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Original Article

Emerald ash borer impacts on visual preferences for urban forest recreation settings

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ABSTRACT

Extensive outbreaks of the emerald ash borer (*Agrilus planipennis*; EAB), an invasive forest insect, are having serious impacts on the cultural ecosystem services of urban forests in the United States and other countries. Limited experience with how such outbreaks might affect recreational opportunities prompted this investigation of visitors to a state park in St. Paul/Minneapolis, Minnesota, USA, where EAB damage is occurring. A photo-questionnaire solicited visitors' visual preferences for trail environments in a discrete choice experiment. Systematically manipulated digital images simulated different levels of EAB impact in combination with other physical and social attributes including trail-proximate EAB-related forest management responses, land use context of the viewscape beyond the trail environment, visitor types, and visitor densities. Results indicated that EAB impacts were significant but of lesser importance than surrounding viewscape development and visitor numbers. Specifically, respondents preferred dense trailside shrub vegetation and low trail user numbers and disliked viewscapes showing city buildings and removal of most ash trees. Results suggest that trail planning should not only consider near-view landscape impacts but also the visual quality of more distant viewscapes, and that urban forest managers need to be aware of how forest insect impacts and subsequent management responses affect recreation setting preferences.

1. Introduction

Urban forest managers today face an increasingly diverse array of land use goals and problems with both ecological and social dimensions. One such problem concerns invasive forest insect outbreaks, which have increased globally due to climate change, trade, and other factors (Herms and McCullough, 2014; Raffa et al., 2008; Straw et al., 2013). Of recent outbreaks, the emerald ash borer (*Agrilus planipennis*; EAB), a beetle native to Asia, is widely regarded as one the most destructive forest pests ever seen in North America, where it has killed more than 10 million ash trees (*Fraxinus* spp.) since it was first identified in the mid-1990s (McCullough and Usborne, 2014; Kovacs et al., 2011). By 2016, EAB had spread to 28 US states (USDA Animal and Plant Health Inspection Service, 2016) across a number of land use types, including urban landscapes. In certain Michigan and Ohio sites, EAB killed over 99% of the ash within a decade of its arrival (Klooster et al., 2013). Similarly, its projected impact in south-central and eastern Europe reveals an urgent need to address EAB management there (Straw et al., 2013; Valenta et al., 2015).

The ecological impacts of EAB have received much attention by urban forest researchers, but less is known about its social impacts, particularly on cultural ecosystem services such as recreation, tourism, and scenic beauty (Daniel et al., 2012; Jones 2016). Within this context, we know little about how EAB impact might influence urban forest visitors' recreation site preferences and choices. Thus, the question arises as to how accepting visitors are to changes in the forest landscape associated with EAB-impacts and concomitant management approaches. Even less is known about the magnitude of EAB impacts to visitor landscape preferences relative to other factors such as the land use context of the surrounding viewscape or the social aspects of

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recreation such as crowding. To date, visitor trade-offs between biophysical characteristics, site management attributes, viewscapes, and social factors have not been investigated in the context of EAB-impacted urban recreation landscapes. The few existing preference studies that do combine physical and social aspects of recreation areas have found that recreationists simultaneously integrate many of these factors in their site choices (Arnberger and Eder, 2015; Manning, 2007; Santiago et al., 2016; Van Riper et al., 2011). Therefore, stated choice approaches such as discrete choice experiments (DCE) (Louviere et al., 2000), which allow for the evaluation of multiple attributes simultaneously, are useful to examine preferences that visitors hold for varying levels of EAB impact, management practices, and spatial and social aspects of recreational areas. Unlike conventional univariate preference studies, a DCE approach allows the analysis of trade–offs among these forest recreation-related factors as visitors have to balance a complex set of physical and social factors to identify their most preferred forest trail setting. Gaining an understanding of relative preferences for urban recreation sites attributes can inform managers about how to address the recreational utility and quality of a site while managing for EAB.

This study employed an image-based DCE to simulate forest stands with varying levels of EAB outbreaks, different forest management practices, viewscapes, and varying visitor uses to investigate forest visitors' visual preferences. Given the coupling of increasing infestation related to climate change and declining resources for urban forestry (Krajter Ostoic and Konijnendijk van den Bosch, 2015), understanding the relative importance of EAB infestation to recreation experiences is essential to inform resource allocation and management decisions of urban foresters and recreation managers. In this study, the term urban forests refers to trees in wooded areas in parks and preserves in an urban area. In addition to this methodological foundation, this study is also conceptually rooted in the psychophysical approach to landscape preference assessment (Daniel and Boster, 1976; Zube et al., 1982) and in socio-psychological theories of leisure dealing with crowding and user conflict (Jacob and Schreyer, 1980; Shelby and Heberlein, 1986).

1.1. Forest landscape preferences

Research on forest aesthetics finds people generally prefer trails within a landscape of mature trees and forest stands with an open structure (Edwards et al., 2012; Ribe, 1989; Ryan, 2005). Larger and near-view clearcuts, dense understory vegetation, high densities of small even-aged trees of the same species, fallow-appearing settings, and the presence of dead wood from timber harvesting or natural processes can negatively affect visitor preferences and associated perceptions of scenic beauty, management acceptability, and/or personal safety (Arnberger and Eder, 2015; Bjerke et al., 2006; Edwards et al., 2012; Hauru et al., 2014; Jorgensen et al., 2002; Ribe, 1990; Ryan, 2005; Tyrväinen et al., 2003). These forest preferences are not always homogeneous. van der Wal et al. (2014) found that the majority of their participants indicated a preference for intermediate to dense understory based on photographs of different forest stands in the UK. Edwards et al. (2012) suggest that preference is highest where understory density is neither very low nor high.

Although several studies have addressed the aesthetic consequences of insect infestations in coniferous forests (e.g. Buhyoff and Leuschner, 1978; McGrady et al., 2016), little is known about the influence of invasive insects on deciduous trees or associated forest management interventions on visitors' visual preferences (Sheppard and Picard, 2006). Landscape preference studies in the context of insect-impacted coniferous forests show public dislike of beetle activity (Buhyoff et al., 1986; Buhyoff and Leuschner, 1978; Sheppard and Picard, 2006). Research on gypsy moth infestation revealed an increased preference for broadleaved forest landscapes experiencing around 30–40% tree mortality, but a sharp decrease in preference for landscapes with higher mortality rates (Hollenhorst et al., 1993).

A range of urban forest management practices exist to treat insect infestations that are relevant to EAB depending on urban forest policy and budgets, progress of EAB infestation, and safety issues. If trees along trails are only slightly impacted by EAB, managers may decide to leave the trees as long as they pose no hazard to visitors, while continuing to monitor for potential safety hazards in the future. If trees are heavily impacted, the main strategy is removing trees along trails and recreational facilities if they pose a hazard to visitors because of falling dead trees or limbs (USDA Forest Service, 2011). For impacted trees not directly bordering the trail, managers may rely on sanitation cutting by removing only infested ash trees to avoid the further spread of the EAB. If infestation persists, larger open patches will eventually result in the forest because of permanent thinning of ash trees (Ryan, 2005).

Urban forestry strategies to reestablish a forest after an insect infestation include planting or reliance on natural succession. Planting considerations depend on timber production goals or the consideration of reestablishing larger trees within a short time. In the latter case, foresters plant new trees of several meters in height and fix these with a stake. This is a rather costly approach compared to natural rejuvenation. Further, forest management response decisions to insect infestation include whether and how much dead wood and cut trunks should be removed (Ryan, 2005). As such, the question arises as to which visual impacts associated with EAB management strategies and practices do urban forest visitors most and least prefer? Previous research reveals forest visitors have varying preferences for forest management practices in response to forest-insect impacts (Edwards et al., 2012; Gundersen and Frivold, 2008; Ribe, 1989, 1990; Ryan, 2005; Schlueter and Schneider, 2016). Schlueter and Schneider (2016) found five of the eight management approaches presented were acceptable to Minnesota state park visitors while the most acceptable were wood regulations, sanitation cutting, and progressive thinning. Three treatments were deemed unacceptable by the public visitors: chemical treatment, complete harvest, and doing nothing.

1.2. Viewscape preferences

While the immediate forest landscape is of concern to site managers and recreationists, it must also be recognized that the character of the viewscape surrounding a recreation site can also influence landscape preferences or trail choices. A viewscape or viewshed is a delineation of the totality of landscape elements visible from a given vantage point (Wilson et al., 2008) and with regard to this study refers specifically to the land uses visible beyond the immediate trail and associated forest environment of the recreation site. Previous studies have analyzed the visual permeability through vegetation (Herzog and Kutzli, 2002; Bjerke et al., 2006; Jorgensen et al., 2002; Tyrväinen et al., 2003) and identified the visual magnitude or sensitivity of landscape exposed to visitors as a function of distance and topography (Chamberlain and Meitner, 2013; Wilson et al., 2008). To date, few landscape preference studies have examined how visitor evaluations of forest settings are affected by what is seen in the surrounding viewscape (Ryan, 2005). Even less work has addressed the importance of viewscapes in terms of visibility of near or far-view city scenes with high-rise residential structures or natural scenes for trail choices of urban recreationists compared to other social and physical characteristics of the trail environment (e.g., Wilson et al., 2008).

Visual impact assessment studies have predominantly found that landscape preferences decrease with increasing degrees of urbanization and that viewscapes with buildings are less preferred than more natural ones (Dupont et al., 2016; Kaplan and Kaplan, 1989). Ryan (2002) assessed the visual impacts of urban sprawl on rural residents and found they perceived views of nature and nearby hills, woods, open fields, roadside vegetation and farms as extremely important to rural character compared to suburban residential categories and country roads. Similarly, Williams (2011) examined the public acceptance of rural land

uses and found that participants showed a strong positive consensus toward traditional agricultural and nontraditional "green" land uses, but had diverse and sometimes conflicting views regarding rural residential development. Other research reveals that viewscapes showing development can be rated high in preference if that development is seen as visually compatible with the land use context (Kaplan and Kaplan, 1989; Ryan, 1989; Williams, 2011; Wohlwill and Harris 1980; Zabik and Prytherch, 2013). Thus, the question arises which viewscapes are incompatible with urban forest visitors' recreational site preferences.

1.3. Social factor preferences

Besides physical factors like EAB impacts, social impacts such as high visitor numbers, non-normative behaviors, and user conflicts can negatively influence the quality of outdoor recreation experience and constrain trail use (Manning, 2007, 2011; Needham et al., 2014; Shelby and Heberlein, 1986). The question arises as to how visitors weigh social factors relative to physical ones in EAB-impacted forests. The relative importance becomes particularly relevant in urban settings as urban trails are frequently used by diverse activity groups which can result in crowding and user conflicts (Arnberger et al., 2010).

Crowding describes a negative evaluation of a certain density or number of encounters with other visitors in a given area (e.g., Shelby and Heberlein, 1986). Several studies confirm that visitor numbers are a very important social factor for people's enjoyment in urban and protected areas and that most recreators prefer few visitors (Arnberger and Eder, 2015; Gobster, 1995; Manning, 2011). Visitors who encountered more visitors than they expected or preferred felt more crowded (Arnberger and Haider, 2005; Manning, 2011; Shelby and Heberlein, 1986).

User conflicts can occur when the presence or behavior of individuals or groups interferes with visitation goals (Jacob and Schreyer, 1980; Schneider and Hammitt, 1995). Several studies of recreation conflict in urban and peri-urban areas exist (Pickering and Rossi, 2016), often focusing on conflicts between hikers and mountain bikers. Moore and Scott (1995) and Moore et al. (1998) examined conflict along a suburban trail, but considered conflict perception only. An urban trail study by Arnberger and Haider (2005) found walkers were preferred to bicyclists on a forest trail, whereas Arnberger and Eder (2015) could not identify a significant influence of user composition on visitors' trail preferences across green spaces. Arnberger et al. (2010) even found positive preferences for higher shares of bicyclists versus walkers among urban forest visitor segments.

The number of dogs and dog walker behavior encountered in recreational settings can also evoke conflict. Arnberger and colleagues (2010) and Arnberger and Eder (2015) found urban forest visitors disliked interactions with dogs, particularly when the dogs were not leashed and were numerous. In these urban studies, dogs and dog walker behavior were less important for visitors' trail choices than the number of visitors, but still more important compared to visitor composition.

1.4. Research questions

As EAB infestation is already significant in many areas of the United States, Russia and imminent in Europe (Straw et al., 2013; Valenta et al., 2015), documenting responses to EAB among urban green space visitors is informative for both management and research.

The following research questions guided the study:

1. What visual preferences do urban forest visitors hold for EAB-impacted and non-impacted urban forest stands?
2. What visual preferences do urban forest visitors hold for forest management practices in response to EAB?
3. How do viewscapes depicting various land use contexts (natural to urban) affect visitor preferences and what is their importance relative to the effects of EAB impacts?
4. How do the number of trail users, number of dogs and dog walker behavior, and trail user composition affect visitor preferences and what is their importance relative to the effects of EAB impacts?
5. Which of these attributes have the greatest and least influence on visitors' preferences?

2. Method

2.1. Study site

The study was conducted in and adjacent to Fort Snelling State Park, located in the Minneapolis-St. Paul metropolitan area of Minnesota (Fig. 1). The 1500 ha park hosts about 900,000 visitors annually and is part of a mix of local, state, and federal lands that comprise the 115 km long Mississippi River National Recreation Area. Ash (predominantly green ash, *Fraxinus pennsylvanica*) has favorable growing conditions in one-third of the park and is estimated to comprise between 5 and 30% of the state park land cover. Two paved state bike trails are within the park. The Greater Minneapolis-St. Paul metropolitan area is the 16th largest urban area in the United States with a 2010 population of 3.25 million (U.S. Census, 2010). Minnesota is an ideal area to study EAB impacts as it lies on the western edge of infestation where a number of options remain to address future impacts. EAB was first found in Minnesota in Hennepin and Ramsey Counties in 2009 near where this portion of the river corridor lies and, by mid-2017, had spread to fifteen Minnesota counties.

2.2. Questionnaire

Although the questionnaire dealt with a range of topics, this paper focuses on visitor preferences for trail environment scenes depicting EAB impacts as well as management responses in the context of various physical and social factors. Socio-demographic and recreation behavior items are also reported for descriptive purposes.

Participants evaluated multiple scenarios of forest recreation trail environments displayed as photorealistic, digitally-calibrated images (Fig. 2). Each scenario depicted three physical and three social attributes, to represent potential alternatives that a visitor might encounter along an urban trail with EAB impacts and management responses (Arnberger and Eder, 2015; Herms and McCullough, 2014; see Fig. 2, Table 1). The digitally calibrated scenarios were created using Adobe Photoshop by storing all attribute levels on individual layers. When compiling the trail scenarios, the layers ensured a specific level was always the same, independent of the other trail environment settings. The base photo used in all visualizations showed a trail in an ash forest along a river. The river setting was chosen because many ash species find optimal growth conditions there and the study area is an alluvial forest. Respondents were not shown images of the specific locale they were visiting, yet there were similarities in landscape appearance with the river-based setting. Many landscape preference studies have successfully used images different from the specific locale the study respondents were visiting or familiar with (e.g., Rom et al., 2013).

The primary physical attribute of interest characterized ash forest conditions in the near-view trail environment and was based on past research in terrestrial environments and expert review. Eight levels of forest stand scenarios simulated a typical EAB infestation and management response ranging from an unaffected, mature ash forest to initial (1-year) and advanced (2–3 year) EAB impacts to various management treatments from removal to planting to natural rejuvenation. The four-level trailside shrubby vegetation attribute portrayed increasing densities of mid-story shrub vegetation reflecting varying levels of eye-level visual penetration. The four-level viewscape attribute portrayed land use contexts ranging from high-rises very close to the trail to natural forest with no buildings.

The three social attributes analyzed included preferences for

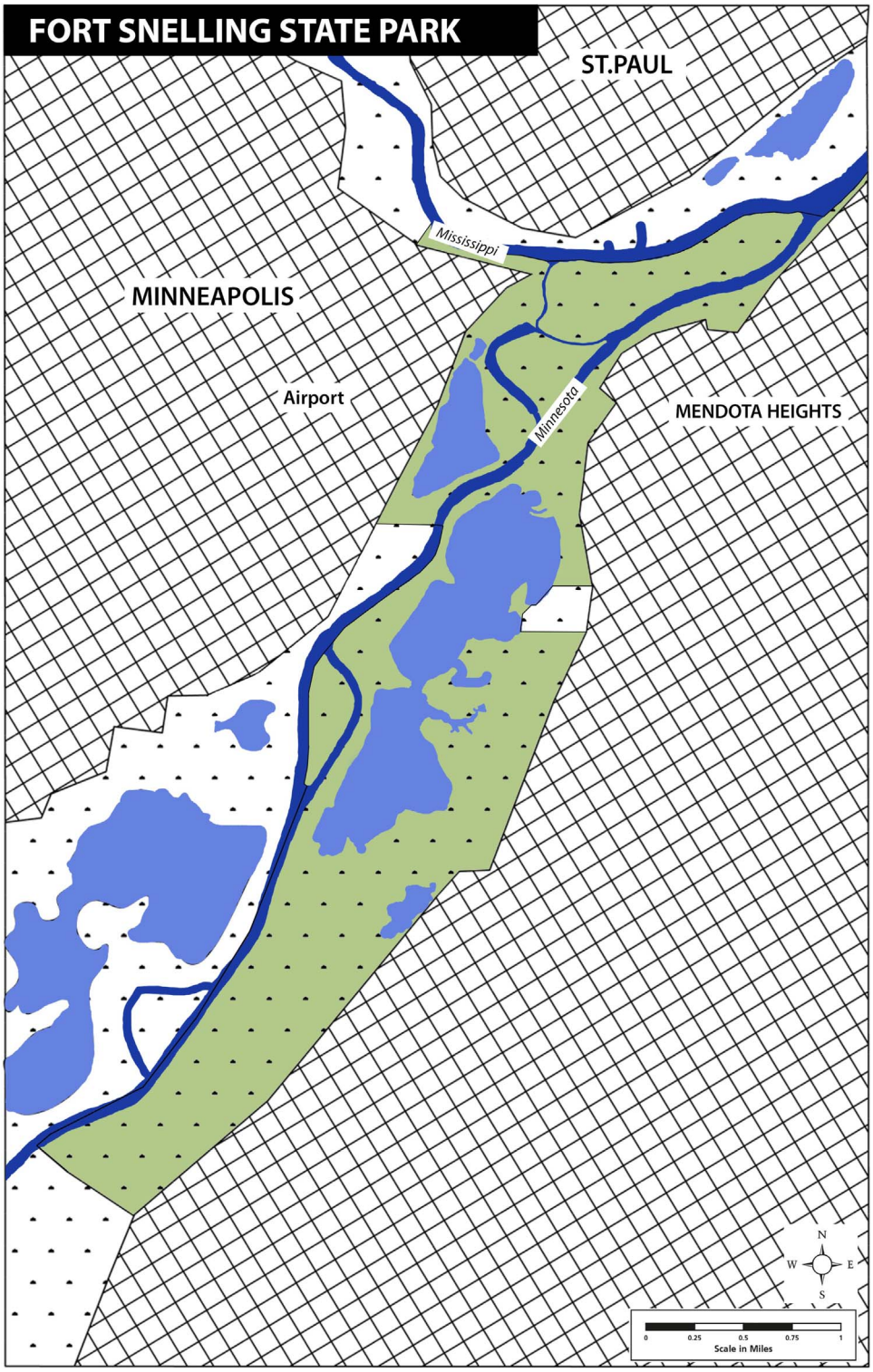

Fig. 1. Study area. The State Park (shaded area) lies along the floodplain (dotted area) of the Minnesota and Mississippi Rivers and is surrounded by urbanization (hatched area) of the St. Paul-Minneapolis Metropolitan Region.

intensities and types of trail uses as potential causes for crowding and visitor conflict. The attributes displayed the number of visitors (i.e., four levels from 1 to 12 visitors), user groups (i.e., four levels showing varying proportions of walkers and bicyclists) and number of dogs and dog walkers' behavior (i.e., no dog, 1 dog leashed, 2 dogs leashed, 2 dogs unleashed).

The exact combination of the attribute levels per scenario depended on an underlying asymmetric orthogonal fractional factorial design (Louviere et al., 2000). Fractional factorial designs involve the selection of a particular subset of complete factorials, so that main effects can be estimated as efficiently as possible without losing substantial information, while analyses of interactions are not possible or very limited. An orthogonal design permits uncorrelated estimates of all main effects of both symmetrical and asymmetrical factorial experiments. Therefore, multicollinearity between the attributes is not an issue, which is often the case in regression modelling.

The 128 scenarios were distributed among eight photo versions of the questionnaire following the factorial design, with each version containing 16 scenarios. For a given photo version, the 16 scenarios were split into four choice sets, with each choice set consisting of four scenarios.

Fig. 2. Examples of three choice sets showing twelve of the 128 total trail scenarios. Each scenario portrayed a unique combination of the three physical and three social attribute levels.

2.3. Data collection

Data were collected during summer 2015 (June to August) through an on-site intercept survey. Data collection included a stratified-cluster sample of visitors with a systematically selected sampling period that varied time of day and day of the week to reflect visitation patterns and capture a diverse visitor segment. Researchers were stationed at frequently-visited park locations such as main access points, visitor

Table 1
Attributes and attribute levels used for the Discrete Choice Experiment.

Attributes	Attribute levels
1) Ash Forest	a) Mature, vital ash forest b) [a]EAB 1-yr impact indicated by some yellow leaves c) EAB 2-3yr impact indicated by more yellow leaves and dead branches without any management actions d) EAB 2-3yr impact with management actions (cut and removal of six infected trees because of safety issues) e) Removal of most ash trees and logs of cut trees left along the trail f) Nine newly planted relatively young ash trees of the same age class and of 3.5 m in height, tied on a stake, along the trail with signs of some natural rejuvenation and presence of dead wood g) Nine newly planted relatively young ash trees of the same age class and of 3.5 m in height, tied on a stake, along the trail, first signs of some natural rejuvenation, and absence of dead wood h) No planted young ash trees but advanced stages of natural rejuvenation with young ash trees of 1–7 m in height and dead wood.
2) Trailside vegetation	a) No trailside vegetation b) Some trailside vegetation c) Dense trailside vegetation d) Very dense trailside vegetation
3) Viewscapes	a) High rises near-view b) High rises far-view c) Rural landscape with farmhouses without any visible high–rise buildings d) Forest, no visible buildings
4) Number of trail users	a) 1 Person visible on the trail b) 4 Persons visible on the trail c) 8 Persons visible on the trail d) 12 Persons visible on the trail
5) Composition of trail users	a) 50% Walkers-50% Cyclists b) 75% Walkers-25% Cyclists c) 25% Walkers-75% Cyclists d) 100% Walkers
6) Dogs and dog walker behavior	a) No dog b) 1 dog leashed c) 2 dogs leashed d) 2 dogs unleashed

[a] EAB = Emerald Ash Borer.

centers, and trailheads. One adult per travel group was asked to complete the questionnaire anonymously and confidentially. No incentives were offered to respondents. Respondents took between 10 and 20 min to complete the questionnaire. For the choice experiment portion of the survey, respondents were asked to choose their most and least-preferred trail environment alternatives from each of the four choice sets presented, with every set consisting of four images displayed on a single page. Respondents were not told the photos depicted different EAB-impacted conditions or management activities. To avoid starting point bias, interviewers systematically rotated the choice-sets of the DCE. Sample size was 316 (response rate = 39%); eliminating incomplete responses resulted in a final sample size of 307. The primary reason for non-response was time − people wanted to get on with their activity or indicated they were too busy.

2.4. Data analysis

Random utility theory (McFadden, 1974) postulates respondents' choices can be modelled as a function of the attributes of the alternatives of a DCE. Alternatives – our forest trail environment scenarios – are defined as a particular combination of attributes and their levels (for example, the attribute visitor numbers is defined by four levels). The selection of one alternative over another implies that the utility of that alternative is greater than the utility of any other alternative (Louviere et al., 2000). The sum of the part-worth utilities (parameter estimates) of the attribute levels depicted in the image yields the total utility of an alternative.

As this DCE was designed as a multivariate study with six variables, the multinomial logit model estimates were all relative to each other. No base alternative or 'no-choice' alternative was presented and therefore no intercept exists. The maximum likelihood analysis produces parameter estimates (part-worth utilities), z-values, and standard errors for each attribute level. All DCE attribute levels were effects coded, where an N-categorical variable needs to be defined by N-1 estimates only (Louviere et al., 2000). McFadden's rho^2 was used to indicate the goodness of fit of the estimated choice models. Values of rho^2 between 0.2 and 0.4 are considered to be indicative of very good model fits (Louviere et al., 2000). The DCE analysis of this study resulted in a reliable model with rho^2 statistic of 0.2 (Louviere et al., 2000; Table 2). All attributes influenced state park visitor choices at least at the $p = 0.051$ level. Model analysis was performed with Latent Gold Choice 4.5 statistical software (Vermunt and Magidson, 2003). The relative importance of each attribute on landscape preferences was calculated by dividing the maximum range of parameter estimates between the levels of one attribute by the sum of the maximum ranges of all attributes (Vermunt and Magidson, 2003).

3. Results

3.1. Sample characteristics

The majority of respondents were white (89%), non-Hispanic (96%) males (51%) with at least some college education (77%). Respondents traveled a mean distance of 22 km to the park, with most (88.5%) starting their trip that day from their primary residence and staying an average of 2.25 h. On average, the visitors had been to Fort Snelling State Park between 8 and 9 times in the last 12 months, including the visit they were surveyed, but the median was 1 visit in the last 12 months. Slightly more than 20% had been to the park too many times to remember. Primary visitor activities included hiking/walking (57.8%), biking (14.1%), dog walking (6.7%), jogging/running (6.1%), and others such as birding/wildlife viewing.

3.2. Forest landscape preferences

Out of the eight ash forest conditions, respondents most preferred EAB-unaffected, mature ash trees (Level (a) of Tables 1 and 2; Fig. 3). The figures can be interpreted as follows: the higher positive parameter estimate (part-worth utility) of an attribute level is (Y-Axis), the greater the preference is for the level. The more negative the parameter estimate of an attribute level is, the less preferred it is. The scenario portraying the beginning of an EAB infestation, with some yellow leaves (b) received lower positive evaluations than a mature forest. Advanced stages of EAB-impacts were less preferred (c, d). A scenario with EAB management response actions (d) was preferred to one without management (c).

Respondents least preferred the scenario showing most ash trees removed with logs of cut trees left along the trail (e), followed by one showing newly planted relatively young staked ash trees, with signs of some natural rejuvenation and dead wood (f). The scenario with newly planted relatively young ash trees but with a removal of dead wood (g) was slightly more preferred. The scenario without planted young ash trees but with advanced stages of natural rejuvenation with ash trees of up to 7 m in height (h) received higher preference scores than attribute levels c to f.

Respondents preferred at least some trailside vegetation and disliked its absence (Fig. 4). However, there was not a significant change in preferences due to different trailside vegetation densities.

Table 2
Parameter estimates, z-values and Wald statistics for attributes and attribute levels of the discrete choice experiment with emerald ash borer (EAB).

Attributes and attribute levels	Parameter estimates	s.e.	z-value	Wald statistic
1) Ash forest	[23.3%]			
a) Mature, vital ash forest	0.574	0.100	5.742	***238.2
b) EAB 1-yr impact	0.358	0.095	3.788	
c) EAB 2-3yr impact without management	0.053	0.095	0.561	
d) EAB 2-3yr impact with management	0.183	0.078	2.356	
e) Removal of most ash trees	−0.690	0.066	−10.507	
f) New single trees, natural rejuvenation, dead wood	−0.533	0.061	−8.681	
g) New single trees, natural rejuvenation, no dead wood	−0.179	0.061	−2.955	
h) Natural rejuvenation, dead wood, no tree planting	0.233	0.075	3.122	
2) Trailside vegetation	[10.0%]			
a) No trailside vegetation	−0.270	0.047	−5.802	***95.7
b) Some trailside vegetation	−0.257	0.047	−5.506	
c) Dense trailside vegetation	0.270	0.048	5.670	
d) Very dense trailside vegetation	0.257	0.048	5.304	
3) Viewscapes	[32.8%]			
a) High rises near-view	−0.902	0.050	−17.896	***507.4
b) High rises far-view	−0.258	0.044	−5.808	
c) Rural landscape with farmhouses	0.283	0.044	6.416	
d) Forest, no visible buildings	0.877	0.047	18.775	
4) Dogs and dog walker behavior	[5.3%]			
a) No dog	0.145	0.052	2.816	**13.5
b) 1 dog leashed	0.027	0.051	0.535	
c) 2 dogs leashed	−0.029	0.047	−0.605	
d) 2 dogs unleashed	−0.144	0.049	−2.933	
5) Composition of trail user	[3.6%]			
a) 50% Walkers-50% Cyclists	0.107	0.047	2.292	(*)7.8
b) 75% Walkers-25% Cyclists	0.027	0.045	0.597	
c) 25% Walkers-75% Cyclists	−0.043	0.046	−0.933	
d) 100% Walkers	−0.090	0.050	−1.801	
6) Number of trail users	[25.0%]			
a) 1 Person	0.534	0.053	10.036	***326.5
b) 4 Persons	0.272	0.044	6.215	
c) 8 Persons	0.013	0.053	0.250	
d) 12 Persons	−0.819	0.050	−16.496	
Rho-square	0.196			

Significant influence of the attribute levels on respondents' choices (N = 307):
(*) $p = 0.051$.
**$p < 0.01$.
***$p < 0.001$.
[%] = relative importance of that attribute for the choices of the sample.

3.3. Viewscape preferences

Respondents least liked seeing high-rises very close to the trail. High-rises in the viewscape more distant to the trail received lower scores and preferences than the farmhouses in a rural landscape. The most preferred level of viewscapes was a forest scenario without any buildings (Fig. 5). The part-worth utilities of the levels "High-rises near view" (negative) and "Forest, not buildings" (positive) were the highest among all attribute levels.

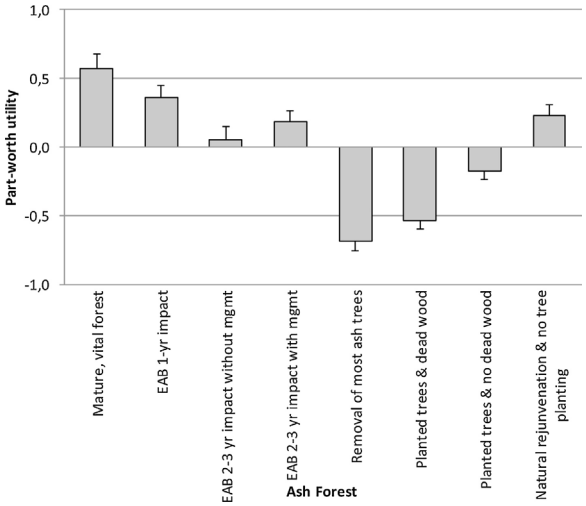

Fig. 3. Part-worth utility parameter estimates for the levels of the attribute "Ash forest" (EAB = Emerald Ash Borer; mgmt. = Management).

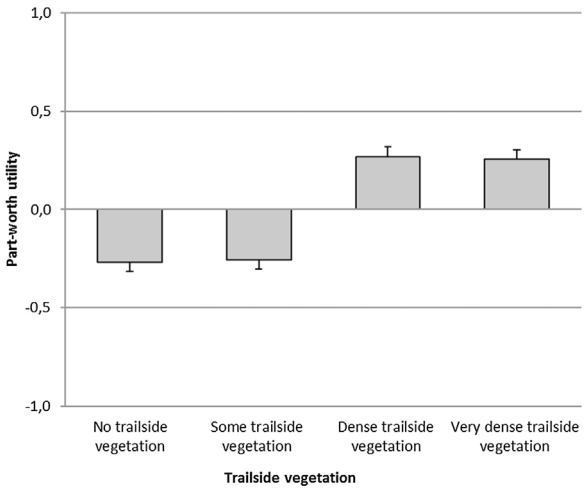

Fig. 4. Part-worth utility parameter estimates for the levels of the attribute "trailside vegetation".

3.4. Social factors preferences

The lower the number of trail users depicted, the more this condition was preferred (Fig. 6). Scenarios with only walkers were disliked, whereas a mix of bicyclists and walkers was preferred (Fig. 7). Respondents preferred no dogs on the trail and disliked two dogs off leash (Fig. 8).

3.5. Relative importance of the attributes

In relation to the other attributes, viewscape was the most important predictor for respondents' trail preferences. The second most important attribute was the number of trail users followed by the ash forest appearance (Table 2). The composition of trail users, dogs and dog walker behavior were largely unimportant to participants and less important than the trailside shrubby vegetation attribute.

4. Discussion

An onsite survey of urban state park visitors found they prefer healthy, natural-appearing forest environments and trails with low visitor numbers. Preferences for EAB forest management practices varied, with natural rejuvenation most preferred and removal of ash trees least preferred. While the condition of the forest environment

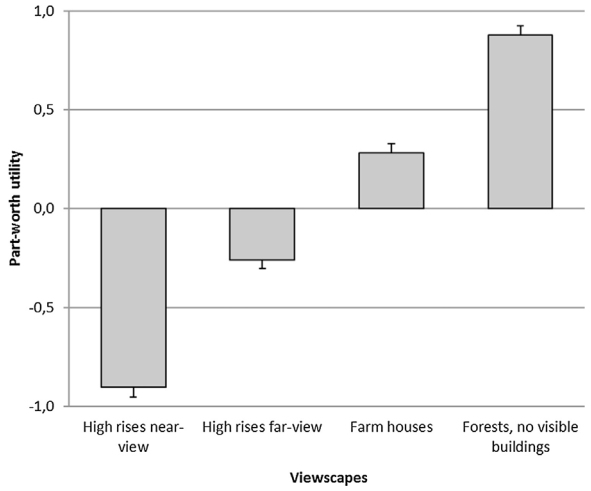

Fig. 5. Part-worth utility parameter estimates for the levels of the attribute "viewscapes".

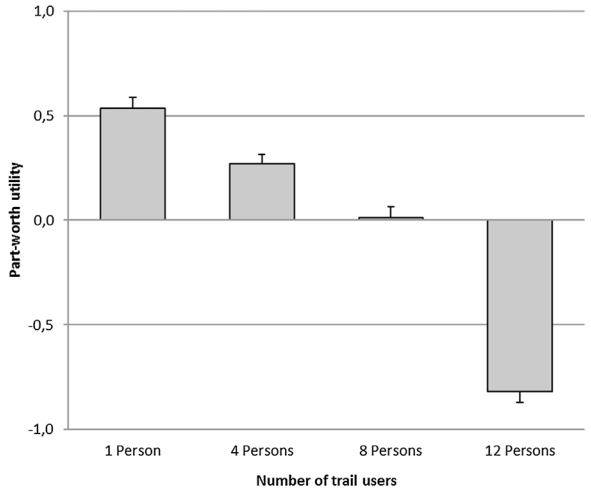

Fig. 6. Part-worth utility parameter estimates for the levels of the attribute "number of trail users".

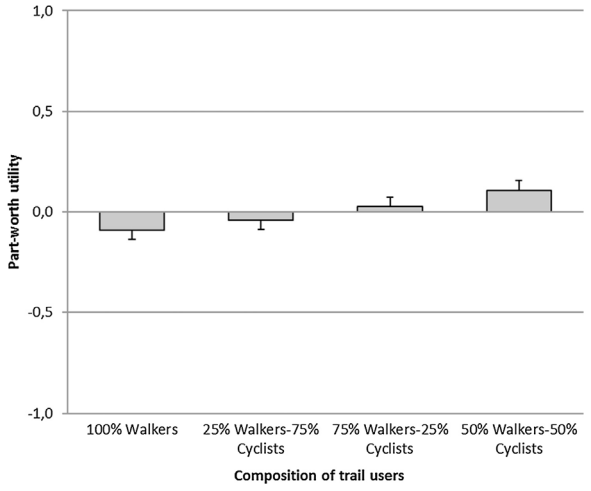

Fig. 7. Part-worth utility parameter estimates for the levels of the attribute "composition of trail users".

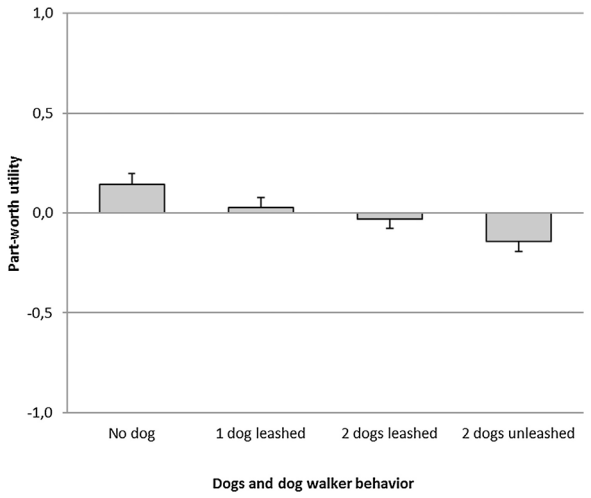

Fig. 8. Part-worth utility parameter estimates for the levels of the attribute "dogs and dog walker behavior".

played a significant role in preferences, urbanized viewscapes and low visitor numbers were the most important attribute levels.

4.1. Forest landscape preferences

When visitors use a trail in an urban forest, most prefer to see a forest with large, healthy green trees and a nearly closed canopy. These results confirm the findings of the forest aesthetics literature (Edwards et al., 2012; Gundersen and Frivold, 2008; Ribe, 1989, 1990; Ryan, 2005). Conversely but consistent with the forest insect impacts literature (Buhyoff and Leuschner, 1978; Buhyoff et al., 1986; Sheppard and Picard, 2006), respondents also disliked higher amounts of dead wood and removal of most ash trees with or without replanting of even-aged trees. Minor treatment interventions did not affect preferences much as indicated by the similar parameter values of the 2–3year EAB impact without any management actions (c) and the same impact with the removal of some trees (d). Consistent with this finding, Ryan (2005) suggests that selective cutting and thinning can actually improve visual quality because of increased visual access. Similarly, Hollenhorst et al. (1993) found that some opening of forest stands increased preferences. If removal of ash trees along trails is necessary for EAB management, managers might consider signage along the trail or other communications techniques to explain the reason for their removal because research shows that people are more accepting of invasive species management efforts if they know why it is being done (McFarlane and Watson, 2008). Managers can also maintain recreation quality by promoting hiking trails to less EAB-impacted sections.

Trail scenarios showing young staked trees (f-g) with or without removal of dead wood received lower preference values compared to natural rejuvenation with varying tree sizes and dead wood (h). It appears that respondents preferred natural succession for the depicted forest landscape rather than costlier treatments such as tree planting. One possibility is that they may prefer a more "natural" character of forest treatments compared to urban park-like reforestation in the context of forest recreation. Another possibility is that the larger tree had a positive impact on preferences (Edwards et al., 2012; Ribe, 1989; Ryan, 2005). Future research might test visual preferences for the planting of mixed-aged trees and of other broadleaved tree species adapted to alluvial forests and mixed forests, as possible, given the preference for species heterogeneity (Termansen et al., 2008).

In contrast to previous studies (Arnberger and Eder, 2015; Bjerke et al., 2006; Jorgensen et al., 2002; Tyrväinen et al., 2003), this study found a preference for dense shrubby trailside vegetation. Visual accessibility of recreational landscapes is usually found to be a preferred factor, as having a view is important for understanding the surrounding environment, finding one's way, and minimizing fear (Herzog and Kutzli, 2002). Consequently, studies have found vegetation removal that interferes with sight along the trails positively affects the recreational value of urban forests (Arnberger and Eder, 2015; Bjerke et al.,

2006; Jorgensen et al., 2002; Tyrväinen et al., 2003). Our contrasting findings may be because all of the images provided some level of visual permeability to views of the valley slopes and the river beyond the trail. The river may also serve as a landmark, which increases orientation to the landscape and is itself a positive predictor of visual landscape preferences (Herzog and Leverich, 2003; Kaplan and Kaplan, 1989). In addition, this study confirms those studies which have found a positive relationship between density of understory vegetation and preferences (van der Wal et al., 2014) or suggested a bell-shaped relationship (Edward et al., 2012). Additional investigations using this DCE in different US sites and nations may contribute to further clarifications whether a preference of understory vegetation in urban ash woodland is bell-shaped or linear, and whether this relationship is influenced by nationality or the rural-urban context.

4.2. Viewscape preferences

Consistent with the landscape preference literature, this study confirms preferences of urban forest visitors for naturally appearing environments and the negative effect of urban land uses (Dupont et al., 2016; Ryan, 2002). At the same time, several studies of urban recreation show that visitors prefer to travel short distances to use urban green spaces (Vogt et al., 2015; Wilhelm Stanis et al., 2009) and that escape from the city is a primary motivation (Frick et al., 2007). Reconciling these seemingly incompatible goals poses a challenge to urban park and forest managers, who may have little control over what happens in the viewscape beyond the boundaries of their own site. In the context of our state park study, findings showed that visitors were more accepting of built features in natural contexts when they fit their ideas of compatibility (e.g., the scenario depicting a rural landscape with a farmhouse or forests), whereas high-rise scenarios were less preferred and perhaps incompatible with their recreational goals and site preferences. Design guidelines that minimize the visual magnitude of development with respect to building height, distance from sensitive viewing areas, color contrast and reflectivity of material, and the like can be of some use (e.g., Wohlwill and Harris, 1980; Ryan, 2005). However, in major urban centers like Minneapolis-St. Paul where land values are high and views *of* natural areas compete with views *from* natural areas, it might be more realistic for recreation site managers to locate trails and/or use vegetative screening to minimize obtrusive elements from view. And while complete escape from the city may not be an option, there may be opportunities to provide spots of relative seclusion within even highly urban settings where visitors can get away from the sights and sounds of civilization to have a quality nature experience.

This study found it was much more important for respondents to avoid seeing any high-rises than to see EAB impacts, removal of most ash trees, unleashed dogs, or varying user compositions. The part-worth utilities of the high-rise and forest levels of the viewscape attribute exceeded that of any other variables. This does not mean that forest management is not an important issue in the urban context, but when respondents considered all six attributes, forest management turned out to be of lower importance. In urban situations, trail planning is not only a matter of managing near-view forest conditions but also of integrating site-scale design considerations with landscape-scale issues. Further, this points to the need and opportunity for cross-sector coordination between urban foresters, recreation managers, and urban and regional planners.

4.3. Social factor preferences

The social attributes had a significant influence on trail preferences, although the importance of the three social components was, in total, lower compared to the forest landscape and viewscape attributes. Social attributes are important because they not only enhance visitors' recreation experience, but in a management context they might also act to moderate preferences when there are trade-offs due to negative physical site attributes (Arnberger and Eder, 2015). For example, our results suggest that visitors might tolerate higher EAB-impacts on the forest landscape when the number of trail users is very low. Previous preference studies which integrated physical and social aspects of recreation areas in one design also observed that respondents balance these various factors in their choices, and that social aspects, in particular visitor numbers, play an important role (Arnberger and Eder, 2015; Manning, 2007, 2011; Van Riper et al., 2011). Santiago et al. (2016), for example, found that reduced visitor numbers significantly increased respondents' willingness to pay for visiting an urban tropical river but the amount of vegetation did not influence their willingness to pay.

The result that study participants disliked a high number of trail users is in line with many other crowding and visitor density studies (Arnberger and Eder, 2015; Manning, 2007, 2011; Needham et al., 2014; Shelby and Heberlein, 1986; Van Riper et al., 2011). This study also confirms that visitor numbers are more relevant than visitor composition and visitor behavior (Arnberger and Eder, 2015; Manning, 2011). Respondents also disliked the presence of dogs, which is consistent with findings from other urban trail preference studies (Arnberger and Eder, 2015; Arnberger et al., 2010).

Previous research reveals user conflicts between bikers and walkers can negatively impact the recreation experience of walkers (Arnberger and Haider, 2005; Jacob and Schreyer, 1980; Schneider and Hammitt, 1995). However, this finding is not consistent within an urban context (Arnberger et al., 2010), and our study found that a mix of bicyclists and walkers was most preferred. Our sample characteristics revealed that most of the respondents cycled within the past year, and in the study site, cycling is allowed and frequently participated in on designated trails. The depicted trail type with its asphalt surface also supports cycling (Gobster, 1995). It is important to note, however, that user group composition played only a marginal role for respondents' choices in this study. Other authors have also found that visitor composition is not very important for trail preferences (Arnberger and Eder, 2015; Arnberger et al., 2010). Whether factors such as these played a role in response to visitor composition, or the stimuli in form of static images instead of videos triggered these responses, remains for future research. Exploring different types of sites and trails would be also of interest. Given the paucity of density-related recreation studies in Europe (Arnberger and Mann, 2008), cross-national work on trail preferences in the context of EAB-infestations would be of interest. Future research may also include assessments of non-White respondents due to the dearth of research on these groups and their projected growth in the United States (U.S. Census Bureau, 2010). Our sample self-identified as 89% White and 96% non-Hispanic. Therefore, research with a variety of samples across demographic and residential origins in the U.S. and Europe would also be of interest.

Urban forest recreation managers have several options to address the social factors that relate to visitor recreation experiences. Ways to disperse use through design or facility capacity might be useful in meeting respondents' preferences for low trail user numbers. Signage could also inform visitors about less-used trails and areas within walking or biking distance. Based on this study, multi-use trails seem to be accepted when the trail is rather wide, smooth surfaced and clearly laid out as shown in the scenarios.

5. Conclusions

While previous studies have identified a number of social and physical trail factors that relate to positive visitor experiences, the visual impacts of invasive species on visitor trail choice and recreation experience has yet to receive adequate attention by researchers. This project used image-based stated choice modelling to address visitor preferences for EAB infestations and management responses. Both physical and social attributes of EAB-impacted forests influenced urban

visitors' trail preferences, with views of city structures and visitor numbers being the most influential, while forest insect impacts were significant but of lesser importance. Results support that urban trail planning should not only consider near-view landscape impacts but also the visual quality of more distant viewscapes.

Urban forest managers need to be aware of how forest insect impacts and subsequent management responses can affect recreation setting preferences as increasing outbreaks of forest insects may occur due to climate change and global trade. Our study shows that while initial impacts have little effect on landscape preferences, when forest recreation sites become heavily-impacted by forest insects their attractiveness can diminish, not only due to the direct effects of damage to trees but also because of forest management practices to restore forest cover and secure visitor safety. Study results indicate that respondents preferred natural succession to tree planting, disliked dead wood and the removal of trees, and preferred rather dense understory vegetation. Moderating the visual effects of clear cuts of ash trees along trails could be done though the immediate removal of cut tree trunks and dead wood from the near-view trail environment, the planting of rather dense and high vegetation along trails by using shrubs, and allowing for and supporting natural rejuvenation with different broadleaved tree species behind the trail-side vegetation.

Our study also shows that recreationists are negatively impacted by highly visible residential buildings and heavy visitor uses. Besides resulting in declines in preference, this may result in user displacement and associated loss of other cultural ecosystem services and benefits such as human health (Daniel et al., 2012; Rosenberger et al., 2012). Overall, effective integration of urban forestry with urban planning will enhance the visual quality of recreational settings.

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