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Drivers of Climate Change Risk Perceptions among Diverse Forest Stakeholders in Maine, USA

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ABSTRACT

Climate change is impacting forest ecosystems, which support key ecosystem services and the general well-being of natural resource-dependent communities in Northeastern, USA. Understanding the determinants of climate change risk perceptions among forest resource stakeholders is critical to eliciting broad support for adaptation. We examined social-psychological drivers of climate change risk perceptions using hierarchical regression based on an online survey of 211 forest stakeholders, representing a wide range of subsectors, in Maine, USA. Using the climate change risk perceptions model (CCRPM), we explained 70% of the variance in risk perception. Political orientation, belief in climate change, social norms, affect, and experience with weather-related impacts were all significant predictors of perceived risk. Mediation results demonstrate that experience with weather-related impacts influences risk perceptions indirectly via attribution and holistic affect. This study advances our understanding of the social-psychological determinants of climate change risk perceptions, with implications for communication and outreach strategies.

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Affect; experience; forest management; forest owners; socio-ecological systems; survey research

Introduction

Forest ecosystems have been and will continue to be, exposed to the impacts of climate change (IPCC 2018). In forests of the Northeastern USA, future climate change projections suggest continued increases in extreme climatic events, changes in the quality of timber/fiber, the types of species that can naturally regenerate, and the timing of forest operations (Fernandez et al. 2020). Forests play a key role in a variety of ecosystem services including clean water and air, carbon storage, biodiversity, and esthetic value (Millenium Ecosystem Assessment 2005). As climate change alters the provisioning of ecosystem services, forest management decisions, particularly adaptation actions, become critical to increasing the forest's ability to respond to change (Evans and Perschel 2009).

From a human dimensions standpoint, climate change risk perceptions can impact the extent to which stakeholders implement strategies to cope with climate variability (Chatrchyan et al. 2017). Risk perceptions are a subjective mental construct of one's

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personal feelings toward the severity and/or likelihood of a threat (Slovic et al. 2004). Public perceptions of risks do not always align with expert judgments of risk. While experts determine risk based on objective, analytical reasoning, judgments of risk by the public rely on subjective emotional and experiential factors (Sjöberg 1998). As an object of risk perception, climate change is unique in that it occurs over large spatial and temporal scales, and therefore is not easily identifiable by the public (Weber 2010). Despite scientific consensus on the reality of anthropogenic climate change, the extent to which climate change is perceived as risk varies substantially among individuals (Oreskes 2004). Studies have found that perceptions of climate change risk can be influenced by a variety of psychological, sociocultural, and cognitive factors, including personal experience and affective reactions, values, personal efficacy, exposure, place attachment, knowledge, trust in information sources, political ideology, and social norms (Akerlof et al. 2013; Leiserowitz 2006; Milfont 2012; van der Linden 2015).

Within natural resource management, climate change risk perceptions have been widely studied (Ameztegui et al. 2018; Blennow et al. 2016; Grotta, Creighton, and Schnepf 2013). Previous research suggests that increased climate change risk perceptions can be important predictors of the perceived need to change, and have been linked to readiness for adaptation within natural resource management (Leiserowitz 2006). In particular, previous experience with climate change impacts, dependency on natural resources, perceived control over risks, and education are all associated with heightened climate change risk perceptions (Blennow et al. 2016; Eriksson 2014). However, a comprehensive social-psychological framework to understand risk perceptions among forest stakeholders has not been fully evaluated. Studies that seek to identify the determinants of climate change risk perceptions often only investigate either specific cognitive or cultural constructs (e.g. education, values, political view) (Ameztegui et al. 2018; Blennow et al. 2016), which while critical to understanding perceptions of risk, do not provide an understanding of the many socio-cultural and psychological determinants which together have the potential to explain the high degree of variance in risk perceptions (van der Linden 2015).

The goal of this study was to evaluate the social-psychological drivers of climate change risk perceptions among a diversity of forest stakeholders in Maine, USA where the forest products industry is a major contributor to the state economy (Correia 2010). Advancing our understanding of the main determinants of risk perceptions is a difficult task given the complexity of climate change; however, it is of utmost importance due to the connection between perceived risk and willingness to adapt to a changing climate (Leiserowitz 2006). Within natural resource management, understanding the drivers of risk perception can help scientists, policymakers, communicators, and consultants engage with land managers to discuss adaptation efforts that promote resilient socio-ecological systems (Morris et al. 2016; Weber 2010). This is particularly true in areas of high forest diversity and mixed ownerships such as Maine.

Conceptual Foundations

In this study, we draw on the climate change risk perception model (CCPRM) to evaluate the social-psychological determinants of climate change risk perceptions (van der

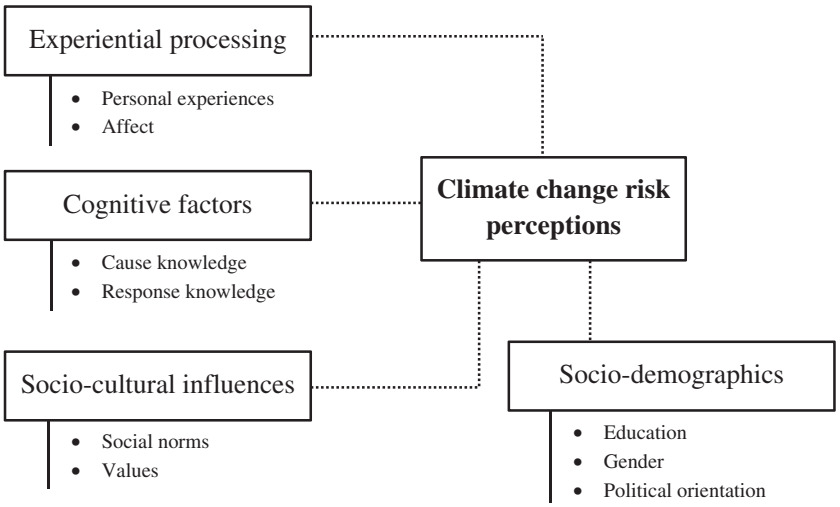


Figure 1. Drivers of climate change risk perceptions. Adapted from van der Linden (2015).

Linden 2015) (Figure 1) among forest stakeholders. The CCPRM consists of four key dimensions: *cognitive factors*, *experiential processes*, *socio-cultural influences*, and *socio-demographics*.

Cognitive Factors

Cognitive factors, including knowledge about the causes and impacts of climate change, as well as knowledge on how to respond to climate change, have been associated with increased risk perceptions (van der Linden 2015). The knowledge-deficit approach suggests that the extent to which individuals feel concerned about and personal efficacy to address climate change is related to how much they are informed about these issues (Milfont 2012). However, the relationship between knowledge and climate change risk perceptions remains unclear, as greater knowledge has been linked to both higher and lower risk perceptions (Myers et al. 2013). Within natural resource management, evidence suggests that greater knowledge about the causes of climate change leads to higher perceptions of climate change risk as well as the perceived need for adaptation (Blennow and Persson 2009). Perceptions of self-efficacy have also been noted as critical to understanding perceptions of risk (Grothmann and Patt 2005). Self-efficacy can promote or hinder action based on what individuals believe they are capable of and is of particular importance in decision-making under uncertainty (Hengst-Ehrhart 2019).

Experiential Processes

Experiential processes include both affect and personal experience with climate change. Climate change refers to statistical changes in long-term averages in the earth's climate and therefore can be difficult to personally experience (Weber 2010). Research has shown, however, that individuals can personally observe and evaluate broad changes in local weather patterns (Howe et al. 2013). Non-scientists generally rely on associative and affective processes via experiential learning to understand climatic stimuli

(Weber 2010). Experiences can invoke strong feelings, making them more dominant in risk processing (Loewenstein et al. 2001), and are correlated with increased perceived risk as well as greater acceptance, level of concern, and engagement with climate change (Akerlof et al. 2013). For those intimately tied to landscapes, the meaning of information on climate change impacts and environmental changes are largely understood through personal place-based experiences (Grotta, Creighton, and Schnepf 2013). Within forestry, personal experience with climate change has been positively related to higher risk perceptions and increased levels of support for conservation strategies (Peterson St-Laurent, Hagerman, and Kozak 2018).

There is growing evidence that suggests experience with climate change influences risk perceptions indirectly through socio-cultural and cognitive processes (Wolf and Moser 2011). Affect, or a fast associative reaction or emotion (e.g. positive or negative), plays an important role in climate change risk perceptions (Leiserowitz 2006). Previous experience with risks (Eriksson 2014) and negative affect toward those experiences both increase perceptions of risk (Slovic and Peters 2006). In addition, individuals can experience climate change indirectly through its impacts (e.g. extreme weather events) (Weber 2010). In this case, however, the impact of experience on environmental behaviors and risk perceptions is largely mediated by whether or not the experience is attributed to climate change (Helgeson, van der Linden, and Chabay 2012).

Socio-Cultural Influences

Socio-cultural influences, largely originating from Douglas and Wildavksy's (1982) cultural theory of risk, include social norms and values as important determinants of risk perceptions (Leiserowitz 2006). Values are orienting beliefs that can guide behavior or cognitive processing (Steg 2016). Three broad value orientations are important for understanding climate change risk perceptions: biospheric, altruistic, and egoistic values (Stern, Dietz, and Kalof 1993). Biospheric values, or those relating to caring for the environment, have been linked to the acceptance of conservation and enhanced forest management strategies to address climate change (Krantz and Monroe 2016).

Social norms reflect an individual's perception of how close friends, family, and peers expect them to think or act (Hogg and Reid 2006). Normative beliefs consist of both descriptive norms, or how people within a group behave, as well as prescriptive norms, which are an individual's perceptions of what others would approve or disapprove of (Cialdini, Reno, and Kallgren 1990). As important social referents (i.e. close friends, family) perceive climate change as a risk, an individual's risk perception intensifies (van der Linden 2015). There is increasing recognition of the role of social norms in adaptation as natural resource managers are likely to consider the expectations of important referents in decision-making (Hengst-Ehrhart 2019). Within natural resource management, social norms have been studied as they relate to forest management (Vulturius et al. 2020); however, the normative dimension of climate change risk perceptions has received relatively less attention. Antecedents of CCRPM, specifically socio-cultural influences, share many similarities with those from the widely used Value-Belief-Norm (VBN) theory. VBN theory posits a causal

model where personal values (e.g. biospheric, altruistic, egoistic) influence beliefs about the environment, awareness of consequences, the ascription of responsibility, personal norms, and pro-environmental behaviors (Stern 2000). High biospheric values can activate personal norms when an individual is concerned about environmental impacts that can threaten the things they value most (Stern 2000). While we did not employ VBN theory, we discuss areas where the theory can help to explain and extend our findings from the CCRPM.

Socio-Demographics

Several socio-demographic characteristics are correlated with higher perceptions of climate change risk. Gender has been identified as a significant predictor of risk perceptions, with women having higher perceptions of risk (Safi, Smith, and Liu 2012). Political orientation has also often been found to play a critical role in perceptions of climate change, with conservatives having lower perceptions of risk compared to those that identify as liberals (Safi, Smith, and Liu 2012; van der Linden 2015). Finally, formal education has been identified as a significant driver of climate change risk perceptions (Blennow et al. 2016); however, other studies have found no correlation between formal education and perceptions of risk (Milfont 2012).

While knowledge, experience, values and norms, and socio-demographics have received individual attention (e.g. Blennow et al. 2016; Grothmann and Patt 2005; Vulturius et al. 2020), there has been a lack of a comprehensive social-psychological framework of risk perceptions within the context of natural resource management. Therefore, our first objective was to examine the extent to which the CCRPM predicts climate change risk perceptions among Maine's key forest stakeholders. Previous literature suggests a dual-processing model, where perceptions of climate change risk are influenced by both an associative effective system as well as a cognitive, rule-based system (Sloman 1996; van der Linden 2014). Personal experience, affective reactions, and beliefs regarding anthropogenic climate change can interact to influence risk perceptions and are critical for engaging resource managers in the issue of climate change (Myers et al 2013; van der Linden 2014). Our second objective was therefore to examine the role of cognitive and affective processes in the relationship between experience and climate change risk perceptions. Based on the literature of the social-psychological determinants of risk perceptions presented above, we advance the following hypotheses:

H_1: Forest stakeholders who have greater knowledge about the causes and increased self-efficacy to respond to climate change will be more likely to have higher climate change risk perceptions.

H_2: Forest stakeholders who have high biospheric and altruistic values, as well as increased social norms to respond to climate change, will be more likely to have higher risk perceptions.

H_3: Forest stakeholders who are female and politically liberal will be more likely to have higher risk perceptions.

H_4: Experience with climate change impacts will lead to increased risk perceptions only if those experiences are attributed to climate change and associated with negative emotions.

Materials and Methods

Study Site

The study was conducted in the state of Maine (45.2538° N, 69.4455° W), which is located in the Northeastern, USA and has the highest percentage of forested land in the USA (Correia 2010). Maine has a diverse ecological forest system, with over 50 tree species (Butler 2017), and is managed by a diversity of forest owner types ranging from non-industrial private landowners to state agencies and large corporations. Maine is currently facing a variety of climate change impacts including milder winters, increasing extreme precipitation events, forest health threats imposed by insects and pathogens, and shifts in forest composition (Fernandez et al. 2020; Soucy et al. 2020).

Data Collection

We conducted an online survey of two Maine forest stakeholder groups from October to November 2019 (Soucy 2020). We distributed the survey to 1,400 randomly selected forestry stakeholders from the Maine Woodland Owners (SWOAM) Association and the University of Maine's Cooperative Forestry Research Unit (CFRU). SWOAM are private non-industrial woodland owners, who have varied goals and perspectives related to forest management. CFRU members are forestry professionals focused on applied forest ecology and management. Together, both groups represent public and private forest sectors, including commercial land managers and non-industrial private landowners. While the groups differ in some aspects (see Authors 2020 for a full discussion), there are no significant differences between the groups for all variables, except for biospheric values. For this reason, we have combined both samples to form a diverse set of perspectives to examine the social-psychological drivers of risk perception that transcend stakeholder type. We used Dillman's Tailored Design Method to increase the response rate. Most constructs were assessed using 5-point Likert scale questions (i.e. strongly disagree to strongly agree) and we created mean scores for several of the constructs and calculated a Cronbach's alpha (α) of reliability to estimate the internal consistency of the items (Cronbach 1951; Vaske 2019).

The survey consisted of five sections measuring participants' knowledge, experiences, socio-cultural influences, socio-demographics, and climate change risk perceptions. Two questions were used to assess participant knowledge about the causes of climate change (Morris et al. 2016) (Pearson correlation coefficient = 0.65). We created a mean score, where higher values indicate the higher belief that climate change is occurring and that it is primarily caused by human activities. Participants indicated their level of self-efficacy, using seven items modified from Lenart and Jones (2014) and Guariguata, Locatelli, and Haupt (2012). We created a mean index of self-efficacy, where higher values indicate higher perceived self-efficacy ($\alpha = 0.760$).

We assessed participants' experience with 19 weather-related impacts modified from Morris et al. (2016). For each impact, participants noted their experience in the last 5 years on a 5-point Likert scale from never to very frequently (e.g. extreme precipitation events, milder winters). We created a mean score of experience with weather-related impacts ($\alpha = 0.893$). From those impacts participants experienced, they were

asked to select those that they attributed (at least in part) to climate change. Responses were converted to a percentage of experiences attributed to climate change. We assessed holistic effect regarding climate change impacts using eight 5-point Likert scales, e.g. "The impacts from climate change make me feel nervous" (strongly disagree to strongly agree). We coded emotions (i.e. happy, hopeful) such that high values indicate higher negative affect in regards to climate change impacts, and created a mean score for affective processing ($\alpha = 0.79$).

We assessed social norms using seven items modified from van der Linden (2015). On a 5-point Likert scale from strongly disagree to strongly agree, participants answered questions about the extent to which they feel socially pressured to reduce the risk of climate change impacts, and how likely they think their important social contacts are doing something to reduce the risk of climate change. We created a mean score for social norms ($\alpha = 0.871$). Participants also indicated the importance of 12 values as "guiding principles in their lives" on a 5-point Likert scale, ranging from not important at all to very important (De Groot and Steg 2007). The 12 measures were composed of four items representing three different value orientations: egoistic ($\alpha = 0.755$), socio-altruistic ($\alpha = 0.817$), and biospheric ($\alpha = 0.839$). Finally, we were interested in socio-demographic information, including participant gender (1 = female), political orientation (5-point Likert scale, with 1 = strongly conservative and 5 = strongly liberal), and the highest level of education achieved (1 = higher education, a professional degree or at least a 4-year degree; 0 = lower education, up to a 2-year degree).

To assess the dependent variable, climate change risk perceptions, we used seven items on a 5-point Likert scale modified from Ameztegui et al. (2018) and Guariguata, Locatelli, and Haupt (2012). The questions related to climate change impacting and posing a threat to *forest ecosystems*, *Maine's forest sector*, and *them personally*. We created a risk perception index using the mean score ($\alpha = 0.921$). Please see the supplemental material for a full description of all measures.

Data Analysis

A total of 302 participants started the survey (22% response rate), and 141 participants completed the survey (10% completion rate). For the variables of interest, the dataset was not missing completely at random ($\chi^2 = 89.92$; $p = 0.046$); therefore, we used multiple imputations, with five imputations, to predict missing values and preserve the relationships among variables based on values from the other survey items (Fox 2016; Vaske 2019). After imputation, we had a total of 211 survey responses (260 data points imputed). We assessed non-response bias by comparing the first wave of responses to the second wave of responses (Filion 1976) for primary subsector, years of experience, climate change risk perceptions, experience, values, norms, knowledge, gender, political affiliation, age, and education using independent samples t-tests for continuous variables and chi-square for categorical variables (Lankford et al. 1995). Only one of the items in the altruistic values construct, *having social justice,* was significantly different between groups, with the first response wave ranking social justice as less important than the second response wave. All variables were normally distributed based on a skewness

cutoff of ±1.0, and outliers were winsorized based on Tukey's (1997) box plot method (Vaske 2019).

We used a theory-based hierarchical multiple linear regression analysis using ordinary least squares regression (OLS) (van der Linden 2015) to explain the variance in climate change risk perceptions and test our first three hypotheses, sequentially using four models, (1) baseline socio-demographics, (2) cognitive factors, (3) experiential processes, and (4) socio-cultural influences. We report standardized beta coefficients and significance values for each variable within each model, and use Cohen's f^2 as a measure of effect size for each model. To investigate our fourth hypothesis, we tested the mediating role of negative affect and climate change attribution on the relationship between experience and risk perceptions (van der Linden 2014; Wolf and Moser 2011). To test both attributions and affect, we conducted a parallel mediation analysis using Haye's PROCESS macros, Model 4, Version 3.1. The purpose of mediation analysis in this study was to assess whether experience (X) exerted an influence on climate change risk perceptions (Y) via the mediators, attribution (M_1), and affect (M_2) (Hayes 2017). Point estimates for the direct and total effects are derived from the linear regression analysis based on p-values at a 95% confidence interval (Hayes 2017). Sampling distributions of indirect effects are derived from 5,000 bootstrap estimates using the bias-corrected method (Hayes 2017; Preacher and Hayes 2008) and 95% confidence intervals are reported. All statistical analyses were performed in SPSS Version 25.0.

Results

Descriptive Statistics

Survey participants held a variety of positions within forestry, with the majority identifying as a landowner (42%), followed by a forester (24%) and land manager (9%) (Table 1). The majority of participants were male (88.1%) and at least 55 years old (63%). Forty percent of participants held a 4-year degree, while 17% held a graduate degree and 10% have a professional degree. Participants had, on average, 25 years of experience in the forest industry, and most worked in companies or organizations that employed 10 or fewer employees (51%). There was approximately equal representation of participants identifying as liberal (30%), conservative (34%), and neutral (35%).

An overview of the intercorrelations among all the variables, their means, and standard deviations is presented in Table 2. Except for gender, all independent variables were significantly correlated with climate change risk perceptions. Seventy-six percent and 68% of forest stakeholders believed that within the next 50 years climate change will have an impact on forest ecosystems and the forest sector, respectively. Sixty percent, 58%, and 35% believed that climate change is a threat to forest ecosystems, the forest sector, and them personally, respectively. Most of the respondents (90%) believed that climate change was occurring, and 70% attributed climate change to primarily human causes, with 24% believing climate change is caused by a combination of human and natural causes.

Table 1. Participant profile for socio-demographic characteristics.

Participant profile	Percent (%) (*N*)
Gender	
Male	88.1 (148)
Female	11.9 (20)
Age range	
18–34	12.9 (22)
35–54	24.0 (41)
55–64	22.8 (39)
65 and over	40.4 (69)
Years of experience	
5 and less	17.7 (40)
6–10	9.7 (22)
11–20	20.8 (48)
21–40	32.7 (77)
41 and over	16.8 (39)
Number of employees within company/organization	
1	33.8 (52)
2–10	18.2 (28)
11–25	8.4 (13)
25–60	8.4 (13)
60 and over	12.3 (48)
Highest education	
High school	1.7 (3)
Some college	1.7 (3)
2 year degree	8.1 (14)
4 year degree	40.5 (70)
Professional degree	9.8 (17)
Graduate degree	16.7 (66)
Political affiliation	
Conservative	34.4 (60)
Liberal	30.4 (53)
Neutral	35.1 (61)
Primary position	
Landowner	42.4 (109)
Forester	24.1 (62)
Land manager	9.3 (24)
Researcher	4.7 (12)
Other*	19.5 (50)

* includes planner, consultant, biologist, government official, technician, and procurement

Table 2. Intercorrelations, means, standard deviations, and reliability measures among variables in the regression analysis.

Construct	1	2	3	4	5	6	7	8	9	Mean	Standard deviation
1. Risk perceptions	(0.92)									3.45	0.85
2. Cause knowledge	0.75***	(0.65)								4.16	0.85
3. Response knowledge	0.16*	0.19*	(0.76)							3.12	0.02
4. Experience	0.19*	0.11	0.03	(0.89)						2.94	0.58
5. Affect	0.68***	0.52***	0.06	0.22**	(0.79)					3.56	0.62
6. Social norms	0.53***	0.51***	0.26**	0.10	0.30***	(0.87)				3.54	0.63
7. Biospheric values	0.55***	0.49	0.13	0.12	0.44***	0.38***	(0.84)			4.12	0.66
8. Altruistic values	0.48***	0.50***	0.14	0.06	0.33***	0.38***	0.75***	(0.82)		3.69	1.12
9. Egoistic values	0.22**	0.11	0.00	0.10	0.14	0.16*	0.19*	0.28**	(0.76)	2.67	0.71

Note: Mean scale reliabilities are provided along the diagonal. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Climate Change Risk Perceptions Model

Model 1 tested the influence of socio-demographic characteristics on climate change risk perceptions, which explained 30% of the variance in climate change risk perceptions

Table 3. Climate change risk perceptions regression results.

Independent variables	Socio-demographics Model 1	Cognitive factors Model 2	Experiential processes Model 3	Socio-cultural influences Model 4
Gender	−0.07 (0.49)	−0.02 (0.81)	−0.02 (0.63)	−0.04 (0.45)
Political party	**0.56 (0.00)**	0.01 (0.907)	−0.01 (0.87)	−0.07 (0.29)
Education	0.08 (0.94)	−0.50 (0.06)	−0.14 (0.58)	−0.11 (0.65)
Cause knowledge		**0.73 (0.00)**	**0.48 (0.00)**	**0.42 (0.00)**
Response knowledge		0.003 (0.96)	0.04 (0.35)	0.01 (0.88)
Affect			**0.43 (0.00)**	**0.39 (0.00)**
Personal experience			**0.12 (0.02)**	**0.11 (0.02)**
Social norms				**0.20 (0.00)**
Biospheric values				0.10 (0.18)
Altruistic values				−0.01 (0.80)
Egoistic values				0.03 (0.51)
Adj. R^2	0.30	0.54	0.69	0.72
Change in adj. R^2		0.24	0.15	0.04
F-change	45.50	53.16	50.02	7.62
Cohen's f^2	0.43	0.32	0.18	0.04

Entries as standardized beta coefficient and significance value.
Bold values indicate a significant determinant in the regression model.

($F(3, 204) = 45.50$, $p < 0.001$, Adj. $R^2 = 0.30$). The political party was the only significant predictor, were being more liberal increased risk perceptions of climate change ($\beta = 0.56$, $p < 0.001$).

Model 2 then tested the added influence of cognitive factors on climate change risk perceptions ($F(2, 204) = 53.16$, $p < 0.001$, Adj. $R^2_{\text{change}} = 0.24$). Knowledge about the causes of climate change and how to respond to climate change explained an additional 24% of the variance in climate change risk perceptions. The greater belief that climate change is occurring and that is primarily caused by human activities correlated with higher climate change risk perceptions ($\beta = 0.73$, $p < 0.001$).

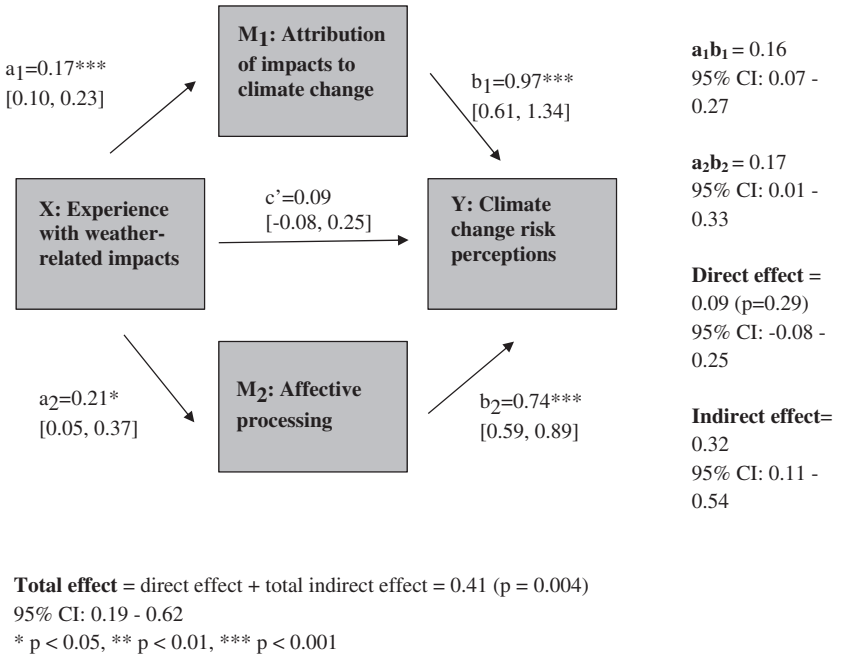
Model 3 explored the added influence of experience with weather-related impacts and affective processing related to climate change impacts on climate change risk perceptions ($F(2, 204) = 50.02$, $p < 0.001$, Adj. $R^2_{\text{change}} = 0.15$). Both experience and affect were significant predictors of climate change risk perceptions, explaining an additional 15% of the variance in climate change risk perceptions. More experience with weather-related impacts ($\beta = 0.12$, $p < 0.05$) and greater negative emotions associated with impacts ($\beta = 0.43$, $p < 0.001$) correlated with greater risk perceptions of climate change.

Model 4 investigated the influence of socio-cultural factors, including broad value orientations and social norms, on climate change risk perceptions ($F(4, 204) = 7.62$, $p < 0.001$, Adj. $R^2_{\text{change}} = 0.04$). Socio-cultural influences explained an additional 4% of the variance in climate change risk perceptions. Greater social norms for climate change adaptation correlated with higher climate change risk perceptions ($\beta = 0.20$, $p < 0.001$).

In the full model, knowledge about the causes of climate change, personal experience, affect, and social norms were all significant predictors, accounting for 72% of the variance in climate change risk perceptions in total (Table 3).

The Relationship between Experience and Climate Change Risk Perceptions

The relationship between experience and climate change risk perceptions was significantly mediated by climate change attribution and holistic effect ($F = 74.54$, $R^2 = 0.56$,



Total effect = direct effect + total indirect effect = 0.41 (p = 0.004)
95% CI: 0.19 - 0.62
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 2. Parallel mediation model showing the direct and indirect paths by which experience with weather-related impacts influences climate change risk perceptions. Indirect, direct, and total effects are reported, along with their respective 95% confidence intervals. Effects are reported as point estimates.

Table 4. Regression coefficients (Coeff.), standard errors (SE), and model summary information for the experience of weather-related impacts parallel mediator model depicted in Figure 2.

		Consequent										
		M_1 (Attribution)				M_2 (Affect)				Y (Risk perception)		
Antecedent		Coeff.	SE	*p*		Coeff.	SE	*p*		Coeff.	SE	*p*
X (Experience)	a_1	0.17	0.03	0.00	a_2	0.21	0.08	0.01	c'	0.09	0.08	0.30
M_1 (Attribution)		——	——	——		——	——	——	b_1	0.97	0.18	0.00
M_2 (Affect)		——	——	——		——	——	——	b_2	0.74	0.08	0.00
Constant	i_{M1}	−0.02	0.10	0.87	i_{M2}	2.92	0.25	0.00	i_y	0.10	0.32	0.75
		$R^2 = 0.12$				$R^2 = 0.04$				$R^2 = 0.15$		
		$F(1,179) = 23.90$, $p = 0.00$				$F(1,179) = 6.52$, $p = 0.01$				$F(1,179) = 74.54$, $p = 0.00$		

$p < 0.001$) (Figure 2, Table 4). Together, 16% of the variance in climate change risk perceptions is accounted for by both mediators and experience with weather-related impacts. Those that more frequently experienced weather-related impacts were more likely to attribute those experiences to climate change, and in turn, had higher perceptions of climate change risk ($a_1b_1 = 0.17(0.97) = 0.16$). Attributing experiences to climate change accounted for 12% of the variance in risk perceptions. The indirect effect of negative affect toward weather-related impacts was also significant and accounted for 4% of the variance in risk perceptions. Those that more frequently experienced weather-related impacts held greater negative affect toward impacts, and in turn had higher perceptions of risk ($a_2b_2 = 0.21(0.74) = 0.17$). When both attribution and effect are statistically controlled, climate change risk perceptions did not change as a function of

experience with weather-related impacts, suggesting that experience only influences perceptions of risk indirectly via cognitive and affective processes ($c' = 0.09$, $t(179) = 1.05$, $p = 0.30$).

Discussion

We surveyed a diverse group of forest stakeholders in Maine, USA to understand the social-psychological drivers of climate change risk perceptions. In doing so, we advanced our understanding of the cognitive, experiential, socio-cultural, and socio-demographic factors that influence perceptions of climate change risk, and therefore may contribute to willingness to engage in adaptation efforts (Leiserowitz 2006). Using a sample of two forestry groups, the current study supports the CCRPM (van der Linden 2015) and builds on our current understanding of the mediating effects of emotion and attribution on the relationship between personal experience and climate change risk perceptions. We found that the majority of respondents believed that climate change has an impact on and presents a threat to Maine's forest ecosystems and forest sector, similar to findings of forest stakeholders in Canada and Europe (Ameztegui et al. 2018; Sousa-silva et al. 2016). Overall, knowledge about the causes of climate change, personal experience with weather-related impacts, holistic affect, and social norms were all significant predictors of climate change risk perceptions, accounting for approximately 70% of the variance, largely supporting our first and second hypotheses.

In regards to the model components, liberals tended to have higher risk perceptions compared to conservatives, consistent with previous findings among both the public (Leiserowitz 2006; van der Linden 2015) and natural resource managers (Ameztegui et al. 2018). Political affiliation was not significant after the first model because it was highly correlated with both cause knowledge and self-efficacy, which is consistent with the findings of Morris et al. (2016). This suggests that while political affiliation is correlated with perceptions of risk, political affiliation does not uniquely explain risk perceptions when knowledge about the causes of climate change is also considered. Our results are similar to Akerlof et al. (2013), which suggest that additional factors, such as belief in experiencing climate change, account for distinct variation in risk perceptions that cannot be fully explained by political affiliation. Out of 211 responses, only 25 of those were female (12%), a percentage that accurately reflects the fact that women are underrepresented within forestry in Maine (Crandall et al. 2020). While our results support the finding that female foresters' perceptions of nature and climate change do not significantly differ from their male counterparts (Storch 2011); due to the small number of women in our sample, there may not have been enough statistical power to detect a difference if one did exist (Dickinson et al. 2012). While previous research has demonstrated the importance of formal education in perceptions of climate change among forest stakeholders (Blennow et al. 2016), we did not find evidence of this relationship. Previous research investigating the drivers of climate change risk perceptions among forest stakeholders have largely focused on private non-industrial landowners (Blennow et al. 2016; Eriksson 2014); therefore, it is possible that in our study that includes commercial landowners, increased formal education does not contribute to heightened risk perceptions. Our study results are also consistent with findings by McCright and

Dunlap (2011) who found that within the USA, level of education is only correlated with greater perceptions of risk among those that identify as liberals. Educational outreach can therefore focus on appealing to individual values by using message frames that center around what individuals care about the most, while avoiding messages that trigger or aggravate ideological or partisan divides (McCright et al. 2013) (see Soucy et al 2020 for a full discussion of message framing). Specifically, strategies could include using trusted information channels (e.g. NOAA, the University of Maine, and Maine Forest Service) to engage landowners in a discussion surrounding adaptation measures that meet their goals (e.g. conservation, sustainable management) while also having a relatively quick economic pay-off.

Knowledge about the anthropogenic cause of climate change was a significant predictor of climate change risk perceptions, supporting findings among both the public and forest owners (Safi et al. 2012). Within the forest industry, it has been suggested that corporations may be hesitant to embrace information regarding climate change that implicates industrial development (Davidson et al. 2003). We, however, did not find evidence of widespread climate change denialism or that those working for larger corporations and industries hold different beliefs related to climate change compared to those working for smaller organizations or themselves. This suggests that climate change denialism may not be playing a large role in perceptions of risk and adaptation in Maine's forest industry, consistent with previous research that found that those working in the forest industry are aware of climate change and its consequences (Soucy et al. 2020). Although self-efficacy was not a significant predictor of perceptions of risk in our study, the concept can still be an important predictor for natural resource managers' intention to take adaptation actions (Lenart and Jones 2014). Self-efficacy and engagement with adaptation can be fostered through learning opportunities that link scientific knowledge with forest stakeholders' own experiences. Additionally, perceived control over risks as well as perceptions of the effectiveness of adaptation actions may be equally important in understanding perceptions of climate change risk among forest stakeholders (Eriksson 2014). Similarly, structural and institutional barriers (e.g. having access to relevant expertise, flexible policy to allow adaptive management) may exist alongside individual barriers to adaptation. Structural constraints can increase vulnerability as landowners may be working within the confines of a socio-political and cultural context that may be maladaptive, which can, in turn, generate perceptions of powerlessness (Andersson et al. 2018; Davidson et al. 2003). While our findings suggest social-psychological factors explain a high degree of variance in risk perceptions, future research can extend our understanding of self-efficacy, perceived control over risks, and perceptions of structural constraints that may be impacting landowners' risk perceptions and adaptive behaviors.

People's knowledge about climate change is largely mediated by external sources of evidence and expertise, which raises the important issues of attention and trust (Weber 2010). It is therefore important to consider what knowledge is available and how it is communicated (Moser and Dilling 2009). Additionally, learning about climate change requires analytical information processing and motivation; therefore, other factors, such as experience with climate change, are important to consider as experiential learning is more likely to occur among people with low engagement in climate change issues (Myers et al. 2013). Our results largely support the importance of experiential learning, as both personal experience and affect were significant

predictors of climate change risk perceptions. In particular, more experience with weather-related impacts and greater negative affect associated with climate change impacts contributed to higher climate change risk perceptions, consistent with previous findings among the public (Akerlof et al. 2013; Leiserowitz 2006) and natural resource managers (Eriksson 2014).

The mediation analysis results provide insights into the cognitive and affective processes that shape the relationship between experience and climate change risk perceptions and also provide support for our fourth hypothesis. We found that experience with weather-related impacts did not directly increase perceptions of risk; rather, only when those experiences were attributed to climate change and/or they were associated with negative emotions or holistic effect, did they result in increased risk perceptions. This supports the critical role of both affective responses in climate change risk perceptions (Keller, Siegrist, and Gutscher 2006) and the importance of attributing those experiences to climate change (Helgeson, van der Linden, and Chabay 2012). Our results provide empirical evidence for dual-processing theories that emphasize the interplay between emotion and cognition (Sloman 1996; van der Linden 2014), suggesting that both associative effective systems as well as cognitive, rule-based systems based on knowledge, are important predictors of risk perceptions.

To our knowledge, this study is the first to identify the mediating roles of affect and attribution on experience and risk perceptions among natural resource managers. Previous research, however, has identified similar relationships that suggest that effect can be understood as both a post-cognitive process, as well as an information processing heuristic that guides risk perceptions (Loewenstein et al. 2001; van der Linden 2014). Our results are therefore unsurprising given that humans quickly process threats into affective responses for immediate threat appraisal (Weber 2006). The implications for communication and outreach, however, are critical. Climate change risk communication and messaging that seeks to draw on natural resource managers' experiences should consider the importance of holistic effect associated with those experiences (Rickard et al. 2016). For example, communicating risks by using narratives from people with direct experience could invoke affect-laden imagery associated with climate change, which in turn may lead to increased perceptions of risk (Keller, Siegrist, and Gutscher 2006). Additionally, our findings suggest the importance of timing adaptation outreach efforts during post-extreme event periods when concerns are heightened, and therefore climate concern may be more salient (Konisky et al. 2016).

Among socio-cultural influences, social norms were the only significant predictor of risk perceptions, while all three value orientations did not significantly contribute to perceptions of risk. Within natural resource management, organizational norms and the opinions of important social contacts can play a critical role in conservation and adaptation behavior (Eriksson 2018). Risk perceptions and responses to climate change emerge in a social context, and the importance of social networks among forest owners has been widely studied as they pertain to perceptions of risk and adaptation (Vulturius et al 2020). The importance of social networks in facilitating knowledge exchange and influencing perceptions is especially true in small-scale private forest stakeholders who depend on their social environment for decision-making (Hengst-Ehrhart 2019). While values did not significantly predict perceptions of risk, consistent with the findings of

Blennow et al. (2016), the high biospheric values evident in the survey indicates that communicating climate change adaptation as a wildlife and forest health concern issue may be useful for connecting with audiences and amplifying the perception of risk (Moser 2014). Bouman et al. (2020) found that perceptions of risk can interact with the VBN process, such that perceptions of risk may enhance feelings of personal responsibility and motivate individuals to take action when they believe there is a threat to something they value (Bouman et al. 2020). Communication strategies can tap into norms by strengthening the awareness of the consequences of climate change while empowering landowners to take responsibility for their actions and engage in conversations that give them the necessary tools to adapt (Johansson, Rahm, and Gyllin 2013; Wynveen, Connally, and Kyle 2013).

Perceptions of risk can have a direct impact on intention to adapt to climate change; therefore, incorporating perceptions of risk in adaptation and risk communication is critical for eliciting broad support for adaptation actions (Chatrchyan et al. 2017). Understanding the myriad social-psychological determinants of climate change risk perceptions can help to develop message frames that target the cognitive, experiential, affective, and socio-cultural dimensions of risk (Moser 2014; Sousa-silva et al. 2016). Our findings support communications that consider the multiple pathways, or routes, of messaging that include both cognitive thinking and affective heuristics (Petty and Briñol 2011). As individuals perceive and interpret climate change in terms of their perceived personal experiences, prior beliefs, and knowledge (Myers et al 2013), the interplay between these cognitive and emotional processing systems will impact the extent to which risk communications influence attitudes and behaviors (Petty and Briñol 2011).

While we surveyed two distinct forestry groups in Maine with a diverse membership, including both commercial and noncommercial land managers and owners, our results do not capture the full diversity of forest stakeholders in the state. Though we are confident with the findings of our analysis and predictions, we have to exercise caution in generalizing to the larger population. Therefore, we cannot say with certainty that results represent all the different groups of people that form the forest industry. However, results serve as a starting point for understanding risk perceptions based on social-psychological determinants among a diverse forest stakeholder population. Future research can build on this understanding by applying the CCRPM to a greater diversity of forest stakeholders, such as those working for non-governmental organizations and federal and state government, as well as natural resource managers more broadly. It is important to note that our sample represents a diversity of forest stakeholders (e.g. land managers, landowners, foresters, etc.), that despite sharing many similarities, are distinct. Future research would benefit from understanding the unique drivers of climate change risk perceptions for each group by performing multiple regression analyses, which we did not have the statistical power to examine given our sample size. While our results seek to understand socio-psychological individual drivers of risk perceptions, we realize there are also structural and institutional considerations that set a socio-political context that may also influence perceptions and actions (Petersen et al. 2019). Investigating the role of the structure of forest ownership will be a key step to extend our understanding of the socio-political context for decision-making. In addition, the

relationships between the social-psychological drivers, climate change risk perceptions, and adaptation actions warrant further exploration, especially in regards to the roles of social norms, perceived self-efficacy, perceived control and effectiveness of adaptation, and the potential moderating role of political ideology on education. Future research would benefit from examining the role of risk perceptions in driving on-the-ground adaptation actions among natural resource managers.

Conclusion

Given the importance of perceptions of risk in willingness to implement adaptation strategies, it is critical to understand the social-psychological determinants of risk perceptions. Using the climate change risk perceptions model (CCRPM), we explained 70% of the variance in risk perceptions among diverse forest stakeholders in Maine, USA. Of significance is knowledge about the causes of climate change, personal experience, affect, and social norms. Additionally, we found that the influence of personal experience on risk perceptions is mediated by climate change attribution and affect. Our findings have implications for risk communication and outreach that seek to connect with natural resource managers and demonstrates that the CCRPM is useful for identifying the key determinants of climate change risk perceptions among forest resource stakeholders. The diversity of forest resource stakeholders in our study, with the inclusion of those representing both commercial and non-industrial forest owners, provides a much-needed analysis of climate change risk perceptions.

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