perception of this knowledge? Second, how, if at all, do men and women differ in their climate change concern? Following the suggestion of Freudenburg and Davidson (2007) and Greenbaum (1995), I analyze the effects of several theoretically important variables on climate change concern that typically have been examined individually in previous environmental concern studies.

Gender, scientific knowledge, and environmental concern

I begin by reviewing past work on gender differences in scientific knowledge and in self-perceptions of scientific competence, before deriving a few key hypotheses. I then more extensively review the literature on the association between gender and environmental concern, focusing specifically on the key theoretical arguments through which scholars explain gender differences.² I derive hypotheses from these claims that facilitate an analysis of the direct and indirect effects of gender on environmental concern.

¹ I use climate change and global warming interchangeably, although the former technically connotes all forms of climatic variability introduced by the warming of Earth's surface and oceans stemming from the increased accumulation of greenhouse gases in Earth's atmosphere. The increased concentration of such gases strengthens the natural "greenhouse effect" whereby the atmosphere absorbs the sun's radiation rather than allowing it to escape into space (see National Research Council 2001, 2008).

² Since this study does not address environmental behavior, I do not review the large literature on the relationship between gender and environmental behavior (see, e.g., Hunter et al. 2004). This review also is limited to the association between gender and environmental concern in the United States.

Gender and scientific knowledge

Much research documents how differences in the ways men and women experience science and math education facilitate gender inequality within the institution of science (e.g., AAUW 1992; COSEPUP 2007) and lead to divergent perceptions of science between adult men and women in the general public (e.g., Fox and Firebaugh 1992; Miller 2007). Largely independent of actual achievement during their science and math education, girls tend to express lesser confidence in their science and math abilities, lower expectations for success in science and math courses, and lesser interest in science and math than do boys (e.g., Jacobs and Simpkins 2006; Jones et al. 2000; Seymour and Hewitt 1997; VanLeuvan 2004). These gender differences first emerge in middle school (e.g., Catsambis 1995), they increase in high school (e.g., Miller et al. 2006), and they persist throughout the college years and beyond (e.g., Etkowitz et al. 2000). This results in young women taking fewer science and math courses in high school and college compared to young men (AAUW 1992; COSEPUP 2007).

The cumulative effect of these dynamics is that men and women differ, on average, in their knowledge and perceptions of science. In the general public, men demonstrate greater scientific knowledge and scientific literacy than do women (e.g., Arcury et al. 1987; Hayes 2001; Miller 2007). Further, women display less confidence in their scientific knowledge and abilities than do men (e.g., Jacobs and Simpkins 2006), and women express less trust in science to solve problems than do men and are more critical of science and technology than are men (e.g., Blocker and Eckberg 1997; Fox and Firebaugh 1992; Olsen et al. 1992). Given these robust patterns, I posit the following two hypotheses about the association between gender and climate change knowledge. First, I expect that *men exhibit more scientifically accurate knowledge about climate change than do women* (Hypothesis 1). Second, I expect that *women underestimate their climate change knowledge more than do men* (H2).

Gender and environmental concern

Initial studies of environmental concern in the 1960s and 1970s typically found no gender differences in environmental attitudes and support for environmental policies (e.g., Van Liere and Dunlap 1980). However, studies since then report the following patterns. Women express more concern than do men about local environmental problems, especially those posing health and safety risks to community members—such as nuclear waste (e.g., Davidson and Freudenburg 1996; Greenbaum 1995; Mohai 1992). Gender differences persist, though to a lesser extent, when the focus is general environmental concern (e.g., pro-environmental attitudes, support for environmental protection) and non-local problems with no identifiable health and safety risks. Especially, when measures of general environmental concern explicitly tap risk perceptions, women consistently express more concern than do men (Bord and O'Connor 1997; Davidson and Freudenburg 1996).³ Overall, then, women are

³ This is consistent with the finding that women are more concerned than are men about a wide range of risks—not just environmental ones (e.g., Slovic 2001).

modestly more concerned about general environmental issues than are men (Blocker and Eckberg 1997; Davidson and Freudenburg 1996; McStay and Dunlap 1983; Mohai 1992).

Over the years, empirical analyses of the relationship between gender and environmental concern increasingly have engaged sociological theories of gender. I now turn to the key theoretical arguments scholars use to explain the effect of gender on environmental concern. Like others in this literature, I organize these perspectives into two groups: those emphasizing gender socialization and those emphasizing the different social roles men and women tend to perform. Most scholars hypothesize that men and women differ in their environmental concern because they vary on some relevant social or cultural characteristic that directly influences environmental concern (see Davidson and Freudenburg 1996). Where relevant below, I identify the name that past theoretical reviews have termed each argument. Interested readers can find further discussion of the hypotheses in these reviews.

Gender socialization perspectives

Gender socialization theorists (e.g., Chodorow 1978; Gilligan 1982) emphasize the different values and social expectations conferred to boys and girls through socialization into their society's dominant culture. Briefly, boys learn that masculinity in the United States means being competitive, independent, and unemotional and entails objectively exerting mastery and control over other people and things. Also, boys realize they are expected to economically provide for their family when they grow up and become fathers. On the other hand, girls learn that femininity in the United States means being compassionate, cooperative, and empathetic and entails connecting with other people and expressing concern about their well-being. Also, girls realize they are expected to enact an ethic of care as a nurturing caregiver when they grow up and become mothers. In short, a masculine identity emphasizes detachment, control, and mastery, while a feminine identity stresses attachment, empathy, and care (e.g., Keller 1985; Merchant 1980).

Studies that find a direct effect of gender on environmental concern (wherein women express more concern than do men)—especially when controlling for key social roles variables—support this simple gender socialization argument. In the past few decades, many studies of environmental concern in the United States include an analysis of gender (e.g., Blocker and Eckberg 1997; Davidson and Freudenburg 1996; Greenbaum 1995; Klineberg et al. 1998; Marshall 2004). Zelezny and colleagues' (2000) finding that young girls report stronger pro-environmental attitudes and beliefs than do young boys provides strong evidence that early years of gender socialization influence males' and females' environmental concern. Gender socialization especially helps explain why women are more concerned than are men about local environmental problems that pose significant health and safety risks for community members (e.g., Davidson and Freudenburg 1996; Freudenburg and Davidson 2007; Greenbaum 1995; Mohai 1992). Indeed, this "Concerns about Health and Safety" hypothesis (Blocker and Eckberg 1997) or "Safety Concerns Hypothesis" (Davidson and Freudenburg 1996) enjoys considerable support in the literature.

Research indicates that Americans do not perceive climate change as having recognizable, immediate health and safety risks to them or their communities. Rather, they generally think of climate change as causing harm to geographically and temporally distant people and other species, such as polar bears (Leiserowitz 2005). Hence, it seems reasonable that climate change survey items are more like generalized indicators of environmental concern than like items tapping risk perceptions about health and safety (see Davidson and Freudenburg 1996: 314).⁴ Thus, I do not expect a large gender divide on climate change concern; rather, I expect that *women express slightly more concern about climate change than do men, especially when controlling for key social roles variables* (H3).

A few other theoretical arguments extend the gender socialization perspective. Scholars identify four such arguments, but I only discuss two since data limitations preclude testing the other two.⁵ Briefly, each claims that men and women socialized respectively into masculine and feminine identities differ on key *beliefs and values* that directly influence environmental concern. A strict interpretation of each holds that these beliefs and values account for gender differences in environmental concern, such that including these variables in a model predicting environmental concern weakens the direct effect of gender.

First, according to the “Environmental Knowledge” hypothesis (Blocker and Eckberg 1997) or “Knowledgeable Support Hypothesis” (Davidson and Freudenburg 1996), some scholars argue that a gender difference in scientific knowledge helps explain gender variation in environmental concern. The argument is that since men tend to have greater scientific knowledge than women and knowledge is inversely related to concern, then men will express less environmental concern than women. Most studies in this area do find that men have greater scientific and technical knowledge than do women (e.g., Arcury et al. 1987; Blocker and Eckberg 1997; Hayes 2001). Yet, this research also finds that knowledge has mixed or inconclusive effects on concern (e.g., Blocker and Eckberg 1997; Davidson and Freudenburg 1996; Hayes 2001). Despite the paucity of evidence supporting the claim of an inverse relationship between knowledge and concern, this argument endures—exemplified in the assertion that informing the public about new technologies and emerging ecological problems will reduce their perceived risks and concern. H1 anticipates that men have greater scientific knowledge than do women, and H4a completes this argument by expecting that *assessed knowledge of*

⁴ Indeed, at least one study finds that general environmental values and beliefs are the strongest correlates of climate change attitudes and beliefs (Kellstedt et al. 2008).

⁵ The other two are as follows. According to the “Trust in Science and Technology Hypothesis” (Blocker and Eckberg 1997) or the “Institutional Trust Hypothesis” (Davidson and Freudenburg 1996), some argue that differences between men and women in levels of trust in science and technology explain gender differences in environmental concern. Many studies find that women tend to trust science and technology less than do men (e.g., Blocker and Eckberg 1997; Davidson and Freudenburg 1996; Flynn et al. 1992; Fox and Firebaugh 1992), and others find that trust in science and technology is negatively related to environmental concern (e.g., Freudenburg 1993; see review in Davidson and Freudenburg 1996). Also, Stern et al. (1993) argue that differences in men’s and women’s value orientations explain gender differences in environmental concern. Indeed, the authors provide evidence that women’s significantly strong embrace of altruism is the basis for gender differences in environmentalism (Dietz et al. 2002).

climate change relates negatively to climate change concern. I further expect that inclusion of assessed knowledge in an explanatory model substantially weakens the direct effect of gender on climate change concern (H4b).

Second, a few scholars reviewed by Blocker and Eckberg (1997) argue that differences between men and women in religious beliefs and religiosity explain gender differences in environmental concern. Briefly, women tend to express stronger religious beliefs and greater levels of religiosity than do men (e.g., Batson et al. 1993; Blocker and Eckberg 1997), and religiosity is associated negatively with environmental concern (e.g., Eckberg and Blocker 1989, 1996; Hayes 2001; Kanagy and Willits 1993). Following from this argument, I expect that *religiosity has a negative effect on climate change concern (H5a)* and that *inclusion of religiosity substantially weakens the direct effect of gender on climate change concern (H5b)*. The simpler version of the gender socialization argument, tested in H3, retains support if the expected effect of gender on concern remains significant controlling for assessed knowledge and religiosity.

Social roles perspectives

Another set of theoretical perspectives focuses not on the effects of gender socialization but on the influences of the social roles that men and women differentially perform in society. Greenbaum (1995:134) captures the general sentiment of these arguments: “The different attitudes of men and women...reflect the different experiences, competencies, interests, and dispositions that come from performing (and being socialized to perform) these different roles.” For the most part, scholars focus on three productive or reproductive roles: employment status, homemaker status, and parenthood.

Several scholars investigate the influence of men’s and women’s differential paid labor force participation on their environmental concern—the “Economic Growth Orientation” (Blocker and Eckberg 1997) or “Economic Salience Hypothesis” (Davidson and Freudenburg 1996). Building upon the socialization perspectives discussed earlier, some early research argued that conventional gender socialization leads men to internalize a “marketplace mentality” and women to internalize a “motherhood mentality.” While the former favors economic growth and exploitation of natural resources for human benefit, the latter favors protection of nature and other species. Early studies assumed that these two orientations were activated by the greater participation of men than women in the paid labor force in past decades (Blocker and Eckberg 1997). Most of this research has produced mixed and generally inconclusive results—see review by Blocker and Eckberg (1997).

Yet, scholars more recently seek to examine the direct effect that labor force participation has on environmental concern independent of gender. In this iteration, scholars argue that employment for pay outside the home leads to greater concern for economic issues and lesser concern for environmental issues for both men and women. Overall, the results for this hypothesis have been mixed (Davidson and Freudenburg 1996; Hayes 2001). Interestingly enough, a few studies challenge this hypothesis by finding that people who are employed full-time are more concerned about the environment than are those who are not (e.g., Blocker and Eckberg 1989;

Mohai 1992). Further, Mohai (1992) reports that women employed full-time are still more concerned about the environment than are men employed full-time.

As a corollary to this employment hypothesis, some argue that a woman's decision to be a homemaker triggers her values of nurturance, compassion, and empathy in such a way as to increase environmental concern—the “Family Roles and Environmentalism” hypothesis (Blocker and Eckberg 1997). Mohai (1992) and Blocker and Eckberg (1989, 1997) examine this hypothesis and find—contrary to expectations—that women with some labor force experience express more pro-environmental beliefs than do women who are homemakers. From the theoretical arguments above, I expect that *full-time employment has a negative effect on climate change concern* (H6) and that *homemaker status has a positive effect on climate change concern* (H7).

Finally, some scholars also investigate the effect that parenthood has on men's and women's environmental concern—the “Parenthood Status” hypothesis (Blocker and Eckberg 1997) or “Parental Roles Hypothesis” (Davidson and Freudenburg 1996). Briefly, theorists expect that parenthood increases “parents' attentiveness to consequences bearing on their sex-typed roles in families: for mothers, concern for their children's health; for fathers, concern for the material well-being of the family” (Stern et al. 1993:331). On one hand, parenthood triggers the nurturance mentality of mothers who become more concerned about the health and safety of their children—and more concerned about the environment. On the other, parenthood triggers the marketplace mentality of fathers who become more concerned with economic growth because of their conventional role as economic provider, leading fathers to be less concerned about the environment (Greenbaum 1995).

Findings in this area seem to be consistent with the theoretical expectation that motherhood increases environmental concern for women (e.g., Blocker and Eckberg 1989; Davidson and Freudenburg 1996; Greenbaum 1995; Hamilton 1985a, b), though slightly fewer studies find that fatherhood decreases environmental concern for men (e.g., Blocker and Eckberg 1989; George and Southwell 1986; Greenbaum 1995). Several other studies find either mixed results or overall non-significance for parenthood status (e.g., Freudenburg 1993; Blocker and Eckberg 1997). Following the theoretical argument, I expect that *parenthood has a negative effect on men's climate change concern and a positive effect on women's climate change concern* (H8).

The study

My data come from the March 2001–2008 Gallup Polls that focus specifically on environmental issues.⁶ Each of the eight Gallup surveys is based on telephone

⁶ Gallup interviewers begin each telephone interview with well-established questions on a range of general topics before turning at the end of their interviews to specific questions on environmental issues. The 2001 poll has a sample of 1060 adults interviewed between March 5–7; the 2002 poll has a sample of 1006 adults interviewed between March 4–7; the 2003 poll has a sample of 1003 adults interviewed between March 3–5; the 2004 poll has a sample of 1005 adults interviewed between March 8–11; the 2005 poll has a sample of 1004 adults interviewed between March 7–10; the 2006 poll has a sample of 1000 adults interviewed between March 13–16; the 2007 poll has a sample of 1009 adults interviewed between March 11–14; and the 2008 poll has a sample of 1012 adults interviewed between March 6–9.

interviews with nationally representative samples of adults (age 18 years or older) in the United States.⁷ For the multivariate statistical analyses, I combined the data from the 8 years into a pooled sample.⁸ The March 2001 survey was the first to include key variables used in this study. Also, 2001 saw the publication of the Intergovernmental Panel on Climate Change's (2001) *Third Assessment Report* and the National Research Council's (2001) *Climate Change Science*. Both publications clearly establish the current scientific consensus that global warming has already begun, that human activities are a significant contributor to global warming, and that mean global temperature will increase between 1.4 and 5.8°C by 2100.

Table 1 provides the description, coding, mean, and standard deviation of the variables in this study. Gallup included three scientific knowledge items across multiple years of this time period. I dichotomized these three climate change knowledge items to conceptually distinguish “scientifically accurate” responses from responses that are less than accurate—given our current scientific understanding of climate change. These three knowledge variables are: timing of global warming (already begun to happen = 1), primary cause of recent global warming (effects of pollution from human activities = 1), and scientific consensus on global warming (most scientists believe global warming is occurring = 1).

Gallup also included three climate change concern items across multiple years of this time period. The original Gallup items contained different numbers of response categories, so I scaled the three items from 0 to 1 to make them comparable. These three concern variables are: worry about global warming (not at all = 0; a little bit = .33; a moderate amount = .67; a great deal = 1), perceived threat of global warming (no = 0; global warming will pose a serious threat to you and your way of life in your lifetime = 1), and seriousness of global warming (seriousness of global warming is generally exaggerated in the news = 0; seriousness of global warming is generally correct in the news = .50; seriousness of global warming is generally underestimated in the news = 1).

For each group of three climate change knowledge items and three climate change concern items, I created a summative index for use in multivariate regression analyses. Both indexes range from 0 to 3, with higher scores indicating greater knowledge and concern, respectively. The climate change knowledge index has a Cronbach's alpha of .685 ($N = 3072$), while the climate change concern index has a Cronbach's alpha of .653 ($N = 4078$). These values are slightly lower than the .700 threshold typically desired when creating scales, yet they do indicate a reasonable level of reliability for a three-item index.

Gender is coded 0 for men and 1 for women. A straightforward measure of perceived understanding of global warming asked respondents to self-report how much they understand the issue of global warming (not at all = 1 to a great deal = 4). Religiosity was coded “never attend church” = 1 to “attend church once

⁷ As is typical in most national surveys, the Gallup Organization employs weighting procedures on the sample data to ensure that the samples are representative of the American adult population. I do not employ data weights when performing multivariate analyses, because weighting can lead to inflated standard errors and misleading tests of significance (Winship and Radbill 1994).

⁸ The lack of a statistically significant temporal trend in the key dependent variables (i.e., the climate change knowledge and concern indexes) indicates that pooling is appropriate.

Table 1 Coding, mean, and standard deviation for variables in the study

Variable	Coding	Mean	SD
Timing of global warming	0 (not yet begun to happen) to 1 (already begun to happen)	.55	.50
Primary cause of global warming ^a	0 (natural changes in the environment) to 1 (effects of pollution from human activities)	.60	.49
Scientific consensus on global warming ^b	0 (most scientists believe global warming is not occurring or most scientists are unsure) to 1 (most scientists believe global warming is occurring)	.63	.48
Climate change knowledge index ^b	Summative index (0–3) = timing of global warming + primary cause of global warming + scientific consensus on global warming	1.80	1.14
Worry about global warming ^c	0 (not at all) to 1 (a great deal)	.59	.36
Perceived threat of global warming ^d	0 (will not) to 1 (will pose a serious threat to you and your way of life in your lifetime)	.35	.48
Seriousness of global warming	0 (seriousness of global warming is generally exaggerated in the news) to 1 (seriousness of global warming is generally underestimated in the news)	.49	.40
Climate change concern index ^d	Summative index (0–3) = worry about global warming + perceived threat of global warming + seriousness of global warming	1.42	.95
Gender	0 (male) to 1 (female)	.52	.50
Perceived understanding	1 (not at all) to 4 (a great deal)	2.85	.77
Religiosity	1 (never attend church) to 5 (attend church once a week)	3.11	1.52
Full-time employment	0 (no) to 1 (yes)	.52	.50
Homemaker	0 (no) to 1 (yes)	.06	.23
Parenthood ^e	0 (no) to 1 (yes)	.37	.48
Political ideology	1 (very conservative) to 5 (very liberal)	2.80	.94
Party affiliation	1 (Republican) to 5 (Democrat)	3.05	1.68
Educational attainment	1 (high school graduate or less) to 4 (more than college graduate)	2.03	1.06
Age	18 to 95 (number in actual years)	46.74	17.33
Race	0 (white) to 1 (non-white)	.17	.37
Annual income	1 (less than \$20,000) to 5 (more than \$75,000)	3.25	1.37
Year	1 (2001) to 8 (2008)	4.48	2.30

Data is weighted

^a Data for 2001, 2003, 2006–2008

^b Data for 2001, 2006, 2008

^c Data for 2001–2004, 2006–2008

^d Data for 2001, 2002, 2006, 2008

^e Data for 2001–2007

a week” = 5. Three dichotomous variables (coded no = 0 and yes = 1) measured whether or not respondents were employed full-time, were a homemaker, and were a parent of a child under the age of 18 living at home. To test H8 (that parenthood has a negative effect on men’s climate change concern and a positive effect on

women's concern), I created a parenthood*gender interaction term using centered scores.⁹ Utilizing higher-order (e.g., interaction) terms in regression models often leads to multicollinearity problems. Interaction terms based on centered scores have a different scale than the original variables, thus greatly reducing these multicollinearity problems (e.g., Aiken et al. 1991; Hamilton 2008).

To rigorously examine the effects of gender and these other factors, I control for several political, social, and demographic variables believed to correlate with these climate change beliefs and attitudes: political ideology, party affiliation, educational attainment, age, race, and annual income. I coded these in conventional ways indicated in Table 1. The survey year was measured simply as “2001” = 1 to “2008” = 8.

I first compare the means (or percentages) for men and women on each of the climate change knowledge and concern items and indexes—largely for illustrative purposes. To test the hypotheses derived earlier, I then analyze the results of several multivariate OLS regression models that examine the effect of gender on the climate change knowledge and concern indexes.

Results

Between 2001 and 2008, slight majorities of Americans believed that the effects of global warming have already begun to happen (54.93% in pooled sample), that temperature changes over the last century are due more to human activities than to natural changes in the environment (59.69%), and that most scientists believe global warming is occurring (63.42%). Yet, only one-third of Americans worried about global warming a great deal (32.88% in pooled sample), believed that global warming will pose a serious threat to them and their way of life during their lifetime (34.83%), and believed the seriousness of global warming is generally underestimated in the news (33.18%).¹⁰ Table 2 displays key comparisons of men and women on each of the climate change knowledge and concern items and indexes.

Gender and climate change knowledge

I turn first to the top two sections of Table 2, which deal with assessed knowledge and perceived understanding, respectively. Because the individual climate change knowledge items are dichotomously coded with “1” representing acceptance of the scientifically accurate knowledge claim, the means for men and women are also the percents of individuals in these groups reporting the scientifically accurate

⁹ For both variables, I calculated an unweighted mean for the pooled sample before creating a centered score (raw score minus mean).

¹⁰ Global warming ranks relatively low on lists of environmental problems citizens worry about. For instance, in 2008, global warming ranked tenth out of twelve environmental problems (above urban sprawl and acid rain) (Jones 2008). For the most part, Americans worry much more about local air and water pollution problems than they do about global problems (such as the loss of tropical rain forests, damage to the earth's ozone layer, and global warming).

Table 2 Climate change knowledge and concern by gender (2001–2008 pooled sample)

Belief or attitude item/index	Men	Women	Gamma ^a
Assessed climate change knowledge			
% who believe the effects of global warming have already begun to happen	.54	.59	.107***
% who believe pollution from human activities are primary cause of global warming	.56	.64	.168***
% who believe most scientists believe global warming is occurring	.60	.66	.141***
climate change knowledge index mean	1.73	1.91	.107***
Perceived understanding			
Perceived understanding of global warming mean	3.04	2.75	-.336***
Climate change concern			
% who worry about global warming a great deal	.29	.35	.162***
% who believe global warming will threaten their way of life	.28	.37	.198***
% who believe the seriousness of global warming is underestimated in the news	.28	.35	.225***
climate change concern index mean	1.29	1.55	.174***

^a Gamma for the relationship between gender and each item/index

* $p < .05$, ** $p < .01$, *** $p < .001$

knowledge claim. The last column is the Gamma value for the relationship between gender and each item or index.

The overall patterns in the top two sections of Table 2 are clear. While women exhibit greater assessed climate change knowledge than do men, men report greater perceived understanding than do women. Looking in the top section, a greater percentage of women than men believe that global warming is happening now (59% to 54%) and is primarily caused by human activities (64% to 56%). Also, a greater percentage of women than men (66% to 60%) agree that most scientists believe global warming is happening.

Compared to differences on the basis of other characteristics, such as party affiliation (Dunlap and McCright 2008), this gender divide in climate change knowledge is not overwhelming. Yet, it is statistically significant, and examination of these percents across each year in the time period (not reported here) suggests that these modest gender differences remain consistent over time. Women hold more scientifically accurate beliefs about climate change than do men, which is opposite of what has been found with other measures of environmental or scientific knowledge in the past (e.g., Arcury et al. 1987; Hayes 2001). The positive Gamma values in the top section suggest rejection of H1, which expects men to exhibit more scientifically accurate knowledge about climate change than women.

Moving to the middle section, we see that men (average = 3.04) perceive a greater understanding of global warming compared to women (average = 2.75). The relationship between gender and perceived understanding is moderately strong with gamma (γ) = -.336. This seems consistent with existing findings that women display lesser confidence in their scientific knowledge than do men (e.g., Jacobs and Simpkins 2006).

Table 3 OLS regression model explaining climate change knowledge index score ($N = 3072$)

Independent variables	Standardized coefficients
Gender	.067***
Political ideology	.170***
Party affiliation	.219***
Educational attainment	.089***
Age	-.101***
Race	-.081***
Income	.045*
Religiosity	-.044*
Year	.005
Adjusted R^2	.15

* $p < .05$, ** $p < .01$,*** $p < .001$ (two-tailed tests)

To more directly test H1, I now examine the effect of gender on assessed climate change knowledge, while controlling for a group of relevant political, socio-demographic, and temporal variables. Table 3 displays the standardized coefficients from an OLS regression model examining the effects of these predictors on the climate change knowledge index.¹¹ Gender has a statistically significant positive effect on individuals' climate change knowledge index scores, when controlling for other relevant variables. The gender differences we saw in the top section of Table 2 hold up in multivariate analyses. While the effect of gender is weak (it alone accounts for only 1% of the variance in climate change knowledge index scores), more importantly, it is in the opposite direction of what H1 expects. Contrary to past research on other environmental topics that found men to be more knowledgeable than women (e.g., Arcury et al. 1987; Hayes 2001), I find that women express more scientifically accurate climate change knowledge than do men. This provides sufficient evidence to reject H1.

Other results in Table 3 are noteworthy. Rarely do existing publications examine correlates of climate change knowledge; rather, they most commonly focus on climate change concern. As such, the following results may be informative. Parallel to political dynamics among elites (e.g., Lahsen 2005; McCright and Dunlap 2000, 2003), political liberals and Democrats in the general public are more knowledgeable about climate change than are their politically conservative and Republican counterparts. As we might expect, educational attainment has a positive effect on climate change knowledge. Younger adults and whites are more knowledgeable about climate change than are their older and non-white counterparts. Two other variables (income and religiosity) appear to have a small effect on climate change knowledge. Increased income leads to greater knowledge, while increased religiosity leads to lesser knowledge. As mentioned earlier, there is no significant trend for climate change knowledge over the time period.

¹¹ The results of this model predicting scores on the climate change knowledge index are similar to the results of separate models predicting values of each of the three individual climate change knowledge items. For space reasons, I only present the results of the former model.

Table 4 OLS regression models explaining perceived understanding of climate change ($N = 3072$)

Independent variables	Model A	Model B
Gender	-.155***	-.155***
Climate change knowledge index	.137***	.140***
Gender*climate change knowledge index		.046**
Political ideology	-.039	-.039
Party affiliation	-.040*	-.040*
Educational attainment	.173***	.171***
Age	-.054**	-.053**
Race	-.020	-.019
Income	.081***	.081***
Religiosity	-.037*	-.037*
Year	.089***	.088***
Adjusted R^2	.12	.12

Note Entries are standardized coefficients

* $p < .05$, ** $p < .01$,

*** $p < .001$ (two-tailed tests)

In order to adequately test H2, that women underestimate their climate change knowledge more than do men, we must examine how men and women perceive their understanding of global warming controlling for their assessed knowledge. Table 4 reports the standardized coefficients from two OLS regression models explaining perceived understanding. Additional analyses (not reported here) demonstrate that gender differences in perceived understanding reduce slightly as scores of the climate change knowledge index increased. Following the suggestion of one reviewer, I created a gender*climate change knowledge index interaction term using centered scores. Model B contains this interaction term.

As we might expect, individuals' climate change knowledge index scores are positively related to their perceived understanding. Yet, when controlling for this (and eight other political, socio-demographic, and temporal variables), gender still has a statistically significant negative effect on perceived understanding. In other words, controlling for assessed climate change knowledge (and other relevant variables), women perceive a lesser understanding of climate change compared to men. Though, the positive coefficient on the gender*climate change knowledge interaction term means that this gender divide is not as large between men and women with greater assessed knowledge than it is between those with lesser knowledge. Overall, H2 receives strong support. Women do underestimate their climate change knowledge more than men do. This supports the results of earlier studies dealing with general scientific knowledge (e.g., Jacobs and Simpkins 2006).

Gender and climate change concern

The bottom section in Table 2 displays the results of comparisons between men and women on the three climate change concern items and the summative index. For the three individual items, the values reported are the percents of men and women expressing a high level of concern. A clear pattern is illustrated. Women express more concern about climate change than men do. A greater percentage of women than men worry about climate change a great deal (35% to 29%), believe global

warming will threaten their way of life during their lifetime (37% to 28%), and believe the seriousness of global warming is underestimated in the news (35% to 28%). As with the climate change knowledge items, these gender differences are not as large as those on the basis of other characteristics, such as party affiliation (Dunlap and McCright 2008). Yet, they are statistically significant, and the positive Gamma values for the three items and the summative index provide preliminary evidence in support of H3.

Table 5 presents the results of multivariate OLS regression models that examine the effects of key gender socialization and social roles variables on climate change concern, while controlling for seven political, socio-demographic, and temporal variables.¹² The performance of the gender variable across the models bears upon H3, the simple version of the gender socialization argument that women express slightly more concern than do men—especially when controlling for key extended gender socialization and social roles variables. The results of Models B and C address extended gender socialization arguments and help us adjudicate hypotheses 4a,b and 5a,b about the independent effects of climate change knowledge and religiosity, respectively. Finally, the results of Models D, E, and F address social roles arguments and bear upon H6 (employment), H7 (homemaker), and H8 (parenthood). Overall, the results in Table 5 provide ample support for the simple version of the gender socialization argument, no support for extended gender socialization arguments, and no support for social roles arguments.

Gender has a statistically significant, positive effect on climate change concern in each of the models in Table 5, controlling for extended gender socialization and social roles variables and other relevant political and socio-demographic variables. Thus, the gender differences seen in the bottom section of Table 2 hold up in multivariate analyses. Women express slightly more concern about climate change than do men, as other climate change public opinion studies find (e.g., Brody et al. 2008; O'Connor et al. 1999; Hamilton 2008; Leiserowitz 2006; Malka et al. 2009). Gender differences in climate change concern are more similar to the rather modest gender differences on attitudes toward general environmental issues than they are to the larger gender differences on concern about local environmental problems—especially those posing immediate health and safety risks to community members (Davidson and Freudenburg 1996; Mohai 1992).

These results provide strong evidence in support of H3. The positive effect of gender is not weakened by inclusion of relevant social roles variables (Models D, E, and F). Nor is it substantially reduced by inclusion of key extended gender socialization variables (Models B and C). All of this supports the simple version of the gender socialization argument (Zelezny et al. 2000) that gender differences in environmental concern cannot be explained away by gender differences in key beliefs and values or in the social roles that men and women differentially perform.

According to Model B, climate change knowledge has a strong, positive effect on climate change concern, even controlling for other key variables. This is strong

¹² To check for possible multicollinearity problems, I examined the variance inflation factors (VIF) from each of the models in Table 5. The greatest VIF in Table 5 is 1.49 in the fully specified model, well below the threshold of 10 that is cause for concern about multicollinearity (see Chatterjee et al. 2000).

Table 5 OLS regression models explaining climate change concern index scores

Independent variables	Zero-order correlation	A	B	C	D	E	F	Fully Specified model
Gender socialization variables								
Gender	.137***	.094***	.062***	.094***	.097***	.091***	.091***	.057**
Climate change knowledge index	.540***		.459***					.437***
Religiosity	-.097***			-.010				.068***
Social roles variables								
Full-time employment	.010				.024			.018
Homemaker	.020					.019		.039*
Parenthood	.012						-.014	-.011
Parenthood*gender	-.008						-.032	-.020
Political ideology	.319***	.190***	.129***	.188***	.191***	.190***	.163***	.129***
Party affiliation	.372***	.263***	.166***	.263***	.263***	.264***	.260***	.185***
Educational attainment	-.024	-.005	-.052**	-.004	-.006	-.004	-.003	-.055**
Age	-.111***	-.122***	-.076***	-.121***	-.114***	-.122***	-.135***	-.093***
Race	.142***	.072***	.099***	.073***	.072***	.073***	.068***	.084***
Income	-.107***	-.071***	-.090***	-.072***	-.076***	-.072***	-.065***	-.084***
Year	.019	.024	.014	.023	.025	.024	.027	.024
Adjusted R ²		.20	.40	.20	.20	.20	.18	.36
Sample size		4078	3072	4078	4078	4078	3066	2060

Notes Zero-order correlations listed are those for each of the independent variables and the climate change concern index. Entries for Models A to F and the Fully Specified Model are standardized coefficients

* $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests)

evidence to reject H4a, which expects that knowledge relates negatively to concern. Between 2001 and 2008, Americans with greater knowledge about climate change expressed greater concern about climate change than did those with lesser knowledge. This supports the results of at least one recent climate change public opinion study (e.g., Wood and Vedlitz 2007), which found the same relationship. Time and time again, environmental concern scholars find that greater environmental knowledge does not lead to lesser environmental concern (e.g., Hayes 2001). Given the positive relationship between knowledge and concern here, I agree with Davidson and Freudenburg (1996) that we should discard the “Environmental Knowledge” hypothesis (Blocker and Eckberg 1997) or “Knowledgeable Support Hypothesis” (Davidson and Freudenburg 1996) at this point.

A strict interpretation of extended gender socialization arguments holds that gender differences on key values and beliefs account for gender differences in environmental concern. H4b expects that inclusion of assessed climate change knowledge in a model explaining climate change concern substantially weakens the direct effect of gender. To evaluate H4b, we must examine the coefficient for gender in Model B (and compare it to the gender coefficient in Model A). Inclusion of assessed knowledge slightly reduces the magnitude of the direct effect of gender, but it remains statistically significant. Thus, there is insufficient evidence to support H4b. Gender still has a direct effect on concern while controlling for knowledge.

Past scholarship argues that religiosity relates negatively to environmental concern. Yet, judging from the results of Model C, religiosity has no statistically significant effect on climate change concern, and its inclusion in the model does not influence the direct effect of gender. These results challenge the findings earlier studies (e.g., Eckberg and Blocker 1989, 1996; Hayes 2001; Kanagy and Willits 1993) and provide substantial justification to reject H5a and H5b. Controlling for relevant political and socio-demographic variables, religiosity is not statistically related to climate change concern, which supports the similar result found by Kellstedt et al. (2008).¹³

The second set of theoretical arguments for gender differences on environmental concern emphasizes the effects of the social roles that men and women differentially perform in society. Models D, E, and F test the effects of full-time employment (H6), homemaker status (H7), and parenthood (H8) on climate change concern. H6 expects full-time employment to be negatively associated with climate change concern, H7 expects homemaker status to be positively associated with concern, and H8 expects parenthood to have a negative effect on men’s concern and a positive effect on women’s concern. Examination of the zero-order correlations between

¹³ The sign and magnitude change for the religiosity coefficient in the fully specified model bears some discussion. The statistically significant, positive coefficient of religiosity in the fully specified model is opposite of the zero-order correlation between religiosity and the climate change concern index (Pearson’s $r = -.097$; $N = 4078$; $p < .001$). I examined a series of partial correlations between religiosity and climate change concern to explore this shift. Controlling for both climate change knowledge and political ideology switches the negative correlation between religiosity and concern to positive (Pearson’s $r = .053$; $N = 3072$; $p = .003$). In other words, the effect of religiosity net of the effects of climate change knowledge and political ideology is positive (opposite of what H5a expects), which is further evidence to reject this hypothesis.

climate change concern and full-time employment, homemaker, and the parenthood*gender interaction term offer no support to these respective hypotheses.

The results of Models D, E, and F confirm this lack of support for H6, H7, and H8, respectively. Full-time employment and homemaker status¹⁴ have no direct effect on climate change concern. The results for these two variables seem typical in a literature in which evidence for these arguments is generally described as mixed or inconclusive (e.g., Blocker and Eckberg 1997; Davidson and Freudenburg 1996). Further, parenthood has no differential effect on the climate change concern of men and women, even though earlier studies did find that parenthood decreased men's environmental concern and increased women's environmental concern (e.g., Blocker and Eckberg 1989; Greenbaum 1995).

The results for the political, socio-demographic, and temporal variables in Table 5 also are worth discussing. These findings for the 2001–2008 pooled sample are quite similar to results of some earlier climate change public opinion studies that examine attitudes and beliefs within the US general public for a single year during this time period. As in several of these studies (Hamilton 2008; Krosnick et al. 1998; Wood and Vedlitz 2007), political orientation exerts a robust influence on individuals' concern about climate change. Self-identified liberals and Democrats express greater concern about climate change than do their conservative and Republican counterparts. Similar to previous studies, younger adults (e.g., Kellstedt et al. 2008; Malka et al. 2009) and non-whites (e.g., Malka et al. 2009; Wood and Vedlitz 2007) express greater climate change concern than do their older and white counterparts, respectively. Past research finds that socio-economic status—e.g., income (O'Connor et al. 1999) and educational attainment (e.g., Malka et al. 2009; O'Connor et al. 1999; Wood and Vedlitz 2007)—relate negatively to concern about global warming. The results in Table 5 support this finding for income but not for education. Finally, as mentioned earlier, climate change concern within the American public has remained unchanged overall during this time period.

Conclusion

The main objective of this paper was to employ theoretical insights from relevant literatures in sociology of science and environmental sociology to examine gender differences in public opinion about climate change—humanity's most serious and expansive global environmental problem. Briefly, climate change offers a theoretically and empirically interesting case for examining gender dynamics, and this study serves as a theoretically focused complement to existing climate change public opinion studies that typically incorporate gender only as a statistical control. Specifically, I examined gender dynamics in both climate change knowledge and concern, and I found that women exhibit slightly higher levels of both than do their

¹⁴ The positive coefficient on homemaker status does achieve statistical significance in the fully specified model. Nevertheless, running even a few variations of the fully specified model with one or more of the key variables removed suggests that this statistically significant, positive coefficient on homemaker status is not sufficiently robust to offer support for H7.

male counterparts, even while controlling for several relevant variables expected to affect knowledge and concern, respectively.

Contrary to past research on general scientific or environmental knowledge (e.g., Arcury et al. 1987; Hayes 2001), women exhibit more scientifically accurate climate change knowledge than do men. Yet, women nevertheless underestimate their climate change knowledge more than do men, supporting the results of earlier studies dealing with general scientific knowledge (e.g., Jacobs and Simpkins 2006). At each level of assessed knowledge, women perceive lesser understanding of global warming than do men.

The results of later multivariate analyses reveal modest gender differences in climate change concern, even when controlling for the effects of other influential variables. Women express slightly greater concern about climate change than do men. That the expected effect of gender on concern remains statistically significant even when controlling for assessed knowledge, religiosity, and each of the social roles variables supports the simple version of the gender socialization argument (Zelezny et al. 2000) that gender differences in environmental concern cannot be explained away by key beliefs and values or in the social roles that men and women differentially perform.

The two extended gender socialization arguments examined here received no support. Contrary to the original theoretical argument—the “Environmental Knowledge” hypothesis (Blocker and Eckberg 1997) or “Knowledgeable Support Hypothesis” (Davidson and Freudenburg 1996)—but consistent with some earlier empirical results regarding environmental concern (e.g., Hayes 2001), assessed climate change knowledge relates positively to concern about climate change. Although theoretically expected to be negatively associated with concern, religiosity has no statistically significant effect on concern.

The results of analyses reported earlier offer no support for the social roles arguments that men’s and women’s differential performance of key social roles in society account for gender differences in environmental concern. Full-time employment, homemaker status, and parenthood do not affect climate change concern as theoretically expected. These results largely confirm an interpretation about gender differences in environmental concern offered by Paul Mohai (1997:166) slightly more than 10 years ago:

... background characteristics, including homemaker and parental status, appear to have little, if any, effect on these [gender] differences [in environmental concern]. This suggests that, to the extent that gender differences in environmental concern do exist, the differing socialization experiences of men and women may account for the differences, rather than the roles they occupy or other structural factors.

Existing climate change public opinion studies typically include gender only to statistically control its effects, while attending more to other variables. Yet, gender is a central concept in the social sciences and it enjoys much theoretical attention. Given gender’s consistent effects on several dimensions of environmental concern in past studies (e.g., Blocker and Eckberg 1997; Davidson and Freudenburg 1996; McStay and Dunlap 1983; Mohai 1992) and its enduring influence on climate

change knowledge and concern documented in this study, future climate change public opinion research may benefit from richer theoretical tests of the effects of gender. I suggest the following three avenues for future research on the influence of gender on climate change beliefs and attitudes.

First, future research should apply the two extended gender socialization arguments not tested here to climate change concern. For instance, Dietz and colleagues (2002; see also Stern et al. 1993) find that differences in men's and women's value orientations explain gender differences in environmental concern. To what extent do differences in men's and women's value orientations explain gender differences in climate change concern? Also, other scholars argue that differences in men's and women's levels of trust in science and technology explain gender differences in environmental concern (see review in Davidson and Freudenburg 1996). To what extent might trust in science mediate the relationship between gender and climate change concern, especially given that Malka et al. (2009) demonstrate that trust in science has a nuanced effect on climate change concern?

Second, given the results here supporting the simple version of the gender socialization argument, future research should better identify when during the life course substantial gender differences in climate change concern first emerge. In their 2-year study of California primary and secondary school students, Zelezny et al. (2000) document significant gender differences in multiple dimensions of environmental concern. Their findings and the results of this study suggest that future research should examine the climate change beliefs and attitudes of primary and secondary school students. In particular, this research should examine the relative importance of different socialization agents (e.g., parents, peers, school) on the development of gender differences in young people's climate change beliefs and attitudes.

Finally, future research should employ refined measures of gender. Continued use of survey items measuring gender as demographically male or female is less than optimal. Yet, social scientists are often dependent upon existing survey data from professional survey organizations that measure gender this way. When social scientists administer our own state or national surveys, we should utilize a single-item or multi-item indicator of gender identity, which measure individuals' masculinity and femininity along a continuum. One such item is Bem's (1993) Sex Role Inventory. Yet perhaps, as some suggest (e.g., Smith 2001), gender is not as important for explaining environmental concern as is a feminist orientation. Somma and Tolleson-Rinehart (1997) find that individuals—both women and men—who support feminist goals express greater environmental concern. Thus, future research should prioritize the use of more refined measures of gender and perhaps examine individuals' beliefs about feminism.

Acknowledgments Thanks are extended to Riley E. Dunlap and the Gallup Organization for making the data available for analysis. The author also thanks Chenyang Xiao for his helpful advice. The author is grateful to the reviewers for their productive feedback.

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