Article

Visitor Perceptions of Bark Beetle Impacted Forests in Rocky Mountain National Park, Colorado

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Abstract

Forest disturbance by bark beetles and other insects is a global issue expected to increase with the warming climate. Visitor aesthetic appreciation of these forests affected by infestations is an important factor for land managers. Environmental education by land managers allows visitors to understand natural disturbances. We explored how the recent bark beetle-caused forest changes were perceived and understood by visitors at Rocky Mountain National Park, Colorado, in reference to the aesthetic model of scientific cognitivism. Visitors completed an on-site questionnaire that was analysed using factor analyses and ANOVAs. Visitors perceived the forest as beautiful, inspiring, and interesting. No direct relationship was found between knowledge and perceptions. Visitor reactions combined affective with less salient cognitive dimensions. These findings emphasise the need to instill primary affective connections to cognitive subject matter in conservation education using knowledge to ameliorate cognitive dissonance associated with naturally disturbed landscapes.

Keywords: bark beetle, scientific cognitivism, visitor perceptions, Rocky Mountains, Colorado, RMNP, natural disturbance, National Parks

INTRODUCTION

In the mid-1990s, bark beetle populations began to increase beyond endemic levels in montane forests around the world. Even-aged stands, mild winters, and prolonged drought fostered an increase in bark beetle populations and made host trees more susceptible to beetle damage (USFS 2011). Bark beetle (primarily mountain pine beetle, Dendroctonus ponderosae Hopkins.; spruce beetle, Dendroctonus rufipennis Kirby; western balsam bark beetle, Dryocoetes confusus Swaine and Douglas-fir beetle, Dendroctonus pseudotsugae Hopkins) population increases have led to large-scale disturbance events of forest ecosystems across western USA and Canada (USFS 2011; Kayes and Tinker 2012). It is estimated that over 22.5 million hectares (55.6 million acres) in the US have been affected by western bark beetle species since 2000 (Paschke 2018). Over 1.6 million hectares (4 million acres) are located in the Rocky Mountain region of northern Colorado and southern Wyoming (USFS 2013). The result is a dramatically changed landscape of forests composed of trees transitioning from green to red; becoming gray, needleless ‘ghost’ trees throughout the Rockies. Bark beetle population increases are not limited to North America but are also of concern in Europe and Asia (Katz 2017). Climate change is affecting forest insect populations both positively and negatively worldwide including ecosystems in North America, Europe, Russia, China, and Australia (Pureswaran et al. 2018).

Recent literature has noted the need for further research into visitor experiences of impacted forests (McGrady et al. 2016;...
Environmental Aesthetics and Scientific Cognitivism

As ecologists strive to gain a greater understanding of ecosystem dynamics in relation to tangible human impacts, the intangible interactions of humans with nature must also be taken into account. Aesthetics explores the sensory, affective, and cognitive reactions to objects and processes that are typically associated with judgments of beauty and feelings of pleasure (Kant 1790; Carlson 2000; Dutton 2001; McMahon 2001; Paden et al. 2013). Aesthetic perception is one of the most universal human experiences and a basic mode of value determination (Dutton 2001). Aesthetic responses lead to affinity and likeability of a place which influences decisions and behavior (Chon and Shafer 2009). As such, cognitive and affective aesthetic judgments are major components in conservation policy, practice, and education (Chon and Shafer 2009).

Carlson (2000) and Gobster (1999) both contend that knowledge is fundamental to environmental aesthetics. In regard to ecosystems, cognitive aesthetics maintains that greater knowledge about the complexities, interactions, and dynamics of ecosystems will yield greater aesthetic appreciation. Cognitive aesthetics are based on the argument that greater knowledge about an object or process will lead to greater understanding and therefore deeper or more appropriate aesthetic appreciation (Carlson 2000; Gobster 1999). According to the natural environmental model (also known as scientific cognitivism) of environmental aesthetics, knowledge of natural sciences provides an appropriate context and essential ability to fully and validly appreciate nature (Carlson 2000). Scientific knowledge provides the “frame” for properly appreciating nature. In the natural environmental model, there is no loss of aesthetic appreciation via scientific knowledge, no “disenchantment,” but instead a conceptual gain. Features that may have been overlooked (e.g., processes of formation and natural function) may stand out due to knowledge (Carlson 2000). As Gobster (1999) stated, “the dramatic, visual elements of the picturesque continue to give aesthetic pleasure, but so do the more subtle and ordinary landscapes of forest ecosystems.”

Scientific Cognitivism and Environmental Education

The current system of environmental education and outreach is largely based on a scientific cognitive model. By increasing public knowledge of evolutionary and ecosystem dynamics, agencies and organizations aim to turn environmental management from anthropocentric to ecocentric values. That is, such environmental education is anthropogenic, but ecocentric. Management based on ecosystem health (i.e., ecocentric) will assure that largely natural (i.e., non-anthropogenic) landscapes continue to exist. Thus, developing an environmental aesthetic around the states and dynamics of nature is both ecocentric and pragmatically anthropocentric. Ecosystem knowledge may provide a means of shaping human desires to align with sustainability via scientific cognitivism. Healthy and dynamic ecosystems, while visually changing and perhaps lacking superficial appeal or prettiness, would therefore be viewed as aesthetically pleasing (Carlson 2000).

Human Dimensions of Bark Beetle Research

Human dimension research, including Social-Ecological Systems (SES) studies, into the current bark beetle epidemic has focussed on a range of visitor and resident responses including knowledge, preferences, attitudes, values, risk perceptions and land management (Flint 2006; McFarlane et al. 2006; Flint 2007; McFarlane and Watson 2008; Müller and Job 2009; Müller 2011; Švajda et al. 2016; Arnberger et al. 2017; Arnberger et al. 2018).

The influence of knowledge on perceptions is mixed. In some studies, knowledge is associated with more positive perceptions of impact, acceptability, and emotions (McFarlane et al. 2006; McFarlane and Watson 2008; Müller and Job 2009; Švajda et al. 2016) as well as expectation of forest recovery (Morris et al. 2018). At the same time, informed participants reported greater loss of scenic quality (Buhoyff et al. 1982). Knowledge also shapes general awareness. Colorado visitors had greater awareness (95%) of beetle presence than visitors to parks in Minnesota (21%) and Germany (69%) (Arnberger et al. 2018). Likewise, visitors to Colorado State Forest State Park (CSFSP) had increasing knowledge of bark beetles between 2011 and 2014 (Larsen-Jacobson and Cottrell 2014).

Dissatisfaction with land management, be it too much or too little, was found in multiple studies. Views ranged from perceiving land managers as not doing enough to control the impacts (with preferences for specific practices such as removal of infested trees), to objecting to perceived threatening and destructive management, to wanting limited or no management at all. Divisions in land management preferences occurred not only between countries, but within local communities as well (Flint 2006; McFarlane et al. 2006; Flint 2007; McFarlane and Watson 2008; Müller and Job 2009; Müller 2011). Viewers also prefer more natural appearing management operations (e.g., irregular clear-cuts) as opposed to those appearing unnatural or anthropogenic (Young and Wesner 2003).

Many studies have investigated preferences, attitudes and values, often supporting earlier findings of forest or green space preferences in relation to disturbance, management or urbanisation. Researchers have found that the public exhibits high sensitivity and general dislike toward beetle impacts (Buhoyff and Leuschner 1978; Buhoyff et al. 1986; Sheppard and Picard 2006; Arnberger et al. 2017; Arnberger et al. 2018). Visual preference and scenic beauty ratings decrease as visible impacts increase (Buhoyff and Leuschner 1978; Sheppard and Picard 2006; Qin et al. 2015; Arnberger et al. 2017; Arnberger et al. 2018). Strength of
perceptions, emotions and issue salience also decreases with time (Flint 2006; McFarlane et al. 2006; Flint 2007; McFarlane and Watson 2008). There was also a difference between negative perceptions of bark beetle impacts in North America (Flint 2006; McFarlane et al. 2006; Flint 2007; McFarlane and Watson 2008) compared to more neutral responses in Germany (Müller and Job 2009; Müller 2011); with differences noted between other European nations as well (Švajda et al. 2016). In general, visitors prefer green, mature, nearly-closed canopy forest stands lacking noticeable insect damage (Buhyoff and Leuschner 1978; Buhyoff et al. 1986; Ribe 1989; Ribe 1990; Young and Wesner 2003; Sheppard & Picard 2006; Gundersen and Frivold 2008; Edwards et al. 2012; Larsen-Jacobsen and Cottrell 2014; Giergiczny 2015; Arnberger et al. 2017; Arnberger et al. 2018). Such forests are positively perceived as “healthy” or “natural” while features such as deadwood, signs of management (e.g., clear cuts) and “abnormal” colors (e.g., red versus green) are perceived negatively (Buhyoff and Lauschner 1978; Buhyoff et al. 1982; Buhyoff et al. 1986; Young and Wesner 2003; Kaufman and Lohr 2008; Arnberger et al. 2017; Arnberger et al. 2018; Morris et al. 2018). The distance of the viewscape also influences perceptions, with near or foreground environments of greatest importance and perception decreasing with distance (Arnberger et al. 2018).

Research Questions

Our study seeks to provide a better understanding of aesthetic perceptions and knowledge of the bark beetle-altered forests of the Rocky Mountains. As a part of the U.S. National Park Service (NPS), Rocky Mountain National Park (RMNP) in Colorado provides both a natural setting of bark beetle-altered forests, along with a diverse population of visitors and a staff focused on public outreach and land management. The visual changes to forests brought about by increased bark beetle activity influence aesthetic perceptions. This study explores aesthetic perception from a cognitive aesthetic framework in an effort to gain new insights into visitors’ cognitive and affective perceptions, and experiences.

Shared perceptions or similarities of experiences among people can be used to identify core themes and factors influencing these experiences. Identifying these factors provides greater understanding of perceptions and beliefs that inform values, communication, education and policy aimed at increasing environmental awareness and ecosystem conservation.

Research questions were:

• How do visitors perceive the dramatically and recently changed landscape (due to bark beetles) in RMNP?
• Does knowledge of bark beetles influence aesthetic perceptions?
• Do visitor perceptions vary according to whether the believed source of the disturbance is natural or anthropogenic?

METHODS

Study Site

The study was conducted at RMNP in northern Colorado. Established in 1915, RMNP now encompasses 107,485 ha. Nearly 95% of RMNP is designated as wilderness and protected from human alterations. RMNP’s easy access, including one of the two points of access being the popular tourist community of Estes Park, Colorado, provides a visitor population ranging from 3 to 3.5 million annually. Visitation peaks in the summer months of June through August (NPS 2014). The survey was given at the Many Parks Curve Overlook along the main road that bisects the park (Figures 1 and 2). At this location, visitors had access to both near-to-mid view landscapes and far view landscapes as defined by Arnberger et al. (2018).

Questionnaire

An exploratory questionnaire was designed for the purposes of this study. This paper discusses quantitative sections addressing affective and cognitive perceptions (Table 1a); perceptions of harm or benefit of anthropogenic and natural forest activities (Table 1b); bark beetle awareness and general knowledge (Table 2); and natural vs. anthropogenic viewpoint (Table 1c), along with a pair of qualitative questions. The survey began with an open-ended question regarding emotional response and closed with an open-ended question regarding forest description. These were intended to elicit aesthetic responses before and after cognitive elements were presented in reference to mixed perceptions in the literature regarding knowledge and positive or negative views of affected forests (Buhyoff and Leuschner 1978; McFarlane et al. 2006; McFarlane and Watson 2008; Müller and Job 2009; Švajda et al. 2016). Most responses were listings of adjectives that were thematically categorised.

Figure 1

View of bark beetle killed trees along study site at Many Parks Curve, Rocky Mountain National Park, Colorado. Photo by Christa Sumner, July 2013
Quantitative items were presented in four major sections in addition to demographics (Table 1). Demographic questions included: sex, age, residence, race/ethnicity, household income and education (Table 3). Section one was a semantic differential scale addressing visitor perceptions of the forest. Opposing pairs of adjectives addressed both affective and cognitive aspects of perceptual response. Positive and negative connotations were used to randomise items on the scale. Section two was a multiple-rating list of different environmental phenomena. Visitors were asked to rate each phenomenon (e.g., lightning-caused fire, agency-caused fire, and drought) based on the perceived impact to the forest, ranging from very beneficial (1) to very damaging (10). Section three covered bark beetle knowledge with a series of statements rated on five-point Likert Scales. Visitors could respond with strongly disagree, disagree, agree, strongly agree or “I don’t know.” Section four was another multiple-rating list addressing ecological conditions (e.g., climate change, bark beetle population increase, and prolonged drought). Visitors responded to each item according to their belief about the ultimate cause of the condition on a spectrum between naturally caused (1) to anthropogenic/human caused (10).

Data Collection

Surveying took place over the course of one week in July 2013 at the Many Parks Curve Overlook area in RMNP in Northern Colorado. Participants were approached by the surveyors on foot or vice-versa. A “next person available” sampling method was used to conduct surveys. All participants were required to be of age 18 years or older. No sampling quotas were used during survey collection. Participation was voluntary and no incentives were given for participation. Eighty-nine surveys were collected and 85 were used for analyses. Incomplete surveys and surveys completed with noted distracting external factors (e.g., acrophobia, agitated haste) were omitted. Surveys in which the participant responded “No” to previous awareness of the bark beetle or mountain pine beetle were not included in bark beetle knowledge assessment and scores.

Data Analyses

IBM-SPSS Statistics 22.0 was used for data analysis. Frequencies were calculated for each demographic category. Median, mean, and interquartile ranges were calculated for each survey item. The median was selected to represent the
measurement of central tendency due to the skewed distribution of many of the results. Unlike the mean, median scores are not influenced as greatly by outliers and therefore present a more accurate reflection of centrality. The interquartile range is the accompaniment measure of dispersion for the median.

Knowledge scores were calculated by averaging the total score for each individual. Responses of “I don’t know” were given a score of 0, with incorrect responses coded as -1 or -2 according to degree and correct responses coded as +1 or +2.

Exploratory factor analysis (EFA) was performed on the following quantitative sections: affective and cognitive perceptions (Table 1a); perceptions of harm or benefit of anthropogenic and natural forest activities (Table 1b); and natural vs. anthropogenic viewpoint (Table 1c). EFA is an acceptable analysis provided that case numbers are equal to or greater than ten cases per variable (Nunnally & Bernstein, 1994). EFA was used to identify latent variables that were comprised of multiple items per section. Factor extraction used Generalised Least Squares and Varimax (orthogonal) rotation methods. Factor scores were calculated using the Anderson-Rubin method. The lowest factor loading to be considered was 0.30 (Hair et al. 1998). KMOs were calculated and sampling was considered adequate for scores >0.5 (Field 2009; Yong and Pearce 2013; Hadi et al. 2016). Bartlett’s Test of Sphericity was also calculated for each EFA to determine strength of relationship among variables with values <0.05 suitable for analysis (Field 2009; Hadi et al. 2016). Reliability was tested with Cronbach’s alpha with a lower limit of 0.60 set for exploratory purposes (Hair et al. 1998). The results of the EFA of the affective and cognitive perceptions section were used to construct two indices: visitor expectations and forest health. These indices were used in subsequent analyses as the dependent variable. Likewise, results of the EFA of the perceptions of harm or benefit of anthropogenic and natural forest activities were used to construct one index, natural disturbance, which was used in subsequent analyses. Lastly, results of the EFA of the environmental viewpoint section were used to construct one index, ecological phenomenon, which was used in subsequent analyses.

Independent ANOVAs were performed on the above indices by demographic and knowledge scores (independent variables) to determine any potential differences among group means. Post-hoc Tukey’s HSD test was used to specify which conditions were significantly different between three or more means in significant ANOVAs.

RESULTS

Demographics

Thirty-nine (46%) of the 85 participants noted previous visits to RMNP. Of these, 23 had visited prior to the year 2000 and 27 had visited since 2000. Seventy-eight participants had noticed the red-gray trees in the forest. Sixty-nine (85%) participants had heard of bark beetles or the mountain pine beetle prior to taking the survey. Only 16 (19%) were regional residents (Rocky Mountain region states: AZ, CO, ID, MT, NM, NV, UT, WY) (Table 3). Thirty-three participants were male and 52 were female. Eighty of 82 participants self-identified as white/Caucasian.

Frequencies

Eighty-five participants completed the semantic differential scales in the affective and cognitive perceptions section (Table 1a). All participants surveyed perceived the forest to be beautiful, interesting, and satisfying to some degree. Similarly, all but one participant found the forest to be natural, all except three rated the forest inspiring, and two described the forest more distressing than comforting. The majority (>75%) of participants rated the forest as alive, free, healthy, complex, and, to a lesser extent, protected (66%). Tame to wild was closely split with nearly half (39, 46%) rating the forest tame to some degree versus wild. Perhaps most relevantly, the three most strongly viewed perceptions all reflected aesthetic judgments (interesting, beautiful, and satisfying).

All participants completed the perceptions of harm or benefit of anthropogenic and natural forest activities section (Table 1b). Non-native species (76, 89%) and drought (72, 85%) were primarily seen as having negative impacts on the forest. Agency-caused fires (62, 73%) and native species (82, 97%) were seen as having positive impacts on the forest. Horse trails and strong winds displayed indifferent responses, whereas lightning-caused fire evoked mixed results.

Eighty-five participants rated their opinion on climate change, prolonged drought, even-aged forests, and wildfire occurrence in the environmental viewpoint section (Table 1c). Participants who had not heard of the bark beetle were removed from analysis of bark beetle population increase. The majority of participants viewed climate change as more related to anthropogenic effects than natural ones with scores of >5 accounting for 79% (n = 67). Prolonged drought (n = 49, 58%), even-aged forests (n = 47, 55%), and bark beetle population increase (n = 42, 61%) were slightly skewed towards natural events, whereas wildfire occurrence was slightly skewed towards human impacts (n = 47, 55%). Distribution of each of these factors showed primarily neutral ratings with the exception of strong extremes on both ends for climate change, even-aged forests, and bark beetle population increase.

Sixty-nine participants had heard of bark beetles and completed the bark beetle knowledge items (Table 2). Only one participant answered all items correctly. Not a single item was answered correctly by all participants. The statement that “a bark beetle’s lifecycle is temperature dependent” had the most correct responses (n = 32, 46%). The autochthonous of the bark beetles to the Rocky Mountains and the statement that they only bore into lodgepole pines each had approximately half of the participants responding with “I don’t know” (n = 32, 46% and n = 38, 55% respectively). The statement...
that “trees have no natural defenses against the bark beetle” was nearly equally divided between correct (n = 26, 38%) and incorrect (n = 27, 39%) responses. The range of average total scores was -1.5 to 1 with a mean of 0.065 (sd = 0.496).

Bark beetle knowledge questions were also analysed according to strength of belief in the answer, regardless whether the answer was correct or not (e.g., a rating of strongly agree and strongly disagree were both given the same score). The number of participants that held strong beliefs in their responses ranged from only six (9%) in relation to bark beetles boring only in lodgepole pines up to 13 (18%) in response to trees’ natural defenses. The averages of the total belief strength ranged from the minimum of 0 to 1.5 (maximum possible = 2), with a mean of 0.73 (sd = 0.416).

### Table 3

**Demographic Profile**

| Demographic          | n  | Frequency | Valid Percent |
|----------------------|----|-----------|---------------|
| **Sex**              |    |           |               |
| Male                 | 85 | 33        | 38.8          |
| Female               | 85 | 52        | 61.2          |
| **Age**              |    |           |               |
| 18-39 years          | 85 | 19        | 22.4          |
| 40-59 years          | 85 | 42        | 49.4          |
| 60-79 years          | 85 | 24        | 28.2          |
| **Education**        |    |           |               |
| <16 years            | 85 | 19        | 22.4          |
| 16 years (Bachelor’s degree) | 85 | 27 | 31.8          |
| >16 years            | 85 | 39        | 45.9          |
| **Annual Income**    |    |           |               |
| Less than $60,000 (USD) | 76 | 17 | 22.4          |
| $60,000 (USD) or greater | 76 | 59 | 77.6          |
| **Household Size**   |    |           |               |
| 1 person             | 85 | 9         | 10.6          |
| 2 people             | 85 | 43        | 50.6          |
| 3 people             | 85 | 27        | 31.8          |
| 4 or more people     | 85 | 6         | 7.1           |
| **Residence**        |    |           |               |
| Regional (Mountain: AZ, CO, ID, MT, NM, NV, UT, WY) | 85 | 16 | 18.8          |
| Nonregional          | 85 | 69        | 81.2          |
| **Race**             |    |           |               |
| White/Caucasian      | 82 | 80        | 97.6          |
| Asian                | 82 | 1         | 1.2           |
| Two or more          | 82 | 1         | 1.2           |
| **Ethnicity**        |    |           |               |
| Hispanic/Latino/Latina | 84 | 3  | 3.6           |
| Not Hispanic/Latino/Latina | 84 | 81 | 96.4          |

**Exploratory Factor Analysis**

EFA revealed two factors in the affective and cognitive perceptions section (Table 1a): visitor expectations and forest health (Table 4). Visitor expectations (Cronbach’s alpha 0.857) and forest health (Cronbach’s alpha 0.773) each contained three items. These two indices together explained 62% of the variation. Two items, free to restrained and protected to vulnerable, successfully loaded onto a third factor, forest management, but failed reliability testing (Cronbach’s alpha 0.438). These two items were subsequently tested individually for significance. Four items (unnatural to natural, simple to complex, tame to wild, and distressing to comforting) did not load highly on either of the factors nor did they combine to
form a reliable third factor and were therefore eliminated in the EFA process.

EFA of the perceptions of harmful and beneficial forest activities section (Table 1b) resulted in only one index, natural disturbance, that consisted of lightning-caused fire, strong winds and drought accounting for 56% of the total variation with Cronbach’s alpha of 0.803 (Table 4). The remaining items were eliminated. Non-native species was eliminated due to highly skewed negative impact results. Native species likewise showed a highly skewed high positive impact. Agency-caused fire was eliminated by a low loading in the final factor outcome.

EFA resulted in one index, ecological phenomena, in the natural vs. anthropogenic viewpoint section (Table 1c) that included three items: climate change, prolonged drought, and even-aged forests (Table 4). Wildfire occurrence did not load high enough to be included. Bark beetle population increase was eliminated due to the low sample size. The disturbance factor accounted for 57% of variance with Cronbach’s alpha of 0.790.

### Analyses of Variance

A significant relationship was found between sex and natural disturbance factor scores (F(1,83) = 8.409, p = 0.005) (Table 5). Males (M = 0.378, SD = 0.949) viewed natural disturbances as having more positive impacts on the forest than females (M = -0.240, SD = 0.964). Age also had a significant relationship with ecological phenomena (F(2, 82) = 6.238, p = 0.003). Participants aged 18-39 years (M = 0.644, SD = 0.863) viewed ecological phenomena to be the result of human effects to a greater degree than older age groups (Ages 40-59: M = -0.287, SD = 0.988; Ages 60-79: M = -0.008, SD = 0.915).

Significant differences were found between education and both natural disturbance (F(2, 82) = 4.592, p = 0.013) and ecological phenomena factor scores (F(2, 82) = 2.955, p = 0.058) (Table 5). Participants with more than a college degree (M = 0.328, SD = 0.993) rated natural disturbance as more positive to the forest than those with less education (M = -0.425, SD = 1.009). Similarly, participants with more than a college degree (M = 0.238, SD = 0.901) viewed ecological phenomena more as the result of human effects than participants with less education (M = -0.445, SD = 1.144). Participants with only a college degree were not significantly related to either factor.

Household size was significantly related to visitor expectations (F(3,81) = 3.040, p = 0.034) (Table 5). Participants with a household size of one (M = -0.932, SD = 1.745) had lower expectation factor scores than households with two (M = 0.145, SD = 0.763) or three members (M = 0.045, SD = 0.926). Income was not significantly related to any factor.

Regional residents (M = 0.867, SD = 0.915) had significantly higher knowledge scores than non-regional residents (M = -0.111, SD = 1.003; F(1, 67) = 9.886, p = 0.002) (Table 5). Importantly, knowledge scores were also significantly related to perceptions of forest health (F(4, 64) = 2.201, p = 0.035). Participants with an average knowledge score of 0 (M = 0.437, SD = 0.564) had a more positive perception of forest health than participants with an average knowledge score of 1 (M = -0.556, SD = 1.107). Strength of belief in knowledge responses was not significantly related to any factor.

Participant awareness of bark beetles (i.e., had heard of bark beetles) was significantly related to both perceptions of forest health (F(1,83) = 8.294, p = 0.005) and ecological phenomena (F(1,83) = 6.200, p = 0.015) (Table 5). A key finding was that participants indicating they had heard of bark beetles previously (M = -0.129, SD = 1.007) perceived forest health more negatively than participants who had not (M = 0.558, SD = 0.768). Also, participants with prior awareness of bark beetles perceived ecological phenomena to

### Table 4

| Varimax rotated factor loadings | KMO | Cronbach's alpha |
|--------------------------------|-----|------------------|
| **Cognitive and Affective Dimensions** |     |                  |
| Visitor Expectations | 0.737 | 0.857  |
| Beautiful to Ugly | 0.713 |          |
| Interesting to Uninteresting | 0.864 |          |
| Satisfying to Dissatisfying | 0.834 |          |
| Forest Health | 0.854 |          |
| Alive to Dying | 0.854 |          |
| Healthy to Sick | 0.716 |          |
| Inspiring to Depressing | 0.587 |          |
| **Harmful and Beneficial Forest Impacts** | 0.668 | 0.803  |
| Natural Disturbance | 0.856 |          |
| Fire, lightning caused | 0.851 |          |
| Strong winds | 0.586 |          |
| Drought | 0.586 |          |
| **Natural vs. Anthropogenic Viewpoint** | 0.622 | 0.790  |
| Ecological Phenomenon | 0.999 |          |
| Prolonged drought | 0.704 |          |
| Climate change | 0.568 |          |
be more related to natural causes (M = -0.126, SD = 1.001), while participants not previously aware perceived more anthropogenic causation (M = 0.544, SD = 0.817). There were no significant findings related to noticing or not noticing the red-gray trees in the forest.

Having visited RMNP prior to 2000 was significantly related to perceptions of protected to vulnerability (F(1,37) = 5.723, p = 0.022) (Table 5). Participants who visited RMNP prior to 2000 viewed the forest as more protected (M = 5.43, SD = 3.012) than those who had not visited before 2000 (M = 3.19, SD = 2.689). Visitation since the year 2000 was not significantly related to any factors.

**Qualitative Pre and Post Descriptions**

At the start of each survey, participants were asked to list three to five responses regarding their view of the forest (Figure 3). The vast majority of responses (n = 139) were superlatives (e.g., awesome, wow, incredible). References to scale (e.g., vast, huge, humbling, grand), positive affect (e.g., fresh, clean, calm, peaceful) and naturalness (e.g., natural, Nature, wild, physical descriptions) were a distant second, third and fourth (n = 31, 21, and 14, respectively). Thoughts of adventure (n = 3), nostalgia (n = 3), NPS management (n = 2) and sadness (n = 1) completed the opening set of themes.

At the end of the survey, participants were asked to describe the forest to a friend (Figure 3). All of the same themes identified in the opening question were mentioned along with four new themes. Superlative responses remained the top theme but dropped in number (n = 86). References to vastness (n = 9) and positive affect (n = 13) also dropped. In contrast, references to naturalness increased (n = 53). Adventure, nostalgia, NPS management, and sadness remained low. The four new themes that emerged were recommendation (e.g., must see), at-risk (e.g., vulnerable, sick, dying), healthy (e.g., healthy to some degree, alive) and anxiety (e.g., heights) (n = 15, 12, 9, and 1, respectively).

**DISCUSSION**

The number of completed surveys was lower than expected based on previous summer visitation numbers. Unseasonal rainfall beginning early in the day reduced the number of visitors stopping at the overlook. Heavy summer rainfall led to severe flooding within RMNP and the gateway town of Estes Park in September 2013 exemplifying the anomalous precipitation events that season.

The racial and ethnic homogeneity of the sample was not anticipated given the tourism function of the park but is consistent with USA park use patterns that indicate lower use rates by racial and ethnic minorities (Stanfield et al. 2005; Krymkowski et al. 2014). The high age and income brackets suggest that the Park draws more attention from retired and upper-class citizens and may indicate unintended discrimination regarding financial and accessibility limitations (e.g., transportation, meals, and NPS entry fees). The relatively low proportion of regional visitors highlights RMNP as a tourist “hotspot” and iconic exemplar of the Rocky Mountains.
The sex of the respondent was only significantly related to perceptions of natural disturbance impacts to the forest. In this case, men perceived natural disturbance more positively than women. Male and female differences in aesthetic and naturalness perceptions and preferences are well documented (Caula et al. 2009; Ode et al. 2009; Maloof 2010; Kalivoda et al. 2014; Ode Sang 2016).

Visitor Perceptions of Bark Beetle Affected Forests

The visitors at RMNP rated the forest highly in regard to beauty despite the prevalence of dead lodgepole pines visible from the overlook and along the roadway. This is in contrast to previous studies that found a general dislike of beetle-impacted landscapes as well as decreases in beauty ratings as beetle damage increased (Buhyoff and Leuschner 1978; Buhyoff et al. 1986; Sheppard and Picard 2006; Arnberger et al. 2017; Arnberger et al. 2018). Factor analysis grouped beauty along with interest and satisfaction in a single factor, visitor expectations, where all three were scored highly positive by visitors. The high level of interest suggests that visitors were engaged with the forest as opposed to making a superficial judgment. It was similarly found that satisfaction and knowledge both increased in CSFSP visitors from 2011 to 2014 (Larsen-Jacobson and Cottrell 2014). Our findings support the idea of an aesthetic experience being affective, cognitive, and sensory.

There are multiple plausibilities to consider at this juncture. First, the visitors might have incorporated into their perception of the infested forests a larger framework including the mountainous topography, experiences with wildlife, and appreciation of a non-urban setting. As such, a scientific grasp of the forest could have deepened their aesthetic judgment, but it might have served only to amplify the positive affect.

It is possible that visitor expectations coinciding with their visit to RMNP (including beautiful scenery, interest in the Park, and an overall satisfying experience) led to self-fulfilling perceptions. However, since the majority of participants expressed awareness of the red-gray trees without being prompted (i.e., pointed out on a nearby hillside), such disillusionment or naïve experience is less plausible. In the factor analysis, cognitive and affective items did not factor out separately, but were dispersed between the factors. This further illustrates that experiences were composed of both affective and cognitive elements. In relation to scientific cognitivism, participants perceived a positive aesthetic experience in the disturbed landscape setting prior to cognitive prompting in the questionnaire and regardless of actual knowledge or belief. This also coincides with the open-ended pre-questionnaire description item which showed overwhelmingly positive affect. Both of these are counter to a scientific cognitivism aesthetic experience which requires a cognitive understanding to fully, appropriately, and aesthetically appreciate the less picturesque, disturbed landscape (Carlson 2000).

These qualities are addressed in Carlson’s (2000) view with emphasis on the role of cognition in aesthetic judgement. The importance of scientific appreciation to environmental aesthetics is also recognized by Rolston (1998), but he further contends that full appreciation of forest aesthetics entails embodiment (participation, immersion, and struggle), sublimity, and sacredness. Our research did not delve into these additional features. The degree, if any, to which typical, short-term visitors would have engaged in embodiment or arguably the experiences of sublimity and sacredness is of question. Moreover from a managerial perspective, scientific understanding will surely have fewer pitfalls than leading visitors or policymakers into the realms of spiritual contemplation. However, further research along these lines could be most valuable in assessing their role in how people actually experience the forest, notwithstanding Rolston’s idealised framework (Rolston 1998; Carlson 2000).

The second factor, forest health, showed positive perceptions of forest condition. The forest was seen as healthy and alive – both cognitive perceptions that were matched with the affective attribution of “inspiring” in factor analysis. In this case, visitors did not interpret the dying and dead individual beetle afflicted trees as a dying forest, but viewed the whole forest as alive and well. This may be an indication of scientific cognitivism at work, such that knowledge of bark beetle impacts is mitigating the perception and allowing for a positive experience (perhaps mirroring findings from CSFSP satisfactory perceptions); however, this interpretation was not fully supported by the results of this study. Forest health was significantly related to bark beetle awareness and knowledge, but it was the visitors with a lower score of 0 that perceived greater forest health than those with an average score of 1. This finding will be discussed further in context of bark beetle knowledge and visitor perceptions.

The individual item, protected to vulnerable, was perhaps more perplexing for visitors to assess, having a lower mean score (M = 6.45). This uncertainty exemplifies the complexities associated with land management as well as the wide range of preferences and opinions regarding appropriate care of the land in terms of protection versus vulnerability (Flint 2006; McFarlane et al. 2006; Flint 2007; McFarlane and Watson 2008; Müller and Job 2009; Müller 2011). Nature is confined to anthropogenic spatial boundaries, in this case, the borders of RMNP. In this way it is seemingly protected by the land managers (i.e., NPS). Yet ecological dynamics including natural disturbances do not adhere to anthropogenic boundaries. Land managers must therefore find ways to allow natural processes to occur while simultaneously being mindful of policies and boundaries. Participants who had visited RMNP prior to 2000 held a significantly positive albeit not absolute perception of protection. As the impact of the bark beetle population increase was still in early stages in RMNP prior to 2000, these visitors were likely able to recall RMNP in a greener state. Previous studies have found visitors with preference towards mature, green forests (Buhyoff et al. 1986; Sheppard and Picard 2006; Larsen-Jacobson and Cottrell 2014; Arnberger et al. 2017; Arnberger 2018). It may be that present visitors were in the
process of overcoming cognitive dissonance brought on by the dramatic visual changes in the forest. This also coincides with adaptation-level models in that visitors with experience of the park in a more verdant state in the past would shift current perception toward less pleasure to some degree (Russell and Lanius 1984). In this case, the park was perceived as slightly less yet still protected. This is also reflected in the post-questionnaire description of “at-risk” — a descriptor that was not present in the pre-questionnaire descriptions, suggesting cognitive prompting. Interestingly, natural appearing land management is preferred over unnatural or anthropogenic management practices, with RMNP adhering to the former (Young and Wesner 2003).

The open-ended questions at the beginning and end of the survey further illustrated visitors’ experiences and judgments. The majority of responses were indicative of aesthetic responses. Superlative, the most prominent response, provided further evidence that the visitors’ experiences were still strongly positive and expressive of beauty. In the opening question, the second most common reaction — reference to vastness — falls in line with the aesthetic sublime. The sublime experience is one in which the subject is overwhelmed by the object and experiences feelings of awe, ecstasy, elevation, and enthusiasm, while retaining a humbling effect on the ego (Carlson 2000; Costelloe 2012; Brady 2013; Paden et al. 2013; Shapshay 2013). The sublime is largely denounced as inappropriate in scientific cognitivism but evokes further discussion that is beyond the scope of this study (Carlson 2000; Shapshay 2013). The theme of “calm and refreshing” elicits emotions coinciding with pleasure. Naturalness, which is referred to in a greater degree at the closing of the survey than at the start, is a more cognitive experience. Its marked increase after the survey reflects the intellectual exercises induced by participation in the survey. Prior to taking the survey, the role of cognition was greatly reduced, suggesting that visitors perceive affective connections to the forest innately and to a greater degree, whereas cognitive connections may require prompting to become salient. Similarly, the ideas of forest health and vulnerability did not appear until after the survey — despite visitors being visually aware of tree mortality — a likely sign of prompting by the survey process. Overall, visitors reported pleasurable affective experiences despite the beetle disturbed landscape, suggesting less of a need for cognitive interventions than proponents claim in order to provide an ameliorating role of knowledge in cognitive dissonance (Carlson 2000).

Bark Beetle Knowledge and Visitor Perceptions

Overall bark beetle knowledge was low, similar to earlier studies (Flint 2006; McFarlane et al. 2006; Flint 2007; McFarlane and Watson 2008). Indeed, the highest number of responses fell in the “I don’t know” category (n = 114 of 276). Regional residents had a significantly higher level of knowledge of the bark beetles than non-residents which agrees with Arnberger et al.’s (2018) findings of CSFSP visitors having greater bark beetle awareness than visitors to parks in Minnesota and Germany. This suggests that outreach efforts have been successful in educating the public of bark beetle impacts in this area.

In general, knowledge scores had a direct relationship with perceptions of forest health, as knowledge increased, perceptions of forest health increased. This pairs with the finding of Morris et al. (2018), in which increased knowledge coincided with positive outlooks of forest recovery. An exception arose with the significant finding of participants with a knowledge score of 0 perceiving the health or well-being of the forest more positively than those with a score of 1. One possible explanation is that individuals with an average score of 0 knew very little about the bark beetle impacts and were therefore rating the forest based on more affective perceptions than cognitive. This exception could then lead to the conclusion that higher knowledge is not needed to have greater appreciation, countering scientific cognitivism (Carlson 2000). However, the general trend showed an increase in positive perceptions with increased knowledge scores (although not significant), which supports Carlson’s philosophical framework.

The strength of belief in knowledge answers did not reveal any significant differences. In this case, confidence in incorrect beliefs did not impact perceptions. This was interesting due to the misperception that the bark beetles are not native to the Rocky Mountains. The negative view of nonnative species’ impacts on the forest was eliminated during EFA due to highly skewed negative ratings. The high frequency of “I don’t know” responses may have offset any potential relationship in regard to belief strength and perceptions. While scientific cognitivism is focused on accurate natural science knowledge for aesthetic appreciation, the role of misconceptions is an interesting nuance warranting future work (Carlson 2000).

Participants with an awareness of the bark beetles had a significantly more negative perception of forest health than those who had not heard of the bark beetles. Awareness is only indicative of whether an individual has simply heard of the bark beetles and is not a measurement of their knowledge. Participants with only a limited amount of knowledge or hearsay perceive the forest and make judgments accordingly. In this case, only a little knowledge or awareness was detrimental to perceptions, suggesting a period of dissonance between naiveté and cognitive understanding. This would be partially in agreement with scientific cognitivism but also include an intermediate pre-cognitive, post-naïveté stage of understanding and aesthetic experience. While media outlets tend to seek out professionals for information regarding outbreaks, sensationalist headlines, from media and agencies alike, intended to grab reader attention and raise awareness may provoke unintended negativity (McFarlane et al. 2016). Participants who had not been exposed to such information would not be influenced in their perceptions.

Unlike awareness and knowledge, notice of affected trees in the forest had no influence on perceptions. At the time of
the survey, the bark beetles had peaked at RMNP and the majority of impacted trees were in the needleless, gray stage. This stage is subtler in appearance than the earlier red stages yet is undeniably indicative of tree mortality. Conducting this survey in a recently affected area in earlier stages may yield more pronounced perceptual impacts from visual recognition of affected trees.

Overall, cognition appears to play an important, but not primary, role in aesthetic appreciation of bark beetle disturbed landscapes. If not a primary mode of aesthetic perception, it is possible that knowledge serves an important secondary purpose in mitigating dissonance and ambivalence caused by unexpected or unpleasant aesthetic experiences. In this way, informed visitors can resolve the dissonance or ambivalence and progress to a positive aesthetic experience. There are multiple psychological and educational models related to change that address cognitive dissonance and ambivalence as part of the change process that are beyond the scope of this paper (Piaget 1952; Miller and Rollnick 2004; Norcross et al. 2011).

Perceptions of Natural vs. Anthropogenic Disturbances

Younger visitors were found to view ecological phenomena as caused by anthropogenic sources more than older visitors, in alignment with findings on environmental concern (Cottrell and Graefe, 1997; Cottrell 2003. The fact that younger participants rated ecological phenomenon as more anthropogenic in cause in comparison to older participants may be a reflection of change in societal values and education. The younger generations have been exposed to messages both in the classroom and in media regarding negative human impacts on the environment (e.g., rainforest destruction, acid rain, greenhouse gases and climate change). Environmental education, both formally and informally taught, can become a part of a person’s value system which in turn influences behavior and decision-making (Schwartz 1968; Silcock and Duncan 2001; Stohr 2013; Barakoska 2014; Türkahraman 2014; Gatersleben et al. 2014; Kenter et al. 2016; Liu et al. 2018). This also aligns with the similar finding of participants with higher education levels rating anthropogenic causes higher than those with lower levels of education.

Participants with awareness of bark beetles rated ecological phenomenon to be more naturally caused. This is again confounded by the differing amounts of knowledge, misconceptions, and naiveté possessed by those asserting some amount of awareness. Participants with awareness included all individuals regardless of knowledge scores. There is a marked distinction being made between anthropogenic disturbances and natural disturbances, as seen in the EFA of disturbance that failed to load agency-caused fires with the other items.

CONCLUSION

Bark beetle and other natural disturbances will continue to occur in forests across the globe. It is important to understand how these disturbances impact forest visitor perceptions and behaviors to inform environmental education in attempts to mitigate negative impacts. This study focused on visitor perceptions of bark beetle impacts in RMNP, including how knowledge influenced these perceptions. Overall, visitors continued to regard the park positively (e.g., beautiful, interesting, satisfying) despite observed bark beetle disturbance, in contrast to previous preference studies (Buhoff & Lauscher 1978; Buhoff et al. 1986; Ribe 1989; Ribe 1990; Young and Wesner 2003; Sheppard & Picard 2006; Gundersen and Frivold 2008; Edwards et al. 2012; Giergiczny 2015; Arnberger et al. 2017; Arnberger et al. 2018). Visitors also perceived the forest as alive and healthy despite evidence of tree mortality and awareness of bark beetle activity.

The role of knowledge in aesthetic perception was mixed. As a case study of scientific cognitivism, this study showed evidence of both cognitive and affective dimensions in perception. Overall, knowledge about bark beetles in the forest did not influence aesthetic perceptions. All of the participants rated the forest as beautiful regardless of the amount of knowledge they possessed. This undermines the importance of knowledge in environmental aesthetic judgment as proposed in scientific cognitivism. The role of cognition, specifically knowledge, was evidently less salient but readily elicited with prompting. The results of the factor analysis illustrate that affective and cognitive dimensions are not separate but combined in perceptions. This implies that environmental education needs to connect information with affective experiences.

This study did not reveal any connection between aesthetic judgment and perceived source of disturbance (anthropogenic or natural), with only a single factor resulting from EFA analysis, natural disturbance. A generational divide was discovered with younger visitors (ages 18-39) perceiving ecological phenomena as anthropogenic in contrast to visitors aged 40-79. This suggests that recent environmental education efforts have been successful in instilling a sense of environmental responsibility.

Based on this study, we believe that cognition may play a secondary role to the primary affective aesthetic experience thus mitigating the role of scientific cognitivism. Instead of knowledge being a requisite of proper environmental aesthetic experience, knowledge may serve as a means to overcome cognitive dissonance and ambivalence associated with unexpected or unpleasant natural aesthetics. In this way, viewers may use information to appreciate disturbed landscapes. This would still affirm the need of environmental education to assist visitors at a cognitive impasse regarding the aesthetics of disturbed landscapes.

As this was a single case study of RMNP which was past the visual peak of bark beetle impact, other studies need to be conducted at other settings and at various stages of disturbance. As the bark beetles have passed epidemic levels in the Rocky Mountains, longitudinal studies can be performed to capture perceptions as the forest undergoes dramatic visual changes following bark beetle infestation. Additionally, studies at
other locales of insect and other natural disturbances can be combined to differentiate isolated factors from general factors.

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