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Perceptions of Ecological Risk Associated with Mountain Pine Beetle (*Dendroctonus ponderosae*) Infestations in Banff and Kootenay National Parks of Canada

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Western Canada is experiencing an unprecedented outbreak of the mountain pine beetle (MPB). The MPB has the potential to impact some of Canada's national parks by affecting park ecosystems and the visitor experience. Controls have been initiated in some parks to lessen the impacts and to prevent the beetle from spreading beyond park boundaries. We examine the perception of ecological risk associated with MPB in two of Canada's national parks, the factors affecting perceptions of risk, and the influence of risk judgments on support for controlling MPB outbreaks in national parks. Data were collected using two studies of park visitors: a mail survey in 2003 and an onsite survey in 2005. The MPB was rated as posing a greater risk to the health and productivity of park ecosystems than anthropogenic hazards and other natural disturbance agents. Visitors who were familiar with MPB rated the ecological and visitor experience impacts as negative, unacceptable, and eliciting negative emotion. Knowledge and residency were the most consistent predictors of risk judgments. Of knowledge, risk, and demographic variables, only sex and risk to ecosystem domains influenced support for controlling the MPB in national parks. Implications for managing MPB in national parks, visitor education, and ecological integrity are discussed.

KEY WORDS: Ecological integrity; forest health; insects; knowledge; park visitors

1. INTRODUCTION

Canada's national parks are managed based on the principle of ecological integrity, which is defined as "a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes."[1] The ecological integrity mandate has brought increased attention to ecological risks (i.e., threats to the health and productivity of species and ecosystems)[2] in the national parks because managing ecological risk is fundamental to achieving ecological integrity objectives.

Traditionally, ecological risk in Canada's national parks has been associated with anthropogenic activities, such as development and industrial pressures, and human use. Most of the effort devoted to understanding ecosystem risk has focused on the natural sciences with little attention paid to understanding the human dimensions of risk management. This article deviates from the traditional approach by examining ecological risk associated with natural disturbance using a perception of risk framework. We compare the relative perception of ecological risk from natural disturbances and anthropogenic hazards and we use several

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elements of risk perception to explore some of the social aspects of risk from a natural disturbance. Specifically, we use some of the characteristics identified in the perception of ecological risk literature to explore risk perception associated with a natural disturbance agent (mountain pine beetle) in two of Canada's national parks.

2. BACKGROUND

Naturally occurring forest insects are viewed by scientists as posing low risk to the longterm health and productivity of ecosystems. Indeed, they are generally considered part of a healthy functioning ecosystem. Under certain conditions, however, when insect outbreaks exceed their historical levels of variation in terms of population size and distribution, they may be viewed as an unnatural phenomenon that has a negative impact on ecosystem health. An example of such an outbreak is occurring in western Canada.

The province of British Columbia (BC) is experiencing the largest forest insect infestation ever recorded in North America.[3] A mountain pine beetle (*Dendroctonus ponderosae*) (MPB) outbreak began in the 1990s. Although the MPB is endemic to mature lodgepole pine (*Pinus contorta*) forests of western Canada and it undergoes periodic population fluctuations, the outbreak has extended the beetle well beyond its historical range. By 2005 the infestation had killed approximately 450 million cubic meters of timber and it is predicted that 80% of the province's mature lodgepole pine will be dead by 2013.[4] The outbreak is expected to have tremendous impacts on timber supply, the forest industry, and forest dependent communities.[5–7] As a consequence of the insect's destructiveness, the government of BC has declared the MPB infestation "a forest health emergency"[8] and described the outbreak as a "catastrophic natural disaster."[9]

Banff and Kootenay National Parks, situated in Canada's Rocky Mountains, are also being affected by the MPB. The MPB is endemic to both parks but Kootenay National Park in BC has a history of MPB outbreaks and has experienced a substantial increase in MPB populations since the 1990s. Historically, the adjacent Banff National Park in the province of Alberta has experienced much smaller outbreaks. Recently, however, the beetle has extended its range into previously uninfested areas of the park, spreading to the park's eastern boundary with provincial Crown lands. The two parks have taken different approaches to managing the beetle. Kootenay National Park has not taken measures for the specific purpose of controlling the MPB outbreak. In contrast, Banff National Park has established three management zones that include no intervention, prescribed burning, and sanitation logging (logging and removal or burning of infested trees).

Parks Canada Agency, which is responsible for management of the national parks, views the MPB in Banff and Kootenay parks as a natural disturbance agent that plays an important role in rejuvenating lodgepole pine forests by creating gaps in the forest cover and increasing growth of young trees and species diversity.[10] According to the principle of ecological integrity, natural disturbance agents, such as native insects and disease, may be allowed to persist and run their course without management interference. In other words, natural disturbance agents are viewed as posing low risk to the health and productivity of park ecosystems. However, decades of fire suppression have been cited as a contributing factor to the beetle outbreak in the parks. Thus, the current outbreak may be viewed as a symptom of an unhealthy, unnatural ecosystem that poses a risk to ecological integrity and warrants management action (such as prescribed burning) to restore ecosystems to more natural levels of variation. Viewed from this perspective the MPB could be perceived as posing a risk to park ecosystems.

In addition to ecosystem impacts, MPB can impact humans by affecting the visitor experience in national parks (e.g., impacting the quality of park scenery, presenting a hazard from dead and falling trees), and potentially impacting local and provincial economies by reducing tourism and spreading beyond park boundaries to commercially important industrial forest lands.

3. PERCEPTIONS OF ECOLOGICAL RISK

Drawing upon perceptions of risk to human health, McDaniels *et al.*[2] characterized several judgments of ecological risk from a variety of hazards to ecosystems in general. Typically, hazards to ecological systems have focused on anthropogenic sources (such as air pollution, toxic waste, and population growth), technologies (such as nuclear power and biotechnology), and natural hazards (such as floods, drought, and earthquakes).[2,11] These studies have provided insight into the characterization of risk and differences among the public and experts on risk judgments with respect to nonspecific ecosystems.

Other studies have examined specific threats such as forest industry activities and their risk to forest ecosystems,[13] a variety of anthropogenic and natural

threats to specific ecosystems such as water environments,[14] global hazards such as climate change on forest[15] and prairie ecosystems,[16] and the risk of industrial activities and natural disturbances to specific hazard domains such as forest biodiversity.[17] However, we were unable to find any studies that examined the perception of ecological risk from natural disturbance in protected areas. This article begins to address this gap by examining perceptions of risk from the MPB to national park ecosystems and the visitor experience.

The literature suggests that the perceived risk from natural phenomena (e.g., floods, earthquakes, volcanoes, and drought) differs from perceived risk of technological hazards in several respects.[2,11] First, natural phenomena tend to receive lower general risk ratings. Second, natural phenomena are perceived as having less impact on ecosystems, species, and humans, being less avoidable, and providing fewer benefits to society. Lastly, perceived risk from natural phenomena is influenced by different factors. Although natural and technological hazards share several influences (such as perceived threat to species, risk to humans, and perceived destructiveness), ecological risk perceptions for technological hazards are influenced by more characteristics than natural hazards, including, for example, perceived benefits and perceived controllability.

Clarifying perceptions of risk from a natural disturbance is helpful in understanding acceptable management responses to the MPB infestation and in developing communications on parks policy and management. Perceptions of ecological risk have been shown to influence public preferences for natural resource policy and management. For example, people who perceive higher ecological risk were more supportive of restrictions on industrial and development activities[14] and perception of risk from the forest industry had a positive association with support for increasing the amount of protected area for the purpose of conserving biodiversity.[17]

To explore the potential contribution of a risk perception framework in understanding public perceptions of managing natural disturbance in protected areas, we use some of the risk characteristics identified in the ecological risk literature, and examine perception of risk associated with a natural disturbance agent (mountain pine beetle) in two of Canada's national parks. This article addresses the following questions: How do park visitors rate the risk from MPB relative to threats from anthropogenic practices and other natural phenomena? What visitor characteristics influence risk judgments of MPB in national parks? Do risk judgments influence support for controlling MPB outbreaks in National Parks?

4. METHODS

Data were obtained from two studies of visitors to Banff and Kootenay National Parks.

4.1. Study 1

The first study examined the general perception of ecological risk from three natural disturbance agents and 10 anthropogenic hazards that could pose a risk to the health and productivity of park ecosystems. Data were collected by mail survey. The sample for the mail survey was obtained from August to October 2003 by intercepting visitors at popular vehicle-based campgrounds (Redstreak in Kootenay National Park and Tunnel Mountain and Lake Louise in Banff National Park), park visitor reception centers located in the towns of Radium, Lake Louise, and Banff, and at two popular day use areas in Banff National Park (Johnston Canyon and Bow Falls). Visitors were sampled on weekdays and weekends. Once an intercept was completed the next available visitor was approached. Because of the logistics involved in conducting a mail survey of international visitors, only residents of Canada were invited to participate in the mail survey. Of the 1,703 visitors intercepted, 794 were Canadian and 573 expressed interest in receiving the mail survey. The questionnaire addressed several aspects of park management, with a focus on managing MPB. In addition to general perception of ecological risk, data were collected on knowledge of MPB, attitudes toward MPB, support for controlling MPB in the parks, and demographics (see McFarlane *et al.*[18] for mail survey details). Following the convention of the ecological risk literature, general risk was assessed as impacts on the health and productivity of ecosystems[2,11] (Table I). Knowledge of MPB was self-rated on a four point scale: 1 = never heard of it; 2 = heard of it but know nothing about it; 3 = heard of it and have some knowledge; and 4 = know a lot about it. To examine support for controlling MPB, respondents rated the management option of "Allowing the outbreak to run its course without intervention" on a scale ranging from 1 = strongly favor to 5 = strongly oppose. Questionnaires were mailed in November 2003. Response to the mail survey was 72.6%.

4.2. Study 2

Study 1 suggested that visitors perceived high general ecological risk from the MPB (see results be-

	Scale Endpoints	*M*	*SD*
General risk			
Please rate how much of a risk you think each item poses in terms of its impact on the health and productivity of ecosystems in Banff and Kootenay national parks	1 = poses no risk 7 = poses a great risk	5.51	1.42
Risk to ecosystems			
Please rate the extent to which you believe the mountain pine beetle will have an impact on park ecosystems	1 = very negative impact 5 = very positive impact	2.42	1.08
Please rate the extent to which mountain pine beetle impacts on park ecosystems are acceptable to you personally	1 = very unacceptable 5 = very acceptable	2.87	1.12
Please rate the level of emotion you feel when you think about mountain pine beetle and its impacts on park ecosystems	1 = very negative emotion 5 = very positive emotion	2.31	0.82
Risk to humans			
Please rate the extent to which you believe the mountain pine beetle will have an impact on the visitor experience	1 = very negative impact 5 = very positive impact	2.33	0.73
Please rate the extent to which mountain pine beetle impacts on visitor experience are acceptable to you personally	1 = very unacceptable 5 = very acceptable	3.02	0.99
Please rate the level of emotion you feel when you think about mountain pine beetle and its impacts on the visitor experience	1 = very negative emotion 5 = very positive emotion	2.46	0.72

Table I. Perception of Risk Scales and Responses

low). This prompted us to conduct a second study in 2005 to explore further some of the cognitive and affective evaluations of risk from MPB. Study 2 collected data onsite from July to the end of October 2005 from Canadians and non-Canadians visiting popular areas in the parks (Lake Louise visitor reception center, Johnston Canyon, and Lake Minnewanka in Banff National Park and Paint Pots and Redstreak campground in Kootenay National Park). Sampling occurred on weekdays and weekends and used the next available visitor approach. In total, 2,364 visitors were intercepted and 1,930 (81.6%) participated.

Assessments of perceived ecological risk have included dimensions related to impacts on ecosystems, impacts on humans, human benefits, avoidability, acceptability, controllability, and knowledge of impacts.[2,11–14] Our approach, though based on this tradition, followed that of other studies[15,16] and used a reduced set of risk dimensions related to the extent, acceptability, and emotionality of impacts on ecosystems and on humans (Table I). Data on knowledge of MPB, support for controlling MPB outbreaks in the national parks, and demographics were also collected. Knowledge of MPB was assessed using two indicators: the self-rated format described in Study 1 and true or false statements.

Although people often express opinions about hazards that they know little about, they are generally aware of the hazard and have some knowledge of the potential impact, e.g., floods or earthquakes. People have at least heard of the hazard and, though they might lack technical knowledge or first-hand experience, they have probably seen media reports on hazard damage in other areas. MPB, on the other hand, is a relatively new hazard; its impacts are localized and largely unknown to people outside the infested areas. The current MPB outbreak in western Canada has only recently begun to appear in local media reports. In this study, for example, 52% of visitors from Alberta and British Columbia indicated they had at least some knowledge of MPB, compared to only 20% of visitors from other areas. We felt that asking detailed questions during face-to-face surveys with visitors who knew nothing about the survey topic would potentially annoy many visitors. Therefore, only respondents who indicated they had at least some knowledge of MPB (responded 3 or 4 on the self-rated knowledge question) were asked to complete more detailed questions on risk, true or false statements about MPB, and support for controlling beetle populations in the national parks. This screening procedure resulted in 515 completed surveys from informed park visitors.

Respondents who indicted some knowledge of MPB rated eight statements as true, false, or not sure. For analyses of ecological risk, we include the three statements that were related to the ecological aspects of MPB. These were: "The mountain pine beetle is a naturally occurring insect in the mountain parks" (true); "Mild winters have contributed to the current outbreak of MPB" (true); and "The suppression of forest fires has contributed to the current MPB outbreak" (true). A knowledge score was calculated for each respondent based on the number of correct answers.

To examine support for controlling MPB, respondents rated the statement "Mountain pine beetle outbreaks should be controlled in the parks" on a scale ranging from 1 = strongly disagree to 5 = strongly agree.

Demographic information collected in both Study 1 and Study 2 included age, sex, and visitor origin. Sex was measured as a dummy variable with 0 = male and 1 = female. To examine the influence of residency on risk judgments, respondents in Study 1 were divided into local residents (those who lived in the provinces of Alberta and British Columbia) and other Canadians. Respondents in Study 2 were divided into local residents, other Canadians, and non-Canadians.

Complete question wording for both studies is available from the authors.

Similar to earlier studies of perception of ecological risk that employed nonprobability samples,[11,13,14] we used *t*-tests and regression analysis to examine the association among variables rather than to generalize to a larger specific visitor population.

5. RESULTS

5.1. Study 1

Respondents to the 2003 mail survey had a mean age of 46, 59% were men, 73% resided in Alberta or British Columbia, and 27% were from other Canadian provinces. On self-rated knowledge, 3.5% indicated they had never heard of the MPB, 25.6% had heard of the beetle but knew nothing about it, 61.5% knew something about the beetle, and only 2.7% indicated they knew a lot about MPB. They supported intervention in MPB outbreaks in Banff and Kootenay National Parks ($M = 4.17$, $SD = 1.09$).

We used principal axis factor analysis with varimax rotation to explore patterns among the risk data and determine if MPB formed part of a natural disturbance construct. Two factors were identified that correspond to natural disturbance and anthropogenic hazards (Table II). MPB was one of three hazards that loaded on a natural disturbance factor.

Results on the general perception of ecological risk to Banff and Kootenay National Parks are pre-

Table II. Ratings[a] and Factor Analysis of Natural and Anthropogenic Hazard Items on Risk to the Health and Productivity of Banff and Kootenay National Park Ecosystems

	M	*SD*	Factor 1	Factor 2	Cronbach's α
Natural disturbance					0.67
Mountain pine beetle outbreaks	5.51	1.42	0.16	0.70	
Spruce budworm outbreaks	4.87	1.44	0.18	0.71	
Naturally occurring forest fires	3.99	1.79	−0.04	0.41	
Anthropogenic hazards					0.86
Poaching of wildlife	5.34	1.68	0.41	0.32	
Industrial activity (such as logging and mining) next to the parks	5.31	1.54	0.75	0.09	
Pollutants found in park rivers, lakes, and streams	5.27	1.47	0.68	0.29	
Land use development next to national parks	5.24	1.57	0.71	0.13	
Introduction of nonnative plant and animal species	5.19	1.51	0.38	0.13	
Tourism development in the national parks	4.92	1.50	0.74	−0.13	
Wildlife deaths caused by motor vehicles and trains	4.77	1.62	0.57	0.18	
The number of people using the parks	4.73	1.37	0.68	−0.11	
Climate change or global warming	4.70	1.64	0.51	0.12	
Emissions from automobiles in the park	4.32	1.59	0.68	0.18	

[a]Rated on a scale from 1 (poses no risk) to 7 (poses a great risk).

sented in Table II. With the exception of forest fires, the hazard items were rated as posing a risk ($M > 4.0$) to park ecosystems. Paired comparison t tests were used to examine differences among the hazard ratings. Mountain pine beetle outbreaks were rated as posing a greater risk than the other natural disturbance hazards, i.e., spruce budworm outbreaks ($t = 9.67$, $df = 360$, $p < 0.0001$) and naturally occurring forest fires ($t = 15.19$, $df = 386$, $p < 0.0001$). MPB outbreaks were also rated significantly higher ($p \leq 0.05$) than the anthropogenic hazards. For example, the MPB was rated as posing a greater risk than industrial activity ($t = 2.12, df = 385, p = 0.0345$) or land use development next to the parks ($t = 2.73, df = 385, p = 0.0067$), tourism developments in the parks ($t = 5.82, df = 386, p < 0.0001$), introduction of nonnative species to the parks ($t = 3.01$, $df = 383$, $p = 0.0028$), and the number of people using the parks ($t = 8.01$, $df = 386, p < 0.0001$). In contrast, naturally occurring forest fires were rated significantly lower than all other hazard items. Spruce budworm outbreaks, although receiving a relatively high rating ($M = 4.87$), was either significantly lower or not significantly different from nearly all of the anthropocentric hazards. The only anthropocentric hazard that was rated lower than spruce budworm outbreaks was emissions from automobiles in the parks ($t = 5.76$, $df = 362$, $p < 0.0001$). Clearly, MPB was viewed as posing a significant risk to the health and productivity of park ecosystems and was perceived differently than the other natural disturbance items.

We used ordinary least squares (OLS) regression to examine the contribution of knowledge of the MPB and demographic characteristics to the judgment of general risk. General risk ratings increased with self-rated level of knowledge, age, and being female (Table III).

Next, we used OLS regression to examine the contribution of the general risk domain, knowledge, and demographics on support for controlling MPB outbreaks in national parks (Table IV). Only general risk and sex influenced support for intervening in MPB outbreaks in the parks. Higher risk ratings and being male were associated with greater support for intervention. These variables explained about 25% of the variance in support.

5.2. Study 2

Respondents to the 2005 onsite survey had a mean age of 51, 57% were men, 40% resided in Alberta or British Columbia, 10% were from other Canadian provinces, and 50% were non-Canadians. Most respondents were not familiar with MPB: 41.8% had never heard of it, 31.4% had heard of the beetle but knew nothing about it, 24.6% indicated they knew something about the beetle, and 2.2% knew a lot about the beetle. Respondents who indicated they had least some knowledge of MPB had a mean score of 2.27 ($SD = 0.79$) on the true or false knowledge statements and were supportive of controlling MPB outbreaks in the parks ($M = 4.27$, $SD = 1.05$).

The onsite surveys conducted in 2005 provided further insight to the perceptions of ecological risk from the MPB. The extent of the impacts, the acceptability of impacts, and the level of emotion associated with the impacts revealed that, on average, park visitors who had some knowledge of the beetle rated the ecological impacts as negative, unacceptable, and eliciting negative emotion (Table I). Similarly, the MPB was rated as having negative impacts on the visitor experience, elicited negative emotion, and unacceptable. However, visitors rated the extent of the

Table III. Standardized Regression Estimates (β) of Variables Associated with Perception of Ecological Risk from Mountain Pine Beetle Outbreaks in Banff and Kootenay National Parks

	General Risk	Risk to Park Ecosystems			Risk to Humans		
		Impacts	Acceptability	Emotion	Impacts	Acceptability	Emotion
Knowledge	0.19*	0.21*	0.26*	0.16*	0.08	0.22*	0.11**
Local resident	0.06	−0.14*	−0.19*	−0.18*	−0.10**	−0.16*	−0.14*
Age	0.11**	−0.07	−0.11*	−0.14	0.07	−0.09**	−0.05
Sex	0.11**	−0.02	0.06	0.02	0.12*	0.01	0.07
F value	6.16	9.82	17.10	10.30	4.21	11.55	4.92
Adjusted R^2	0.054	0.066	0.113	0.069	0.025	0.078	0.030

*$p < 0.01$.
**$p < 0.05$.

Table IV. Regression Analysis of Factors Influencing Support for Controlling Mountain Pine Beetle (MPB) Outbreaks in National Parks

	Support for Controlling MPB	
	2005 Onsite Survey	2003 Mail Survey
General risk	na	0.51*
Risk to ecosystems		
Impacts on park ecosystems	−0.11**	na
Acceptability of ecosystem impacts	−0.16*	na
Emotional response to ecosystem impacts	−0.22*	na
Risk to humans		
Impacts on experience	0.07	na
Acceptability of experience impacts	−0.07	na
Emotional response to experience impacts	−0.01	na
Knowledge	0.01	0.01
Local resident	0.02	0.05
Age	0.03	−0.00
Sex	0.03	−0.16*
F value	12.37	17.49
Adjusted R^2	0.186	0.254

*$p < 0.01$.
**$p < 0.05$.
Note: na = not applicable.

visitor impacts less negatively ($t = 1.92$, $df = 505$, $p < 0.0556$), more acceptable ($t = -3.82$, $df = 510$, $p < 0.0001$), and eliciting less negative emotion ($t = -5.15$, $df = 509$, $p < 0.0001$) than ecosystem impacts. Visitors from the local area (residents of Alberta and British Columbia) perceived more negative impacts on ecosystems and the visitor experience, were less accepting of the impacts, and experienced more negative emotion than visitors from other provinces or countries (Table V). However, only differences between the local residents and non-Canadians were significantly different.

Multivariate analysis (OLS) showed that greater knowledge of MPB was associated with a more positive assessment of the extent of impacts, greater acceptability of impacts, and more positive emotion (Table III). In contrast, being a local resident influenced assessments negatively. Visitors from local areas assessed ecological and human impacts more negatively, were less accepting of the impacts, and expressed more negative emotion than other visitors. Age had a negative influence on acceptability of impacts with older visitors rating the impacts less acceptable. Sex only influenced impacts on the visitor experience, with women rating the extent of the impacts as more positive than men. The domains of acceptability and emotion on both the risk to park ecosystems and the risk to the visitor experience were influenced by the same factors: acceptability was influenced by knowledge, residency, and age; and emotion was influenced by knowledge and residency. Knowledge had a greater effect than the other variables on acceptability but residency had a greater effect on emotion (judged by the higher beta values). The extent of impacts to park ecosystems and the visitor experience, however, differed in their explanators. Extent of impacts to park

Table V. Mean[a] Ratings of Perception of Risk by Visitor Origin

	Visitor Origin		
	Local	Other Canadian	Non-Canadian
General risk[b]	5.58 (1.44) a	5.33 (1.35) a	na
Risk to ecosystems			
Impact on park ecosystems[c]	2.23 (1.04) a	2.54 (1.27) a,b	2.54 (1.05) b
Acceptability of impacts on park ecosystems[d]	2.62 (1.12) a	2.86 (1.20) a,b	3.06 (1.07) b
Level of emotion[e]	2.14 (0.80) a	2.38 (0.78) a,b	2.43 (0.82) b
Risk to humans			
Impact on the visitor experience[c]	2.23 (0.73) a	2.28 (0.73) a,b	2.41 (0.72) b
Acceptability of impacts on visitor experience[d]	2.83 (0.98) a	3.00 (0.93) a,b	3.17 (0.99) b
Level of emotion[e]	2.34 (0.69) a	2.48 (0.76) a,b	2.59 (0.71) b

[a]Any two means that do not share a letter are significantly different according to Tukey's studentized range test ($p \leq 0.05$).
[b]Rated on a scale from 1 (poses no risk) to 7 (poses a great risk).
[c]Rated on a scale from 1 (very negative impact) to 5 (very positive impact).
[d]Rated on a scale from 1 (very unacceptable) to 5 (very acceptable).
[e]Rated on a scale from 1 (very negative emotion) to 5 (very positive emotion).
Note: na = not applicable.

ecosystems was influenced by knowledge and residency whereas extent of impacts to the visitor experience was influenced by residency and sex.

Next, we examined the influence of risk to ecosystems and risk to humans, knowledge, and demographics on support for controlling the MPB (Table IV). Only the risk to ecosystem domains influenced support for controlling MPB. The more negative the perceived ecological impacts, the less acceptable, and the more negative emotion associated with the impacts, the more support for controlling MPB. Emotional response to ecosystem impacts had the greatest influence on support for controlling MPB outbreaks. The extent, acceptability, and emotionality of impacts on the visitor experience, knowledge, and demographics did not influence support for controlling MPB outbreaks. This suite of variables explained 19% of the variance in support for controlling MPB.

6. DISCUSSION

This article provides some insight into how people view the ecological consequences of a MPB infestation in two of Canada's national parks and suggests that a risk perception framework can contribute to understanding pubic perceptions of ecological hazards in protected areas. This current exploration of perceived ecological risk showed that park visitors perceived MPB as a risk to park ecosystems. This view is in contrast to the management agency's, which views MPB as an agent of ecosystem renewal. However, visitors were supportive of the agency's approach of intervening in MPB outbreaks.

Studies of ecological risk have shown that natural phenomena tend to receive relatively low or moderate general risk ratings compared to technological hazards.[11] This article, however, shows that a natural disturbance agent (MPB) was rated as posing greater ecological risk to national parks than anthropogenic hazards and other natural phenomena (fire and spruce budworm). Why does the perception of risk associated with MPB seem to differ from that of risks from other natural phenomena? We suggest three possible factors that could explain this result. First, MPB might not be viewed as a natural phenomenon, at least not at its current population levels and distribution. Rather than being viewed as an agent of ecosystem renewal, MPB was viewed by park visitors as a threat to the health and productivity of park ecosystems, the impacts were judged as unacceptable, and visitors supported controlling MPB populations in the parks. Second, it is predicted that as the timber supply in BC diminishes, communities dependent on the forest industry will experience an economic decline.[7] Similarly, in Alberta there are predictions that the MPB could impact timber supply and forest-dependent communities. Governments, industry, and media have stressed the potential for catastrophic impacts from the MPB infestation. Thus, the anticipated impacts beyond the park boundaries may be influencing judgments of risk for the parks. Third, the MPB is not like other natural hazards such as floods, hurricanes, and wildfire, which tend to have a clear beginning, middle, and end.[11] The current MPB outbreak in western Canada began over a decade ago, is expected to continue for several more years, and many of its impacts will only be realized decades into the future. Thus, the extended life of the hazard's occurrence and impacts may be influencing risk perceptions.

Knowledge and residency had the greatest effects and were the most consistent visitor characteristics that influenced risk judgments. In Study 1, a higher level of self-rated knowledge was associated with higher ratings of general riskiness to ecosystems. Among the informed visitor sample in Study 2, however, ecological knowledge of MPB (true or false statements) was associated with more positive assessments of impacts, acceptability, and emotion. This finding is consistent with other studies in which experts (an informed group) had lower ratings of ecological risk than lay people[13,14] and in which lay people with high knowledge perceived less risk to forest biodiversity from natural disturbance.[17] This suggests that enhanced ecological knowledge decreases both the cognitive (i.e., impacts and acceptability) and affective (emotion) judgments of risk. This could be due to an understanding of the function of MPB in park ecosystems among the informed park visitors. If so, then designing communications to inform the public about the ecological aspects of MPB and its role in park ecosystems may be an effective strategy for influencing risk perceptions. However, local residents in Study 2 perceived higher negative impacts, were less accepting of the impacts, and experienced more negative emotion. The influence of residency on risk judgments could be due to local park visitors reflecting upon their experiences with MPB and information they have received beyond the parks' boundaries.

This article found that among park visitors with some knowledge of MPB, risk to ecosystems was rated higher than risk to the visitor experience. Even though the visitor impacts were rated as negative, visitors

were more accepting of these impacts than impacts to ecosystems. This suggests the social construction of risk to protected areas might differ from ecological risk assessments in nonprotected environments. For example, a consistent finding in the ecological risk literature is that lay people tend to rate risk from natural phenomena as having greater impacts on humans than on natural environments.[2,11] Our analysis, however, suggests that informed park visitors viewed greater risk to park ecosystems than the visitor experience. Further evidence of this was found in the effects of perceived risk on support for controlling MPB outbreaks in the parks. In Study 1, the higher the perceived general risk to the health and productivity of park ecosystems, the more support for controlling the MPB. Similarly, in Study 2 the extent, acceptability, and emotionality of impacts to ecosystems influenced support for controlling the beetle in the parks, whereas risk judgments of the visitor experience had no effect on support for controlling MPB. Thus, it appears that visitors' support for management intervention is not centered on their own park experience but rather on the parks' ecosystems. The focus on ecosystem impacts suggests that visitor assessments are consistent with the national parks' priority of protecting ecological integrity.[1] It also suggests that control measures aimed at restoring ecosystem health and communications that address ecosystem concerns will appeal to park visitors.

In conclusion, as far as we are aware, perception of ecological risk research has been confined to ecosystems that are subjected to multiple activities and land use objectives. This article extended this line of inquiry to protected areas and has provided some insights into the perception of risk associated with a natural disturbance agent in Canada's national parks. Clearly, the MPB was judged differently than other natural disturbance agents and anthropocentric hazards. However, considering the extreme nature of the MPB outbreak in western Canada and the relatively recent emergence of this hazard, our results might be atypical of perception of risk from other natural disturbance agents. Given the importance of managing ecological risks in protected areas, more research is needed on public perceptions of ecological risk associated with specific hazards. In particular, although this article provided some insights there were limitations. The sample in Study 1 consisted of only Canadian residents at popular visitor sites and Study 2 consisted of visitors who indicated they had some knowledge of MPB. The extent to which the findings presented here are representative of a broader visitor population is worthy of further investigation. In addition, we used a reduced set of ecological risk dimensions. For example, only visitor experience was used in assessing impacts on humans. The most significant human impacts might be on local communities where the beetle could impact people's livelihoods. Including community impacts as a component of the human impacts domain and including additional domains (e.g., avoidability) would provide a more comprehensive assessment of ecological risk judgments for protected areas.

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