

Using conjoint constitution to understand responses to slow-moving environmental change:

The case of mountain pine beetle in north-central Colorado

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Abstract (160 words): A growing body of work exists on the social implications of forest insect disturbances. However, although increasingly explored, there remains a need to further understand social responses to large-scale forest insect disturbances over time. This requires longitudinal investigations into people's conceptualizations of their changing local environments, associated risk perceptions, and forest management preferences in the context of forest insect disturbance-related changes to the landscape. Within the context of the mountain pine beetle

outbreak that affected approximately 3.4 million acres of Colorado forests, this study is a ten-year follow-up to a 2006-2007 study that explored local responses to the outbreak. Using qualitative interviews with 54 informants from nine north-central Colorado communities affected by the outbreak, this paper incorporates a social construction approach known as ‘conjoint constitution’ to examine the interplay between slow-moving biophysical changes to the landscape as a result of the outbreak, communities’ understandings and risk perceptions of these changes, as well as shifts in locals’ thinking about forest management.

Key words: conjoint constitution; environmental change; forest insect disturbance; mountain pine beetle outbreak; risk perception

1 Introduction

2 Slow-moving environmental changes have increasingly gained attention among scholars
3 exploring the short- and long-term consequences of climate change, such as drought, flooding,
4 and sea-level rise (Allen et al. 2010; Pedruco et al. 2018; Porfiriev 2015). Such studies have
5 examined the social implications of and responses to these evolving events, including migration,
6 adaptation, policy change, as well as economic and public health outcomes (Birkmann et al.
7 2010; Fischer and Frazier 2018; Millman 2018; Porfiriev 2015). In the context of slow-moving
8 environmental change research, however, the social implications of forest insect disturbances –
9 although increasingly explored – remain understudied. This is despite the fact that such
10 disturbances are expected to increase as a result of changing climatic patterns (Dale et al. 2001;
11 Johnstone et al. 2016; Pureswaran et al. 2015; Seidl et al. 2017). Importantly, while scholars
12 have studied the ecological and social effects (e.g., risk perceptions and levels of concern) of
13 forest insect outbreaks and other forest disturbances (for instance, Dale et al. 2001; Fellenor et al.
14 2018, 2019; Johnstone et al. 2016; Urquhart et al. 2017; Urquhart, Marzano, & Potter 2018;
15 Urquhart et al. 2019), there is an ongoing need to investigate *change over time* with regard to
16 people’s evolving conceptualizations of their landscapes, their perceptions of risk, and changes
17 in forest management preferences in response to large-scale forest insect disturbances (for
18 exceptions, see Flint 2007; Gordon et al. 2013; Qin, Flint, and Luloff 2015).¹ In an effort to
19 address this gap in the literature, we present findings from qualitative fieldwork within nine
20 north-central Colorado communities heavily affected by the mountain pine beetle (*dendroctonus*
21 *ponderosae*, hereafter ‘MPB’) outbreak that affected parts of the Rocky Mountains starting in the

¹ For the purposes of this paper, we characterize forest insect outbreaks *as* forest disturbances. However, for consistency, we use the term “outbreak” to describe the MPB event throughout.

late 1990s. From 1996 to 2014, the outbreak killed roughly 3.4 million acres of Colorado lodgepole pine forests, leaving communities and federal forest management agencies to deal with the environmental, economic, and social consequences that followed (Colorado State Forest Service (CSFS) 2017; Negrón and Cain 2018).

The work presented here builds upon a previous study conducted in the north-central Colorado region in 2006-2007 (Flint, Qin, and Daab 2008; Flint, Flint, and Ganning 2012; Qin and Flint 2010). However, the current findings are derived from data collected from 2017-2018 in which we asked participants from the same nine north-central Colorado communities to reflect on environmental and social changes over time in connection with the MPB outbreak. We employ a conjoint constitution approach, introduced by Freudenburg et al. (1995), to understand the evolution of risk perceptions, community interactions with the landscape, and forest management preferences over time as a result of the outbreak. A conjoint constitution approach represents an analytical and theoretical framing that challenges preconceived notions of what has traditionally been viewed as “strictly social” and “strictly environmental” – moving instead to an understanding that these two “realms” are interrelated and informed by one another. We incorporate this concept into the current paper to organize and present the qualitative data in a way that not only captures change over time with regard to people’s risk perceptions and understandings of their local environments, but also captures the complexity and interrelatedness of society and the environment.

Conjoint constitution and risk perception over time

Conjoint constitution is a way of understanding societal-environmental dynamics. Leveraging the assumptions of this approach in examining slow-moving environmental change provides a unique lens that is grounded in the claim that “what might be taken as the separable

social and physical aspects of the situation were in fact at each stage conjointly constituted - connected with one another as much as are the opposing poles of a magnet” (Freudenburg et al. 1995: 387). Conjoint constitution allows for critical examination into the various ways society and the environment are interrelated and mutually constituted, based within an argument that scholars should move beyond scholarship that analytically separates what historically has been viewed as separate domains for consideration (Fisher 2006; Freudenburg 2002; Freudenburg et al. 1995; Kulcsar, Selfa, and Bain 2016).

One way in which the society-environment relationship is conjointly constituted is through the environmental risks posed to society and how society responds - either in taking actions that exacerbate or mitigate risk. Environmental risk perception research has produced critical insights into the ways individuals and communities come to understand risks and whether perceptions precede responsive behavior (Flint and Luloff 2007; Kasperson et al. 1988; Lo 2013; Paton, Smith, Daly, and Johnston 2008; Stallings 1995; Wachinger, Renn, Begg, and Kuhlicke 2012; Whitmarsh 2008). However, although perceived risk, whether attenuated or heightened, is a critical process that influences how society interacts with the environment, relatively little work has tracked change over time with regard to risk perception (Brenkert-Smith et al. 2013; Dake 1992; Gordon et al. 2013; Kasperson et al. 1988; Pidgeon, Kasperson, and Slovic 2003; Qin et al. 2015). The fact that a majority of studies concerning risk perception and response to environmental threats rely on a cross-sectional approach limits what we know about the dynamic nature of environmental risk perceptions and concerns (Bubeck and Botzen 2013; Hannibal, Liu, and Vedlitz 2016; Rogers 1997; Siegrist 2013). This gap is particularly evident in natural resource-based communities, such as those found in north-central Colorado, which provide

useful contexts for understanding changing perceptions and decisions in evolving social and ecological systems.

Conjoint constitution allows for an analysis of the highly interactional ways that communities respond to long-term environmental changes beyond mediating factors concerned with how risk communication attenuates or amplifies risk perceptions (Brenkert-Smith et al. 2012; Pidgeon, Kasperson, and Slovic 2003; Pidgeon and Henwood 2010). This framework has the potential to build upon the social amplification of risk framework (SARF) by giving more attention to the *environmental cues* that affect risk perception (Fellenor et al. 2019; Kasperson et al. 1988). Conjoint constitution allows for a deeper, more complex understanding of peoples' relationships with their environments and how these relationships subsequently inform risk perceptions -- focusing beyond social mediators (media and other forms of communication) as primary factors for influencing risk perception. Our approach complements Gordon and colleagues' (2013) typological framework that takes into account the intersecting biophysical, social, and cultural processes that contextualize community risk perceptions over time. This comprehensive matrix approach is similar to the approach we took with our multi-method study design; however, we focus on a particular thread of inquiry concerning the role of the biophysical environment and its reciprocal relationship with social and cultural factors that influence risk perception and management preferences.

In the case of the MPB outbreak, slow-moving environmental change has not only yielded human interactions (the primary focus of the inquiry presented here), but is simultaneously the result of similar societal-environmental interactions (e.g., forest management, climate change). As discussed in our analysis of findings, a conjoint constitution approach provides a lens that moves beyond solely understanding community responses to the outbreak,

which may vary across time and space, to one that captures how interpretations of the environment, societal responses, and changing environmental conditions are dynamic and interdependent (Lidskog and Waterton 2016; Lockie 2015). This allows for a recognition of how conceptualizations of the environment, including perceived risks and responses to these changes, take place along evolving environmental conditions - that society and the environment are mutually constituted (Lidskog and Waterton 2016; Lockie 2015). Local environments are not stable nor solely acted upon, but rather undergo continual change as a result of natural and/or societal processes. Conceptualizing the environment as dynamic necessitates an understanding that risk perceptions and actions associated with environmental change are also dynamic.

Study background

The 1996 mountain pine beetle outbreak

Beginning in the late 1990s, the MPB outbreak affected large swaths of the Rocky Mountain region including Colorado, Wyoming, South Dakota, and parts of Mexico and British Columbia forests (National Park Service (NPS) 2018; USFS 2010). According to the U.S. Forest Service (USFS N.D.(a)), by roughly 2012, MPBs “have killed nearly all mature lodgepole trees in northern Colorado and southern Wyoming.” MPBs are native species to Colorado, but a number of factors caused them to grow and spread at the intensity and scope at which they did, such as warmer winters and the buildup of dense, homogenous forests of the same age (Beetle Bark Symposium 2005; Carroll 2010). Since 1996, the MPB outbreak has affected roughly 3.4 million acres of lodgepole pine forests in Colorado (CSFS 2017; Negrón and Cain 2018). However, since 2011, rates of infestation have substantially decreased due to a lack of available “food” for the beetles.

At the start of the epidemic, infected trees remained green and seemingly “healthy” - making it difficult for the general public to visually recognize the outbreak as a problem. In subsequent years, green MPB-infested lodgepole pine forests starkly changed color, and copper-red colored trees overtook the landscape. This phase of the outbreak is particularly notable, since it also marked a shift in public awareness and risk perception, which we discuss in the findings section of this paper. After affected trees’ needles turned copper-red, they eventually dropped their needles and faded into gray, now dead-standing forests.

2006-2007 mountain pine beetle study in north-central Colorado

As indicated in the introduction, the current study builds upon a 2006-2007 study led by Flint and Qin to examine local responses to the MPB outbreak in north-central Colorado (Flint, Qin, and Ganning 2012; Qin and Flint 2010). The research design employed in the previous study included key informant interviews, mail surveys, and secondary biophysical and socioeconomic data analysis (e.g., aerial surveys and U.S. census data) throughout the same nine north-central Colorado communities represented in this paper: Breckenridge, Dillon, Frisco, Granby, Kremmling, Silverthorne, Steamboat Springs, Vail, and Walden. (See Figure 1 below with study area circled (USFS N.D.(b).))

[Figure 1 here]

Within the study region, the MPB outbreak has affected approximately 1.6 million acres, although the nine communities experienced differential rates of infestation (CSFS 2019). The communities also vary in terms of their geographies, local economies and histories, as well as population sizes. Population sizes throughout the nine study communities range from roughly 600 to over 12,000 people. Most of these communities’ economies are recreation or tourism-related, with six ski resorts represented in Breckenridge, Dillon, Frisco, Granby, Steamboat

Springs, and Vail areas. Other forms of recreation include fishing, hunting, camping, and hiking. Ranching and other forms of industry such as logging also exist within some of these study communities, including Kremmling, Walden, and Granby.

Methodology

As part of the larger study, we employed a mixed methods approach to data collection that includes: key informant interviews, household mail surveys, secondary socioeconomic and biophysical data analysis, and a media analysis of five local and regional newspapers between 2006-2018 pertaining to the MPB outbreak. For the purposes of the work presented here, however, analysis and discussion are derived from qualitative, key informant interviews with 54 participants throughout the study area, including four individuals outside of the study area (Denver Metro).^{2,3} A breakdown of participants by community and county are provided in the table below.

[Table 1 here]

Recruitment of study participants ran from October 2017 to July 2018 and initially focused on recruiting the original 2006-2007 study participants. When an original study participant was unavailable due to change in position, movement out of the area or otherwise,

² These four individuals were included in the study due to their organization's partnership with the U.S. Forest Service, Colorado Forest Service, and the Natural Resource Conservation Service to mitigate forest risks - including parts of the north-central Colorado region.

³ 'Key informants' is a term we use to group and describe the range of participants included within this study. It generally refers to people who are knowledgeable about local issues and community actions in response to the MPB outbreak. With the exception of the four individuals from Denver, all study participants live and/or work within the study region and bring multiple perspectives to the table. Where applicable, we include a description of each participant including their role as well as time lived/worked within their communities and/or the north-central Colorado region more broadly using the following format: Location Informant # (Role, Tenure) (e.g., Grand County Informant 1 (Forester, 10+ years tenure)).

recruitment then focused on identifying and recruiting individuals who currently fill the original participant's vacated positions.⁴ Of the 54 individuals interviewed, 12 were participants from the 2006-2007 study.

Interview participants were asked their permission to record, and in instances in which individuals declined or the setting was too loud to record, extensive hand-written notes were taken. Interview data were digitized, transcribed by a paid transcription service (Rev.com), and subsequently analyzed using NVivo11 and NVivo12 qualitative analysis software. We initially used an open-coding strategy in which we created high-level codes informed by the interview guide. These codes were divided along themes pertaining to perceived environmental and social change, community participation in addressing the outbreak, and local economy, to name but a few examples. We subsequently refined and built off of these initial codes through axial or second-level coding throughout the data analysis process in which members of the research team consistently met, compared notes, and eventually finalized a set of codes and subcodes for qualitative data analysis (Berg 2004; Saldaña 2009).

Complementing these formal interviews are a number of community meetings and informal meetings with a range of individuals throughout the north-central Colorado region, which were captured through hand-written and digitized note-taking. In total, members of the research team *informally* met with 10 additional stakeholders and attended 11 community meetings in the study area to learn from community members about forest health concerns and activities, gather suggestions and insights about individuals to be recruited for the study, as well

⁴ In our attempts to contact previous interviewees, we were unable to find updated contact information for a majority of these individuals. Given this, we were able to contact 45 previous interviewees. Upon reaching out to these 45 individuals, a majority did not return emails or phone calls for study participation. Others had either moved out of the region or declined to be interviewed (n=4).

as to share relevant updates pertaining to the project discussed here. Participation in community meetings allowed engagement with residents living in the study area on topics pertaining to the MPB outbreak, forest health, and other forest issues, providing the research team with a deeper understanding of the context in which residents live. Consequently, participation in and reflections of these meetings aided in the interpretation of interview data and were essential in developing a deeper contextual understanding of communities' experiences of and responses to the outbreak. Three community forums (included in the number of community meetings above) in Grand County, Routt County, and Summit County provided an opportunity for researchers to share study insights and solicit engagement around key themes - including convergence and social license around forest management – as discussed in the next section of this manuscript.

Findings

The central line of inquiry during the interviews was to understand participants' perspectives on environmental and social changes resulting from the MPB outbreak. They were asked to reflect on these changes over the past ten years or since their time in the community, as well as how, if at all, they think community perceptions of forest management have changed. Multiple themes from the interview data spanned across communities, including an evolution of risk perception alongside the MPB outbreak cycle, changing interactions with the environment, and shifts in forest management preference. In the subsections that follow, we discuss 1) how the outbreak evolved alongside residents' "stages of grief" in response to environmental changes through which feelings of sadness, anger, fear, and acceptance arose from changes to the landscape; 2) how residents' interactions with their local environments have changed as a result of the outbreak; and 3) a noticeable shift in thinking about forest management stemming from

the outbreak within some communities, representing a theme of convergence in opinions of and preference for forest management.

The central purpose of this paper is to discuss broad trends associated with a reconceptualization of the landscape, associated risks, and forest management preferences. In so doing, this paper attempts to capture the complexity of society-environment relationships over time using the MPB outbreak as an example of how the “natural” and the “social” are mutually constituted. Analysis and discussion of these overarching themes throughout the study area is an important first step in understanding change over time with regard to people’s risk perception and responses to the outbreak. Although nuances exist within and among communities across the study region and provide an essential backdrop for understanding the mutually constituted ways in which societal-environmental relationships change over time, this dimension is largely outside the scope of the current paper. Subsequent work will examine differences in perception and response within and among communities, with a central focus on the importance of community context for understanding these nuances (Anonymous et al. *in development*).

MPB outbreak and the “stages of grief”

The MPB outbreak, as described above, followed a relatively linear series of events from initial infestation of lodgepole pine to what are now gray, dead-standing trees. All study participants identified the stages resulting from the MPB infestation against the forest landscape: 1) infected, yet green and seemingly “healthy” trees, 2) to copper-red colored needles of the lodgepole pine, and, 3) eventually to the current stage of gray, dead-standing and fallen trees. These stages took place over roughly a decade’s time and affected – and continues to affect – communities within and around north-central Colorado forests at varying rates. Alongside the recognizable, biophysical changes that occurred within Colorado lodgepole pine forests,

216 informants commonly referred to general feelings of denial, fear, anger, uncertainty, sadness,
217 and, eventually, acceptance among community members – what they equated to the “stages of
218 grief.” As a forest manager and resident from Grand County explained:

219 *When the pine beetle [came] in, there was strict denial. Like, no, this isn't happening. We*
220 *were watching various parts of the county - different communities - go through these*
221 *stages of grief. It was very apparent because people love their forest. It was green, it was*
222 *never gonna change. Don't mess with my trees. That process was just interesting as hell*
223 *to watch. - Grand County Informant 1 (Forest Manager, 20+ year tenure)*

224 A state forester and resident from Routt County also witnessed what he referred to as “stages of
225 grief,” specifically denial, when it came to residents’ response to the outbreak.

226 *What I lived through as a forester was the initial stages of this, which we came to, and I*
227 *certainly came to view as the stages of grief, where you would come and you'd see the*
228 *beetle pitch tubes, and seeing the way the epidemic was growing so rapidly, you're like,*
229 *"Oh. You know, your trees have been hit, and they're dead, they don't know it yet." "No, it*
230 *can't be. You're wrong." It's like, "Well, I wish I was wrong, but I don't think I am."*
231 *There's a sort of denial that this could be happening... - Routt County Informant 1*
232 *(State Forester, 20+ year tenure)*

233 He later described the anger he witnessed from members of the community as they coped with
234 the immediate and looming effects of the outbreak: “*There was definitely a lot of anger. People*
235 *were mad at something. Sometimes they were mad at us. 'How could this be happening? Why*
236 *didn't you do something about it?'*”

237 Public interest throughout these communities, including a desire to become educated
238 about the outbreak and participate in forest management decision making processes, peaked
239 during the copper-red stage of the outbreak. This interest was largely attributed to the starkness
240 of red lodgepole pines against the landscape as well as a frequently reported fear of wildfire
241 associated with these changing conditions. Compared to when the infected lodgepole pine trees
242 were still green, the changing of the tree needles to copper-red created a space for meaningful
243 engagement and action in response to the outbreak. As participants explained, community-level

and individual perceptions of risk evolved with the MPB cycle – as the trees changed color, so did people’s risk perception, generally speaking. When the trees turned red, there was a heightened sense of fire risk. However, there is also a shared opinion among several participants that as the needles fell and lodgepole pines turned gray, levels of concern and public interest fell with them:

There was a high level of interest that's changed over time ... there was pretty good information available to people ... plus the trees were dying, and you could see that. They turn red, and then they were dead. After the peak of the epidemic, the trees and public interest have sort of faded together. –Routt County Informant 1 (State Forester, 20+ year tenure)

There was a lot of community engagement when everything was red and it was in their face. What I've definitely seen, it's just been normalized that it happened. - Vail Informant 1 (City government employee, 10+ year tenure)

However, wildfire risk and safety in the form of falling trees remain two of the top reported concerns among participants. Fear of wildfire, in particular, amplified over the course of the outbreak and remained a frequently mentioned area of concern among informants.⁵

In addition to community responses of denial, anger, and fear, several informants noted an eventual position of acceptance among community members as the effects of the outbreak, including the current state of gray, dead-standing trees, increasingly came to be seen as an unavoidable indicator of an ever-changing forest. While there are individuals hoping to see a regeneration of the forest to what it was before the outbreak, some interviewees note a growing acceptance among community members to the fact that ecological change is inevitable. This

⁵ Informants’ reporting on their perceptions may have also been entangled with seasonal factors during the study period. For instance, during the fieldwork this study, Colorado was experiencing a particularly dry winter with low snowpack that alerted study participants about a potentially dangerous wildfire season. This may have caused wildfire risk perceptions to amplify among participants, especially during the latter half of 2017-2018 winter season. Future work will explore these elements of time and the implications of temporality in understanding social responses to environmental change not only over the long-term, but within the research study period as well.

theme of acceptance, as we discuss later on, also reflects an evolution in perspective and preference for forest management throughout several of the study communities as a result of the outbreak. Community meetings in Summit County revealed similar sentiments as residents discussed the changes they had witnessed and emotions they experienced since the inception of the outbreak. Changes in social responses to and perceptions of risk associated with the outbreak are well understood through a mutually constituted perspective of society-environment relationships that highlights the role of the environment in influencing social response. What this theme of “stages of grief” demonstrates are the types of ways individuals within these communities reacted to local environmental dynamics *over time* and how their emotional responses and risk perceptions are connected to noticeable changes to the environment.

Changed interactions with the landscape

The outbreak significantly altered how many community members interact with local landscapes. This not only concerns people’s emotional reactions to aesthetic changes across the forest viewshed, but also ways that people work and recreate within and around MPB-affected forests. We provide examples of these changed interactions from three overarching perspectives that repeatedly appeared throughout data collection and analysis: recreationists, those who work on or with the land for a living, and those engaged in wildfire response.⁶

Colorado’s forests offer a wide range of recreational opportunities throughout the year. These include, but are not limited to, mountain biking, cross-country skiing, hiking, hunting, fishing, and camping. However, because of the outbreak, participants explained that those who

⁶ In some cases, there is overlap among participants in that they may interact with the landscape both through their work and through recreation. We add clarification in instances where this overlap exists. Although some people may interact with the environment primarily through their work-related roles, they may still be residents who are recreationists.

286 recreate in and around affected forests have had to change how they engage in certain activities
287 due to issues of safety and inconvenience. Dead, dying, and fallen trees pose safety risks both in
288 terms of potential physical harm and individuals becoming trapped or rerouted. This is a concern
289 among those who engage in such activities as well as forest managers with limited means and
290 resources to effectively clear trails, roads, and campsites. One resident and federal land manager
291 from Kremmling (resident for roughly 5 years) explained that in recent years these concerns have
292 increased and will remain an issue for the next several years as forest managers work to address
293 fallen trees. During an interview with two Grand County fire officials (both residents for 20+
294 years), they explained that the current phase of the outbreak involving dead, dying, and rotting
295 trees has not only resulted in communities' desire to clear these trees out of surrounding forests,
296 but a heightened sense of concern among and for recreationists:

297 *"[It's] truly hazardous to be walking in the woods these days. Trees are falling without*
298 *warning. They don't make any noise anymore. They're so rotten at the base, they just fall*
299 *over."* – **Grand County Informant 2 (Firefighter, 20+ year tenure)**

300 A Breckenridge firefighter shared the following as an example of changed interactions
301 with the environment among mountain bikers:

302 *Even recreational stuff now is becoming a big thing. Like I said, a lot of the guys that*
303 *bike, serious bikers up here, are carrying saws because trees are just down across their*
304 *favorite trails from one day to the next and that's just kind of where we're at with the*
305 *beetle epidemic.. a little bit of wind and stuff's blowing over.* – **Breckenridge**
306 **Informant 1 (From Grand County, employed in in Breckenridge for 10+ years)**

307 Windy days, in particular, create concern for forest managers who note the safety issues for
308 hikers, campers, and other recreationists. In some cases, before forest management officials were
309 able to remove dead and dying trees from trails and campsites, they had to close sites down for
310 the safety of the public (Berwyn 2008; Dudley 2009). Multiple interviewees explained the
311 necessity of carrying saws when entering the forest in the event that they might become trapped
312 by fallen trees. Although people's interactions within the forests have always necessitated an

313 awareness of risks, this has expanded to more seriously consider falling trees – especially on
314 windy days.

315 Some interviewees hunted within MPB-affected forests or knew of the experiences of
316 other hunters who noted changes in migration patterns that they attributed to beetle kill. A retired
317 USFS employee living in Granby shared that in addition to positive changes some individuals
318 have perceived as a result of the outbreak (e.g., diversification of the landscape), he also noted
319 hunters' complaints about changed migration patterns:

320 *But we're seeing some good things, where Aspens are taking hold. Spruce fir are getting*
321 *kind of a head start before they're crowded out. Grasses and forbs are coming up that we*
322 *haven't seen, but then again, with the trees falling down, critters can't migrate. Some of*
323 *the wildlife corridors have changed. Seems like the hunters are complaining about that.*
324 *The patterns have changed.* – **Granby Informant 1 (Retired, ~30 year tenure)**

325 A resident and city government employee from Vail explained how dead and rotting trees have
326 affected his ability to hunt:

327 *From a hunting standpoint, areas that I've hunted for years now, I can't even walk*
328 *across the forest. I think what that's going to eventually do is concentrate everybody*
329 *down to those areas that have been heavily maintained, which I think for some people it's*
330 *not going to really affect because they're used to staying on trails and staying on*
331 *established roads. I think for those people that are used to just generally using the*
332 *broader forest, I think that's going to have a major impact. Hunting, for instance, I think*
333 *is going to have a substantial impact long-term from the beetle outbreak.* – **Vail**
334 **Informant 1 (City government employee, 10+ year tenure)**

335 These insights illustrate the impact of rotting and fallen trees on individuals' ability to recreate in
336 ways they once did prior to the outbreak. Adjusting their recreational activities by hunting,
337 hiking, or camping in different locations and carrying saws are examples of the ways individuals
338 have had to adapt their interactions with the landscape.

339 A second perspective on changed interactions with the landscape comes from those who
340 work on forest land. For those who work in and around the forests as loggers, ranchers, and
341 forest or land managers, in addition to physical safety concerns, they mentioned other ways in

342 which the outbreak has affected their ability to carry out daily tasks. A rancher living near
343 Steamboat Springs expressed his frustration with having to continually fix fences crushed by
344 fallen trees as well as the need to clear dead trees in and around his property for the protection of
345 his cattle. He went so far as to say that “*the fences have become double or triple the work*
346 *because of all the beetle kill and it’s dangerous.*” From a ranching perspective, he also expressed
347 concerns regarding wildfire evacuation for his cattle:

348 *We have a [USFS grazing] permit that we can put whatever, 300 cows on [from] July 1*
349 *‘till October 1. ... and where the cows are, where we take them it’s I don’t know, 60%*
350 *beetle kill on the pines maybe. It’s dangerous in a way for fire. We’ve been riding,*
351 *gathering the cattle before and wind comes up and trees are now starting to fall because*
352 *they’ve been dead so long. So we get out of there if the wind comes up.*

353 *And we can’t go where we used to on some of the horse trails – not forest maintained*
354 *trails but trails the cattle used to use because the down timber’s so bad. The main thing*
355 *we’re worried about is fire, with the cattle being up there and everything’s brown, if a*
356 *fire breaks out we have to get the cattle out quick. – Steamboat Springs Informant 1*
357 **(Rancher, life-long resident)**

358 Other interviewees who work closely with ranchers, such as one Bureau of Land Management
359 employee who lives in Kremmling, echoed the concerns mentioned above with regard to cattle
360 protection. He shared stories of cattle getting killed or trapped as a result of fallen trees,
361 explaining that this will likely be an issue for years to come.

362 Representing a third perspective, participants engaged in wildfire response noted
363 additional physical safety issues associated with fighting wildfires in the midst of dead and fallen
364 trees in beetle kill areas. The following quote from a Summit County fire department employee
365 illustrates these concerns:

366 *As we have seen in other areas... if we get a fire in the beetle kill area, we can’t safely*
367 *send firefighters in to fight it. They can’t fight it on the ground. You have the dual threat*
368 *of snags that can fall and kill firefighters. You have downfall that is like pixie sticks. If the*
369 *fire gets in there, there’s really no amount of chain sawing and line digging that is going*
370 *to get the fire out. You’re talking bulldozers to overturn this stuff because it’ll burn*

underneath them, smolder for weeks and months. – **Summit County Informant 1 (Fire department employee, 20+ year tenure in Silverthorne)**

He went on to later state that, from a firefighting perspective, “*we just call it fuel. They’re no longer trees. They’re just fuel.*” Others echoed the difficulty and inability to send firefighters into such areas for fear of their personal safety. For a majority of firefighters in the region, as multiple informants explained, they have not had much experience engaging in wildfires in these contexts. Indeed, there is still much to learn about the implications of firefighting in beetle kill-affected areas in such a way that considers new risks firefighters face as a result of a changed landscape (Collins et al. 2012; Jenkins et al. 2012; Klutsch et al. 2011).

As the above examples show, study participants throughout the study area reported having to change the way they work and recreate within beetle kill-affected forests. This change in behavior is directly associated with a change in risk perception that is intricately connected to the visible alterations to the landscape. Changing environmental conditions in the form of dead and dying trees prompted behavior changes among residents and visitors such that their interactions with the environment are stymied by new and enhanced threats. Using this outbreak to understand both the environment and social responses to environmental change as dynamic necessitates a perspective that views societal-environmental relationships as conjointly constituted.

Convergence in forest management preference: A social license for forest management

Historically, the communities of Granby, Kremmling, and Walden have been considered more or less accepting of certain forest management practices (e.g., tree thinning, logging) compared to other communities in the study area (Flint, Qin, and Daab 2008; Flint, Qin, and Ganning 2012). This relates, in large part, to the unique local histories and economies of these communities. For instance, the towns of Granby, Kremmling, and Walden have economies

395 rooted in an ongoing experience with logging and other forms of extractive industries. This
396 familiarity with logging practices and economic reliance on such industries likely made
397 informants from these communities more attuned to forest management and industry practices
398 that involve tree removal in the form of clear-cutting or thinning. Towns within Summit County,
399 Vail, and Steamboat Springs, conversely, heavily rely on tourism and recreation to sustain and
400 grow their economic bases. Forest products industries, clear-cutting and thinning mitigation, for
401 instance, have historically been perceived as less positive/not appropriate within the cultural
402 context given that it conflicts with the pristine, resort destination characterization of these areas
403 (Flint, Qin, and Daab 2008; Flint, Qin, and Ganning 2012). Indeed, local histories and economic
404 bases are closely associated with how communities and community members within this region
405 perceive certain forest management practices.

406 In addition to questions focusing on observable environmental and social changes
407 emanating from the MPB outbreak, a question within the interview guide also asked participants
408 to consider ways in which communities' forest management preferences changed, if at all, as a
409 result of the outbreak. A majority of informants' responses represent an overarching theme of
410 convergence, with informants describing similar, but not completely aligned, understandings of
411 and preferences related to forest management. In fact, notions of 'convergence' and 'social
412 license' were also observed being discussed in community meetings as social outcomes resulting
413 from the outbreak. For instance, in areas that have historically resisted or were more
414 apprehensive about certain forest management practices such as Vail and those within Summit
415 County, the data demonstrate a shift in thinking from calls for "preservationist" approaches to
416 more "proactive" forest management practices (Flint, Qin, and Daab 2008; Flint, Qin, and
417 Ganning 2012). Shifts among resistant communities provide momentum and "windows of

418 opportunity” for some forest management practices. As such, the MPB outbreak, as forest
419 managers within the study articulated, allowed – even if temporarily - for a *social license* for
420 proactive forest management. A Breckenridge firefighter reflected on these changes in his
421 community and place of work, explaining that:

422 *For the most part what started 10 or 11 or 12 years ago when we first started*
423 *[conducting] the first few treatments [to address beetle kill trees], people were*
424 *adamantly against what we were doing and it over time got better and better but now we*
425 *almost don't hear complaints when these clear cuts start. We get a lot less complaints... I*
426 *don't even hear my friends complain about it anymore. - Breckenridge Informant 2*
427 **(Firefighter, 20+ year tenure)**

428 A public official from Silverthorne who works for Summit County government also expressed
429 the changes to management preference she witnessed following the outbreak:

430 *I would say, before the epidemic people were very attached to the forest as it was. Did*
431 *not want it disrupted. [They] would not have supported cutting projects. And that evolved*
432 *pretty quickly when the forest just.. died.*

433 *...And there definitely was an evolution of acceptance of cutting dead trees, as well as*
434 *living trees. There was an evolution of a sense of responsibility to cut trees to do fire*
435 *mitigation around private homes. - Silverthorne Informant 1 (Summit County official,*
436 **20+ year tenure)**

437 She added that the outbreak allowed the opportunity for changes to development codes
438 that likely would have been difficult to institute without a convergence in opinion and support
439 for mitigating actions.

440 *I think right now that ... fire safety, is very much on the top of people's minds. And I think*
441 *that's what we'll get from our surveys. We are assuming that, in that we are going*
442 *forward with some pretty aggressive changes to our development code, which will*
443 *require fire mitigation at a higher level than what we've required before, which will mean*
444 *cutting down trees within 30 feet or 100 feet of your structure... And if we were to have*
445 *done that 10, definitely 12 years ago, people would have been outraged. For us to be*
446 *telling them to cut trees down next to their homes. Now, I think we will have support for*
447 *that. - Silverthorne Informant 1 (Summit County official, 20+ year tenure)*

448 Echoing these sentiments, an informant from Granby who is now retired from the U.S.

449 Forest Service discussed a sense of convergence in opinion among opposition groups in the area

450 (e.g., environmentalists and loggers). Until the beetle outbreak, he explained, forest mitigation
451 was not a priority nor was it on the forefront of people's minds.

452 *Before the beetles, I don't think we were doing enough proactive forestry only because*
453 *the way the system was. The public input could shutdown good forest practices.... Until*
454 *the Healthy Forest Initiative where kind both sides, the tree huggers and the cutters,*
455 *came together and came to a consensus and said, "Okay, we'll allow this much," and,*
456 *"We'll allow here," with some regulations on how, when, and what. That's changed. And*
457 *that was kind of the early parts of the beetle epidemic when that started. It's just the way*
458 *it was. - Granby Informant 1 (Retired, ~30 year tenure)*

459 Even in areas that generally have supported proactive forest management and logging, some
460 informants noted that calls for forest management and industry options increased during and
461 following the MPB outbreak. As one logger from Walden argued,

462 *Yes, [perceptions of forest management] changed. Generally, we've always had a strong*
463 *support in the community for logging, but it's probably even stronger now. It's very*
464 *difficult for these folks to go up, what we call the Big Creek Area, where we had our big*
465 *Beaver Creek fire two years ago and see all that stuff that got burned, because it all*
466 *could have been made into two-by-fours or something. It's a little difficult, because if*
467 *we'd have logged it, we would have cleaned it up. Now, all those dead, burned trees are*
468 *just going to eventually fall down and lay there on the ground. And I don't think the*
469 *Forest Service or the BLM has any major plans to clean that up. In general, it's a*
470 *stronger position in our community for forest management. - Walden Informant 1*
471 *(Logger, life-long Colorado resident, Walden 40+ year tenure)*

472 The term "social license" was referenced multiple times by informants and repeated
473 within community meetings to describe the general sense of opportunity that forest and land
474 managers felt in their efforts to move forward on forest management projects that previously
475 would have been met with resistance. A state forester out of Routt County described the general
476 shift in thinking among residents in the area from certain forms of management having a
477 negative connotation to viewing it more or less as a necessity for a healthy forest.

478 *I think there's, again, increased social license for management, if done appropriately.*
479 *People are comfortable that it's thoughtful, and that there's some sort of trust that's*
480 *developed, I think, with that. That's a change from a less accepting public, 20 or 30 years*
481 *ago. - Routt County Informant 1 (State Forester, 20+ year tenure)*

482 However, he went on to explain that while this general sentiment remains following the
483 outbreak, some newcomers and second homeowners still tend to be more resistant to
484 management practices such as clear cutting and thinning, stating:

485 *Not all of [newcomers and second homeowners].. but some of them simply don't want to*
486 *see it, hear it. They came here to enjoy it, and they certainly don't want to see a log truck.*
487 *We're generally okay if we're not right in their face, but sometimes, if it's a more visible*
488 *situation, there's some pushback. Again, I would perceive that more of that pushback is*
489 *from folks who are not invested as much in the community. - Routt County Informant 1*
490 **(State Forester, 20+ year tenure)**

491 A Vail government employee also used the term “social license” to describe changes in forest
492 management preference within and surrounding Vail:

493 *I would say that there's more of an acceptance of forest management now than there has*
494 *been. I would say the beetle kill has given the social license to once again actively*
495 *manage the forest. - Vail Informant 1 (City government employee, 10 + year tenure)*

496 As demonstrated from the analysis and excerpts above, the MPB outbreak, while
497 devastating in its outcomes, opened opportunities for proactive forest management that did not
498 necessarily exist throughout many of the study communities prior to the infestation. Shifted
499 understandings of the environment, including forest health and understandings of risk, are
500 directly attributed to this general shift in preference for forest management. Importantly, while
501 convergence does not equate to a consensus in opinion and preference among residents - nor
502 does it imply that these outcomes are permanent or long-term - the significance of this shift as
503 articulated and found within the data is notable and telling of educational and mitigative
504 “windows of opportunity” that may arise from similar forest disturbances.

505 **Discussion & conclusion**

506 The dynamic nature of a changing landscape may be apparent as a forest shifts from
507 green to copper-red to gray – even if those changes take place over a decade. A community’s
508 understanding of and engagement with a changing landscape is no less dynamic. A conjoint

constitution approach yields an opportunity for a deep interpretation of interplays between what has historically been viewed as distinctly “social” and “environmental” toward a more complex understanding of the mutually constituted societal-environmental relationship. The data from the qualitative portion of a larger project that sought to understand the dynamic nature of risk perception in light of a MPB outbreak provides a case-in-point of this interplay. The data demonstrate changed perceptions of and interactions with local landscapes, which represent the confluence of social-environmental change. As the outbreak in north-central Colorado evolved, participants experienced stages of grief alongside these changes. In the interviews, they reflected on their changing perceptions of their landscape, including how community risk perceptions amplified alongside changing forest conditions. Simultaneously, community members who recreated or worked within affected forests reported adjusting the ways they interacted with them. The very nature of their interactions changed in reaction and response to a changing landscape. In the context of the MPB outbreak, these findings support the need to recognize risk perceptions of, and social responses to, changing environmental conditions as indicative of the *dynamic* and *interconnected* nature of society-environment relationships (Lidskog and Waterton 2016; Lockie 2015).

The concept of conjoint constitution is well-suited to understand the interconnectedness of people’s perceptions of risk, behaviors, and environmental change over time, especially as management practices and policies are adjusted to a changing landscape. During and following the MPB outbreak, people’s perceptions and knowledge of their local landscapes shifted in response to changing environmental conditions, as did receptivity to some forest management practices. Their responses, however, are not simply reactionary but are mutually constituted with what they see as a changing landscape and their interactions with it. Consequently, these

relationships and associated perceptions of risk and environmental change over time can inform preferences for management practices and policy pertaining to forest management. Indeed, opinions, like the environment, are not static and will continue to evolve (Hannibal, Liu, and Vedlitz 2016).

Before the outbreak, forests throughout north-central Colorado were overgrown with same-age, same-species, mature lodgepole pine forests that made the ecosystem more susceptible to forest disturbances. In this way, the MPB outbreak caused the affected communities to grapple with a significant change to their landscape, but provided the opportunity to gain understanding of the dynamic nature of the environment. While the work described here documents shifts in thinking about the dynamic nature of forests in light of a slow-moving environmental disturbance, we cannot necessarily anticipate the extent to which the opinions and increased acceptance of certain forest management practices documented in this study will persist. What this work does demonstrate is that data captured at the intersection of societal-environmental systems, such as social responses to forest insect disturbances, may reveal management and educational opportunities that take into account the dynamic nature of risk perceptions in response to environmental change.

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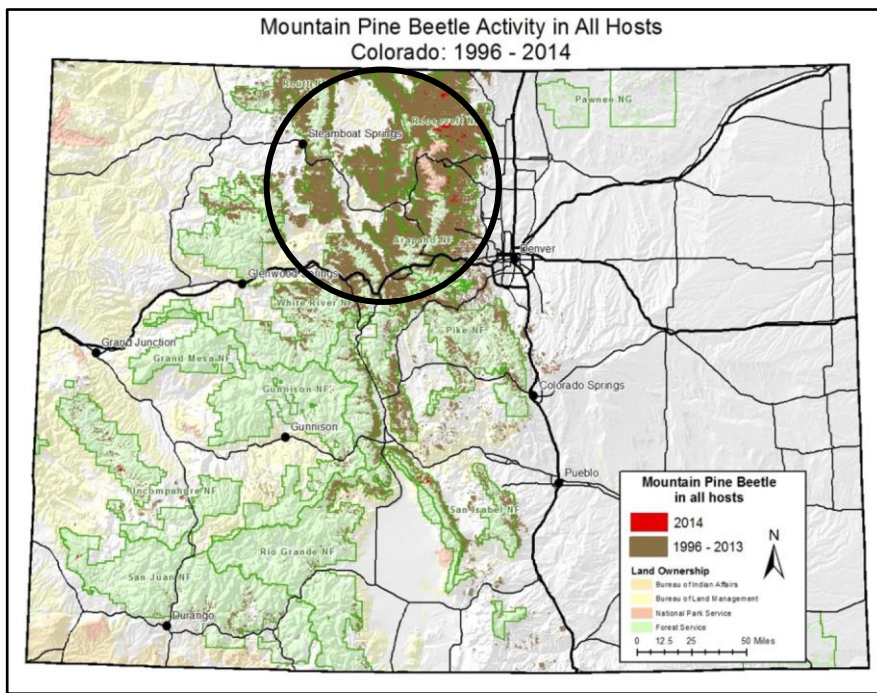
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706

Figures & Tables

707 **Figure 1. U.S. Forest Service aerial detection survey with study area highlighted**



708

709 (Source: USFS N.D.(b))

710 **Table 1. *Number of participants by county and community***

County	Community	Number of Interviews
Eagle	Vail	7
	Eagle County*	3
Grand	Granby	2
	Kremmling	2
	Grand County*	6
Jackson	Walden	6
Routt	Steamboat Springs	4
	Routt County*	6
Summit	Breckenridge	4
	Dillon	1
	Frisco	3
	Silverthorne	2
	Summit County*	4
Outside study area	Denver	4
TOTAL		54

711 *When asked to define their community, some participants identified themselves as being a part of a
712 county, rather than a single community. However, these individuals lived and/or worked in specific
713 communities within the study area. There are five counties included within the study area: Eagle, Grand,
714 Jackson, Routt, and Summit counties.