

Research Paper

Restoring a “scenically challenged” landscape: Landowner preferences for pine barrens treatment practices

Paul H. Gobster^{a,*}, Arne Arnberger^b, Ingrid E. Schneider^c, Kristin M. Floress^a, Anna L. Haines^d, Michael J. Dockry^c, Claire Benton^c

^a Northern Research Station, USDA Forest Service, 1033 University Pl. Ste. 360, Evanston, IL 60201, USA

^b Institute of Landscape Development, Recreation and Conservation Planning, University of Natural Resources and Life Sciences Vienna, Peter Jordan-Straße 82, 1190 Vienna, Austria

^c Department of Forest Resources, University of Minnesota, 1530 Cleveland Ave. N., St. Paul, MN 55108 USA

^d Center for Land Use Education, University of Wisconsin-Stevens Point, 800 Reserve Street, Stevens Point, WI 54481 USA

HIGHLIGHTS

- Scenic aesthetic defined by small spatial configurations and high tree density.
- Ecological aesthetic identified by prior experience and latent class analysis.
- Design and experiential opportunities can increase pine barrens appreciation.

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ABSTRACT

A pine barrens is an open, fire-dependent ecological community once prevalent in sandy areas of northern Wisconsin (USA). Efforts to restore pine barrens on public lands have been hampered in part because their character does not conform to many people's ideals of Northwoods forest scenery, challenging land managers on how to balance social and ecological goals. We studied the manager-relevant attributes of a pine barrens restoration site to predict nearby landowners' landscape preferences and to ascertain whether their preferences differed. We designed a discrete choice experiment where different levels of six attributes of pine barrens were systematically manipulated in visual choice scenarios and presented to landowners (N = 542) of small, family forest parcels in an online survey. Half of the respondents read an informational statement about barrens ecology and management prior to judging the scenarios for visual preference, while everyone answered questions about their knowledge and experience with barrens. Results showed dominant preferences for scenarios indicating a Northwoods “scenic aesthetic,” with smaller openings, higher tree density, and lower fire intervals and understory shrub density. Latent class and a priori segmentations revealed smaller subgroups of landowners had higher preferences for more open treatment designs tending toward an “ecological aesthetic,” and while previous experiences at pine barrens helped to distinguish subgroups, prior knowledge and information did not. Implications are discussed for restoring pine barrens in a social context.

1. Introduction

Although perceived naturalness is a key predictor of people's landscape preferences, not all natural landscapes are equally preferred. This is especially so for open, flat ecological communities whose natural characteristics elude conventional ideals of landscape beauty. In studying this disjuncture between natural and aesthetic quality,

environmental philosophers have called wetlands a “difficult beauty” to appreciate (Carlson, 1999) and prairies “a failed resource” (Evernden, 1983) in the eyes of the public. Saito (1998) collectively termed such landscapes “scenically challenged,” and while pine barrens have been little-studied within the humanities or social sciences (Gobster et al., 2021), they would likely also fall into this category.

Pine barrens are open, fire-dependent savanna communities with

* Corresponding author at: Northern Research Station, USDA Forest Service, 1033 University Pl. Ste. 360, Evanston, IL 60201, USA.

E-mail address: paul.gobster@usda.gov (P.H. Gobster).

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sparse, pine-dominant canopies growing scattered or in clumps over an understory of shrubs, grasses, and forbs. Northern Wisconsin, where this study is focused, was the historical center of jack (*Pinus banksiana*) and red pine (*P. resinosa*) barrens once prevalent across large areas of relatively flat, sandy glacial outwash in the Upper Great Lakes Region of the U.S. and Canada. Because of fire suppression and afforestation activities, most pine barrens have disappeared from the landscape and been replaced by a continuous canopy forest idealized by local residents and visitors as the natural scenery of the “Northwoods” (Shapiro, 2013). While these stakeholders generally support forest restoration goals (Floress et al., 2018), a project to restore and expand pine barrens raised concerns of nearby landowners of small family forests (SFI, 2014) due to proposed changes in the landscape’s appearance and management practices used. This prompted land managers to seek input from our research team on how to accomplish ecological goals within a broader social context.

In this paper we describe the results of an image-based discrete choice experiment (DCE), where we asked landowners near our Lakewood Southeast Project study area about their preferences for visualizations depicting different pine barrens restoration treatments. We were particularly interested in how treatment designs could maximize landscape preferences while accomplishing ecological goals, and whether knowledge of pine barrens ecology would increase preferences for more open, fire-dependent landscape characteristics.

2. Background and hypotheses for research

2.1. Key visual characteristics of pine barrens

While landscape preference research on pine barrens is sparse, past ecological and social studies provide some insight into their relevant visual characteristics. Historical ecology techniques (Eagan & Howell, 2005) have helped identify key pine barrens characteristics of the Upper Great Lakes Region (Lampereur, 2013; Radeloff et al., 2000), showing they are highly variable but tend to be open, prevalent on dry sandy soils, and subject to frequent fires. These characteristics drive other structural and compositional elements including pine or pine-oak canopy trees; a heath-like groundcover of shrubs, forbs, and grasses; and abundant wildlife.

Two earlier social investigations by our team help further specify the selection of attributes and levels for the DCE. In focus groups with landowners near the Lakewood Southeast Project (Floress et al., 2018), a small-scale landscape preference task showed that ratings of forest scenes declined as tree cover decreased and the landscape appeared more open and barrens-like. In an expert-based Delphi study (Gobster et al., 2021), a regional panel of land managers and researchers characterized pine barrens as ecosystems dependent on periodic fires that maintain the openness of the landscape by burning off intolerant woody plants while fostering the growth and reproduction of fire-adapted trees and shrubs. These fires produce a horizontal landscape structure of variable spatial configuration including large openings with no canopy trees and areas with low-to-moderate density trees growing scattered or in clumps. Variable fire intervals produce a heterogeneous vertical structure of canopy trees, an understory with varying densities of shrub cover, and standing dead trees.

2.2. Landscape type preferences

Explanations for public distaste of open, “scenically challenged” landscapes can be found across major landscape preference theories. Evolutionary theories assert that humans are biologically predisposed toward preferring landscapes that afford basic needs for survival, with studies of biome preferences generally showing that semi-open forest landscapes characteristic of human origin on the African savanna are preferred over wide-open landscapes such as grasslands, deserts, and heathlands or densely forested landscapes (Falk & Balling, 2010). These

findings comport with Kaplan and Kaplan’s (1989) information-processing theory that humans prefer landscapes with optimal levels of mystery and complexity that invite exploration yet have sufficient coherence and legibility to avoid getting lost (Kaplan & Kaplan, 1989). Across a number of studies, Kaplan (1985) found forests with mature trees of moderate density and open understories that were more spatially defined with good visual access were preferred over farmland, bogs, and sparsely-stocked forests with low spatial definition. Formalist theories have also been applied to landscape and suggest landscapes with high variety in lines, forms, colors, and textures such as mountain-forest-lake complexes are preferred over flat, homogeneous forests and grasslands lacking such distinctions (Bell, 2001).

Preference studies of specific open natural landscapes are difficult to generalize, but findings generally show that landscape heterogeneity can increase preferences. In grasslands, trees growing in large clumps (Williams & Cary, 2001), scattered or isolated (Sherren et al., 2011), or in planted shelter belts (Cook & Cable, 1995) were preferred over treeless expanses. However, treeless grasslands of native grasses and forbs with visually conspicuous colors (Lindemann-Matthies et al., 2010) and textures (Becerra et al., 2017) indicating higher species diversity were preferred over homogeneous managed pasture or crop cover (Williams & Cary, 2001). In wetlands and bogs, diverse scenes with lush groundcover, areas of open water, and spatially-defining trees were preferred over homogeneous scenes showing dry, brown, sparse groundcover and open, treeless expanses (Dobbie & Green, 2013; Hammitt, 1980).

2.3. Forest treatment preferences and preference differences

Because of past fire suppression and afforestation activities, pine barrens restorations often require extensive tree removal and other treatments to re-establish historic conditions. The forest treatment preferences literature thus has great relevance to our work. Ribe, 1990 and Ribe (1991) studies of treatment preferences for Wisconsin Northwoods’ forests show that a high proportion of big trees, moderate density of smaller pole-sized trees and saplings, low groundcover, presence of a few distinctive trees, and low amounts of dead trees, slash, and bare ground best predicted preferences. Others have found that creating small openings can increase preferences by adding visual diversity to mature, closed canopy conditions (Brush, 1979), thinning (tree density reduction) is preferred to clearcutting (removing all trees) (Shelby et al., 2005), and light thinning is preferred over heavy thinning (Vodak et al., 1985). Large clearcuts are strongly disliked, though their visual impact lessens if edges appear natural and tree clumps and single large trees are left to break up expanses (Palmer et al., 1993). Slash left from tree removals is strongly disliked but can be mitigated by lopping, chipping, removal, or burning, although burning can also reduce preferences (Anderson et al., 1982; Ryan, 2005). Finally, studies typically find higher preferences for stands with a rich understory of forbs or grasses, and while some shrub cover can be preferred, substantial cover reducing visual access is usually disliked (Edwards et al., 2012; Nielsen et al., 2018).

Preference differences have been studied through comparisons between a priori classifications like stakeholder groups and by empirically-defined, latent class groupings. One a priori classification salient to our investigation is landownership, and whether landscape preferences of landowners differ from the general public, other stakeholder groups, or landowner subgroups. Here, studies of small family-forest landowners show that they hold preferences similar to those of the general public (e.g., Brush, 1979; Vodak et al., 1985), and prefer managing forests for aesthetics over economics (e.g., Erickson et al., 2002). Becerra et al. (2013) found that while overall ranking of grassland treatment preferences were consistent among landowners, natural resource professionals, and the general public, in some cases the magnitude of ratings differed. Sorice et al. (2012) found that management preferences and motivations may differ between “lifestyle-oriented” owners and those

Table 1
Hypotheses and analyses for research.

Hypotheses	Analyses
H1 Overall preferences for restoration design treatments: Restoration design attributes relating to the spatial configuration of openings and density and distribution of trees would most strongly predict preferences for pine barrens scenes.	Compare relative weights of attributes
H1.1 Spatial configuration attributes: Landowners overall would prefer designs with smaller openings bounded by dense foreground trees characteristic of a Northwoods scenic aesthetic over designs with larger openings and sparse background trees characteristic of a pine barrens ecological aesthetic.	Compare weights of individual attribute levels
H1.2 Fire attributes: Landowners overall would prefer designs with moderate burning intervals without signs of burned groundcover or standing dead trees characteristic of a Northwoods scenic aesthetic over designs with burned groundcover and standing dead trees indicating frequent burning characteristic of a pine barrens ecological aesthetic or designs with dense shrub cover indicating infrequent burning.	Compare weights of individual attribute levels
H2 Preference differences: Differences in preferences among landowners would conform to the characteristics of scenic and ecological aesthetics-	See sub-hypotheses below
H2.1 Knowledge and preference differences: Landowners who were given information about the ecological characteristics and importance of pine barrens and/or had prior knowledge or experience of pine barrens and their management would have higher preferences for scenes showing more open, frequently burned landscapes characteristic of a pine barrens ecological aesthetic, while landowners who were not given information or had no prior familiarity would have higher preferences for more closed forest scenes characteristic of a Northwoods scenic aesthetic	a priori segmentation based on information intervention, prior knowledge, and/or prior experience
H2.2 Preference heterogeneity: If other (latent) preference heterogeneity is present, it would distinguish landowners with different scenic (majority) and ecological (minority) perspectives on aesthetics	Latent class analysis, exploratory covariate analysis

who are production oriented or have multiple management objectives.

Latent class analyses have also helped to identify landscape preference segments. Dhakal et al. (2012) found the majority of visitors preferred forests with a diversity of tree ages and lower tree density, while others preferred to keep forests in their current, homogeneous state. De Valck et al. (2014) found support among residents for limited removal of non-native coniferous forest plantations to restore broadleaf forest and small openings of heathland but about a third of respondents highly supported large-scale forest and heathland conversion. Finally, Nordén et al. (2017) found a majority of forest stakeholders preferred management scenarios affording a more varied stand age, structural composition, and diversity of tree and bird species, but about a third preferred even-age monocultural stands reflecting a timber production focus.

2.4. Restoration treatment design, knowledge, and the ecological aesthetic

Another research stream on forest treatment preferences examines efforts to restore ecosystem structure and biodiversity (Gobster, 1999). While findings often show a convergence between what is perceived as natural and what is preferred aesthetically, some restoration treatments do not conform to people's ideals of landscape beauty. For example, leaving dead downed wood and standing dead trees can increase species diversity but often reduces preferences (Arnberger et al., 2018; Gundersen et al., 2017; Gundersen & Frivold, 2011). Likewise, prescribed burning is needed to maintain the health of fire-dependent ecological communities, but visibly charred vegetation can reduce preferences (Ryan, 2005).

In explaining these divergent cases between what is natural and what is preferred, Gobster (1999; see also Gobster et al., 2007) distinguishes between a scenic and an ecological aesthetic and argues the latter can more usefully guide forest ecosystem management. Knowledge is a key element in adopting an ecological aesthetic, where information and experience with otherwise unfamiliar, scenically challenged landscapes builds aesthetic appreciation. Empirical studies show that information and prior experience can increase ecological landscape preferences (e.g., Gundersen & Frivold, 2011; Van der Wal et al., 2014), though contrary findings also exist (Hill & Daniel, 2008). Other research by Nassauer (1995; Li & Nassauer (2020)) shows that an ecological aesthetic might be communicated visually to people through design, where treatments such as configuring the size and shape of openings, leaving distinctive large trees, and planting or managing for colorful wildflowers and edible berries provide "cues to care" to aid public understanding and appreciation of otherwise unfamiliar treatment practices.

2.5. Hypotheses for research

The literature reviewed above guided the choice of attributes and levels for our DCE. To further structure our work, we posed two main hypotheses and four sub-hypotheses regarding preferences for the design of restoration treatments and preference differences (Table 1).

Because openness is a key characteristic of pine barrens and a major predictor of landscape type and forest treatment preferences, we expected that restoration design attributes relating to the spatial configuration of openings and density and distribution of trees would most strongly predict preferences for pine barrens scenes. Specifically, we hypothesized that landowners overall would prefer designs with smaller openings bounded by dense foreground trees characteristic of a Northwoods scenic aesthetic over designs with larger openings and sparse background trees characteristic of a pine barrens ecological aesthetic (H1.1). Fire is another key characteristic of pine barrens but its effects are less visually dominant compared to openness. Given research findings that recent signs of fire and dense shrub cover are often perceived negatively, we expected that restoration design attributes relating to fire frequency would be significantly but less strongly related to preferences for pine barrens scenes. Specifically, we hypothesized that landowners would prefer designs with moderate burning intervals without signs of burned groundcover or standing dead trees characteristic of a Northwoods scenic aesthetic over designs with burned groundcover and standing dead trees indicating frequent burning characteristic of a pine barrens ecological aesthetic or designs with dense shrub cover indicating infrequent burning (H1.2).

While we expected these openness and fire-related design attributes and levels would best predict overall preferences for pine barrens, the literature also indicates that there can be preference differences. We explored potential variations using a priori and latent class analyses with the expectation that any differences in preferences among landowners would conform to the characteristics of scenic and ecological aesthetics. For the a priori analysis, we hypothesized that landowners who were given information about the ecological characteristics and importance of pine barrens and/or had prior knowledge or experience of pine barrens



Fig. 1. The Lakewood Southeast Project (hatched boundary) is a 15,000 ha area of pine barrens and dry forest ecological communities located within the Chequamegon-Nicolet National Forest in Northeastern Wisconsin. The project area falls within the Northeast Sands ecoregion, which along with the Northwest Sands (far left) are sandy areas of glacial outwash that contain the greatest concentration of remnant pine barrens in the state. They straddle the North Central Forest and Northern Highland ecoregions, an area of many lakes and dense forest cover popularly known as Wisconsin's Northwoods (Base map credit: Wisconsin Department of Natural Resources).

and their management would have higher preferences for scenes showing more open, frequently burned landscapes indicating an ecological aesthetic. Conversely, landowners who were not given information or had no prior familiarity would have higher preferences for more closed forest scenes indicating a scenic aesthetic (H2.1). For the latent class analysis, because openness and fire-dependency are key attributes of pine barrens we suspected that if there was preference heterogeneity, it would distinguish landowners with different scenic (majority) and ecological (minority) perspectives on aesthetics (H2.2). Beyond this general hypothesis, we explored whether other measures from our survey would covary with the latent classes.

3. Methods

3.1. Project and study area description

The Lakewood Southeast Project is a landscape-scale effort to restore pine barrens and associated dry forest communities on a 15,000 ha area of the Chequamegon-Nicolet National Forest in Northeastern Wisconsin (Lampereur, 2013; Fig. 1). The project lies within the Northeast Sands ecoregion, one of two lobes of sandy glacial outwash that intercede a broader region of dense forest cover popularly called Wisconsin's Northwoods. It is this broader region that is most familiar to residents and visitors, because after the forests were logged during the Cutover period of 1880–1920, most of the original 2.3 million ha of pine barrens were reforested with jack and red pine plantations (Epstein, 2017; Chap.



Fig. 2. Left: Base photo of a wide-open barrens used in construction of the visual choice scenarios, taken at Spread Eagle Barrens State Natural Area in June 2016. The burn unit pictured here has been actively managed by the Wisconsin Department of Natural Resources since 1979 and had last been burned in 2011. Right: The 72 ha viewshed of the photo was mapped onto a 2014 leaf-off Google Earth aerial image and divided into four equal-area distance zones. This procedure helped guide placement and scaling of digital tree imagery and other landscape features according to the fractional factorial design for the DCE.

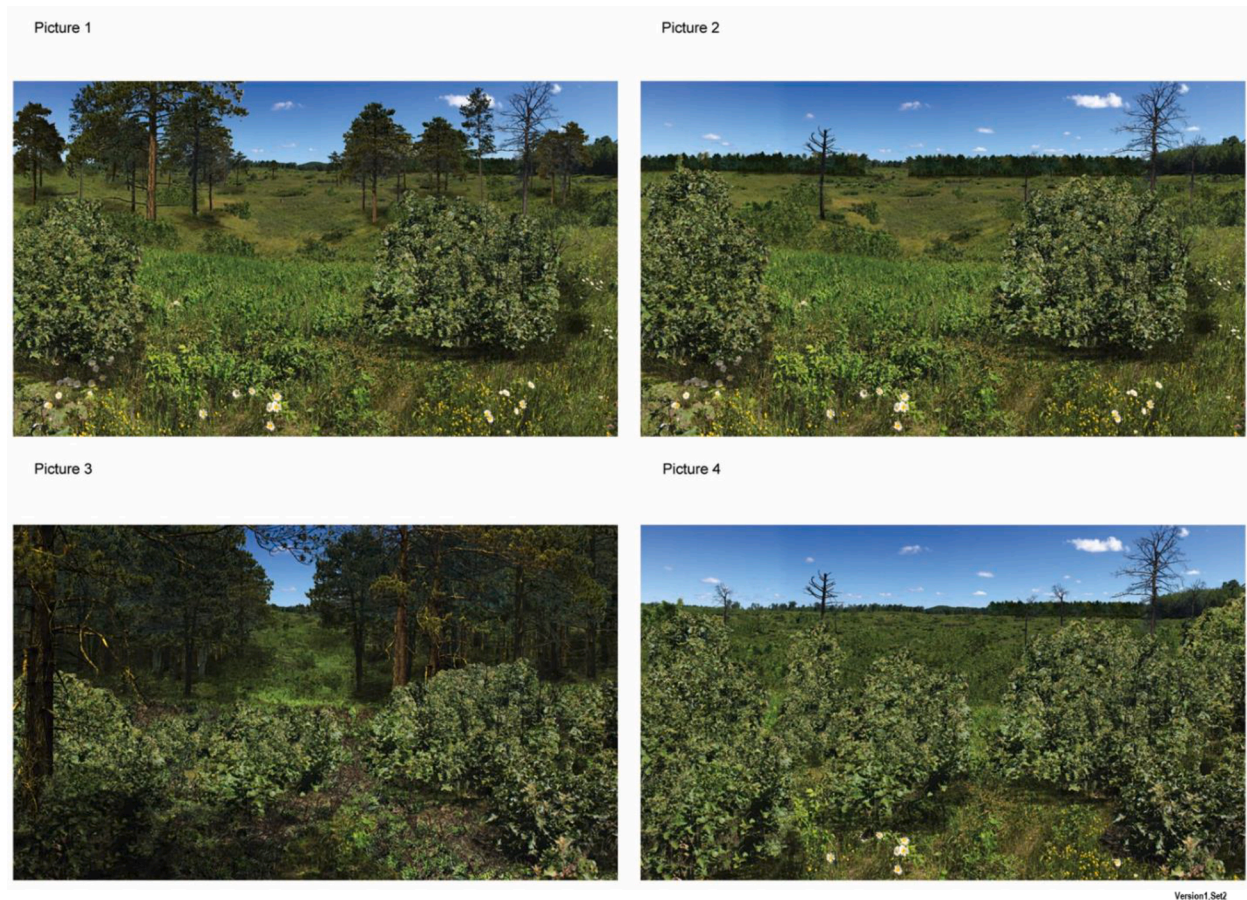


Fig. 3. Example choice set used in the discrete choice experiment (DCE). Each respondent viewed four choice sets and was asked to choose their most preferred photo from each set. 32 choice sets of 128 different visual choice scenarios were needed to complete the design for the DCE.

7). Subsequent decades of fire suppression have made these areas a high wildfire risk, particularly those near retirement and second homes in the expanding wildland-urban interface. While the project was conceived to address these ecological and social issues, aesthetic concerns raised by nearby landowners about tree removals and prescribed burning have added to the complexity of management, spurring this investigation.

3.2. Research design

To address our hypotheses (Table 1), we designed a discrete choice experiment. DCEs provide a powerful means to understand how people weigh and trade off multiple preference attributes relevant to an object such as a landscape (Johnston et al., 2017; Louviere et al., 2000). In constructing a DCE, different levels of an attribute represent the range of potential alternatives (e.g., high, medium, and low tree density). The DCE design systematically pairs different combinations of attribute levels together in choice scenarios. By asking participants to choose their preferred scenario in a series of choice sets, the relative weights of each attribute and attribute level affecting their preferences can be identified. Choice scenarios are typically presented using verbally-specified attributes and levels, though visual choice scenarios using digitally-calibrated photographs are increasingly used in landscape preference studies (Ebenberger & Arnberger, 2019; Shr et al., 2019).

Guided by the literature and our Delphi study, we defined levels of six key visual attributes of pine barrens: spatial configuration, tree density, tree distribution, fire interval, shrub density, and standing dead trees. These attributes were combined and presented as visual choice scenarios in an online survey sent to forest landowners near the Lakewood Southeast Project. To evaluate preference differences, we included an information intervention for half of the respondent sample and other

questions dealing with past knowledge and experience, along with other items that could help explain landowner subgroups identified by the latent class analysis.

3.3. Scenario construction

We constructed each visual choice scenario from a base image of a wide-open pine barrens photographed at Spread Eagle Barrens, a State Natural Area with a long history of restorative management located in the same ecoregion as our study area (WDNR, 1995; Fig. 2 (left)). Specific attribute levels and combinations were then layered on the base image in Adobe Photoshop using imagery of vegetation elements also captured at Spread Eagle Barrens. Given that our primary concern was for how the visual landscape conveys information to stakeholders about ecological design alternatives (Patterson et al., 2017), the scenarios were constructed with the intent to accurately portray the salient visual attributes related to preference and presented without any accompanying verbal information.

The spatial configuration attribute characterized the overall openness of a scene, providing the horizontal landscape structure within which tree density and distribution attributes further defined the scene's openness character. We first mapped the base photo onto a 2014 leaf-off Google Earth aerial image and divided the resulting 72 ha viewshed into four equal-area distance zones originating from the observer viewpoint (Fig. 2 (right)). From this we defined six attribute levels of spatial configuration, with three levels of increasing openness showing trees concentrated in the foreground (zones 1–2), midground (zones 2–3), and background (zones 3–4). Three other levels explored additional treatment design options, one level evenly distributing trees across all zones and the other two placing 1% of all trees close to the observer viewpoint

in zone 1 and the rest of the trees distributed within zones 2–3 or zones 3–4, respectively.

Tree density and distribution attributes further defined scene openness. We included four levels of overstory tree density from 5 to 35% of land cover, reflecting the range characterized by the Delphi panel (Gobster et al., 2021). We calculated the total number of trees potentially covering the area then distributed trees according to the respective density attribute level and spatial configuration attribute. For a 5% cover with about 50 m² per tree, about 700 trees were necessary. Higher tree densities reduced the sense of openness, especially when they appeared in foreground and midground spatial configurations. In these cases, trees were placed so a small view corridor was always present in the image, allowing a view to the background zone for respondents to get a sense of the scale of the entire landscape. Nevertheless, many trees behind a closed tree line were not visible. For tree distribution, three levels showed trees either scattered in the landscape, grouped as clumps, or appearing as a 1:1 mix of both tree distributions.

The remaining three attributes related directly or indirectly to fire as a restoration treatment. Based on Delphi panel findings, we simulated three different levels of prescribed fire intervals: 3, 10, and 30 years. A 3-year interval was seen as optimal for maintaining the health and diversity of the pine barrens landscape and for reducing wildfire risk, while a 30-year interval compromised ecological function and increased wildfire risk. Each interval simulated conditions just before the next fire through changes in understory vegetation and tree habits, with higher fire frequencies showing lower understory vegetation and greater thermal pruning of trees. The 3-year interval showed dark open patches of ground and a darker bark of trees to simulate fire charring.

The shrub density attribute showed four levels of density ranging from 0 to 60% of land cover. This attribute presented a major forest management concern because of the fast basal resprouting of oak (*Quercus* spp.) and aspen (*Populus tremuloides*) trees and other shrubs in the absence of frequent fire or other means of control (e.g., herbicide). Shrub density also defined varying degrees of visual penetration. While all other attributes were independent from each other, the height of shrubs, not their amount, depended on fire interval.

The final attribute, standing dead trees, was included to help assess preferences for features of particular importance to wildlife. The number of standing dead trees ranged from 0 to 8 and were always shown in zone 1. One attribute level showed four dead trees with flowering blueberry (*Vaccinium angustifolium* and *Vaccinium myrtilloides*) bushes in the immediate foreground. Blueberries are a desirable food source for wildlife (and people), who seek out patches that are most bountiful after an area is burned.

3.4. Survey design and hypothesis testing

Our DCE presented the scenarios to respondents in an online questionnaire, where the exact combination of attribute levels for each scenario was defined by an underlying asymmetric orthogonal fractional factorial design (Johnston et al., 2017; Louviere et al., 2000) following the Addelman-type asymmetric main effects plan (Addelman, 1962). Fractional factorial designs involve selection of a particular subset of complete factorials, so that specific effects of interest can be estimated as efficiently as possible without losing substantial information. In this design, 128 scenarios were needed to assess a main effects model for both hypotheses, with six attributes and their levels. As we used an orthogonal design, multicollinearity between the attributes is not an issue; the design assigned each attribute level the same weight. To minimize respondent burden, the scenarios were divided into 8 survey versions of 16 scenarios. Thus, each respondent evaluated 1 version showing 16 scenarios, grouped into 4 choice sets with 4 scenarios per set. Each choice set displayed 2 × 2 scenarios on a single page display. For each of the four choice sets, respondents chose their most preferred alternative out of the four scenarios presented (Fig. 3).

The survey was also designed to test hypothesis 2.1 about how the

effects of knowledge might explain subgroup preferences for pine barrens. For half of the respondent sample, the choice task was preceded by a one-paragraph information statement describing pine barrens and efforts to restore them in Wisconsin, while the other half (control) received a brief general statement about forest management (see Appendix). Each statement was accompanied by a photo taken from a pre-treatment restoration site in our study area and described to respondents as the typical look of the current landscape. In addition, all respondents were asked questions after the DCE about their knowledge of pine barrens (4 levels), prior experience visiting pine barrens (yes, no, don't know), and names of specific sites they may have visited (5 sites in Wisconsin + "other"). Other questionnaire items included length (years), size (hectares), and reasons for property ownership (8 items); family or self-employment in the forest industry (yes/no); perceived acceptability of forest restoration practices (11 items) and perceived importance of public forest management goals (11 items); recreation activity (20 items) and group affiliation (open-ended); and demographics (4 items). To improve questionnaire clarity and efficiency, the survey design and visualizations were reviewed by two pine barrens experts and a draft questionnaire with choice scenarios was pretested by nine individuals.

3.5. Population sampling

Family-forest owners of property of 0.1 ha or larger within a 16 km radius of the Lakewood Southeast Project in rural Oconto and Marinette Counties were sampled. In Wisconsin more than 350,000 family-forest owners hold 57% of the 6.9 million ha of the state's forestland and ownership within our study area is quite common (SFI, 2014). From a potential population of 10,560, landowner names were separated by county. For each county, we randomly selected an initial sample of 1250 and attained a final total of 2417 usable addresses. Individuals were mailed a letter soliciting their participation in a survey about managing public forest lands in Northeastern Wisconsin. Respondents were directed to the online survey prepared in Qualtrics using a unique identification number and could request a hard copy format if desired. A follow-up postcard was mailed after 10 days, followed by another letter request two weeks later.

3.6. Data analysis

Random utility theory (McFadden, 1973) postulates that respondents' choices can be modelled as a function of the attributes of the alternatives of a DCE. The alternatives, as portrayed in the visual choice scenarios, were defined as particular combinations of attributes and levels. The choice of one alternative implies that its utility is greater than the others in the choice set (Louviere et al., 2000). As this DCE was designed as a multivariate study with six variables, the conditional logit model estimates were all relative to each other. As a 'no-choice' alternative was not presented, no intercept exists. The maximum likelihood estimation produces part-worth utilities, z-values, and standard errors for each attribute level. All attribute levels were effects-coded, where an N-categorical variable needs to be defined by N-1 estimates only. For hypothesis 1, the relative importance of each preference attribute 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 & Magidson, 2005).

For hypothesis 2.1, a priori segmentations analyzed if landowner preferences differed as a function of the information intervention, their knowledge, or prior experience with pine barrens. For hypothesis 2.2, latent-class choice modelling was used to identify potential subgroups of landowners with heterogeneous preferences for pine barrens treatment designs. Three goodness-of-fit indices helped to identify the appropriate number of segments: minimum Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), and Akaike Information Criterion 3 (AIC3) (Kemperman & Timmermans, 2006). The lower of any of these

Table 2

Parameter estimates and standard errors for attribute levels of the overall DCE and latent class analysis (N = 542).

Segment number and segment size	All		Segment 1		Segment 2		Segment differences Wald test
Attributes and attribute levels	Parameter estimates	s.e.	Parameter estimates	s.e.	Parameter estimates	s.e.	
a) Spatial configuration	75%		76%		44%		***177.9
1) Trees in foreground (Zones 1 & 2)	***1.929	0.076	***4.039	0.444	***0.764	0.154	
2) Trees spread across Zones 1–4	***1.683	0.073	***3.752	0.430	0.184	0.184	
3) Trees in midground (Zones 2 & 3)	***−1.775	0.153	***−3.501	0.727	***−1.026	0.191	
4) Trees in background (Zones 3 & 4)	***−2.502	0.172	***−5.487	1.181	***−1.077	0.244	
5) Trees in midground (Zones 2 & 3) and 1% forest cover foreground	***0.284	0.072	0.061	0.288	***0.626	0.121	
6) Trees in background (Zones 3 & 4) and 1% forest cover foreground	***0.382	0.081	**1.136	0.345	***0.529	0.118	
b) Tree density	8%		11%		5%		***36.9
1) 5% tree cover	***−0.315	0.058	***−0.795	0.119	0.114	0.102	
2) 15% tree cover	0.064	0.057	−0.039	0.101	−0.018	0.103	
3) 25% tree cover	(*)0.107	0.061	(*)0.231	0.128	0.013	0.112	
4) 35% tree cover	*0.144	0.058	***0.604	0.150	−0.109	0.107	
c) Tree distribution	3%		5%		5%		*8.8
1) Scattered trees	0.015	0.063	*0.274	0.123	−0.127	0.105	
2) Clumps of trees	(*)−0.100	0.056	**−0.332	0.121	0.080	0.107	
3) Mix of scattered trees and clumps	0.085	0.058	0.058	0.111	0.047	0.105	
d) Fire interval	6%		4%		17%		*10.1
1) 3-yr. interval	***−0.252	0.054	−0.110	0.099	***−0.513	0.113	
2) 10-yr. interval	*0.124	0.052	−0.138	0.098	**0.320	0.105	
3) 30-yr. interval	**0.128	0.049	**0.248	0.092	(*)0.194	0.102	
e) Shrub density	5%		3%		22%		***32.3
1) 0% cover	0.062	0.051	*−0.212	0.100	***0.391	0.107	
2) 5% cover	**0.138	0.052	−0.064	0.093	**0.324	0.098	
3) 30% cover	−0.062	0.062	0.171	0.119	(*)−0.194	0.112	
4) 60% cover	**−0.137	0.055	0.105	0.105	***−0.522	0.121	
f) Standing dead trees	4%		2%		7%		4.7
1) 0 dead tree	0.034	0.047	−0.039	0.084	(*)0.184	0.096	
2) 4 dead trees	**−0.151	0.056	−0.048	0.126	−0.123	0.122	
3) 4 dead trees & blueberries	0.036	0.062	−0.077	0.122	0.063	0.114	
4) 8 dead trees	0.081	0.055	(*)0.164	0.098	−0.123	0.105	
Pseudo-R ² : 0.28/LC: 0.41							
Observations: 2162							
Log-likelihood: −2125.1/LC −1987.5 BIC: 4233.0							

Significant influence of the attribute levels on respondents' choices: (*) $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

Relative importance (%) of individual attributes.

values, the better the model and its segment-solution. As disputes exist about the reliability of these indicators, the appropriate number of segments should be chosen based on multiple criteria (Scarpa & Thiene, 2005). Prior knowledge about and visitation to pine barrens were included as covariates to help explain possible segment differences in pine barrens site choice. Additional covariates were tested in the model for improved description as well as prediction of the segments. Covariates were either nominal or continuous variables; nominal variables were effects-coded. The Wald test was used to test the significance of the sets of parameters and whether coefficients were equal among classes (Vermunt & Magidson, 2005). We assumed that the scale factor is 1 and the same over the segments but we did not analyze scale heterogeneity. DCE modeling and segmentation analyses were performed with Latent Gold Choice 5.1. Descriptive analyses were performed with IBM SPSS Version 26.

4. Results

4.1. Profile of respondents

566 respondents completed 60% or more of the questionnaire (23.4% usable return rate) and 542 completed the DCE. An average of 67 respondents (range 62–71) rated each scenario across the 8 survey versions. Respondents included 26% year-round residents, 38% seasonal

residents, and 33% non-residents (e.g., camping, day visits) who owned property ranging from 0.1 to 200 ha (median = 1.2 ha, SD = 19.34). Respondents owned their property an average of 20 years (SD = 14.55) and about half of them spent seven or more weeks there per year. Their most important reasons for owning property included rural solitude, natural beauty, and recreation (all greater than 90% agree/strongly agree) while income generation was least important (7%). Nineteen percent had some knowledge about pine barrens and another 2% knew a lot about them, while 25% had only heard about barrens and 54% had never heard of them. As for experience, 20% had visited a pine barrens before, and those who had most often named other public restoration sites located within the Northeast Sands ecoregion. Socio-demographics showed respondents averaged 62 years in age (SD = 11.8), 77% were male, 93% were white, 40% had a college degree or higher, and only 2.5% worked or had a family member who worked in the forest industry.

4.2. Overall preferences

Findings, averaged over the entire respondent sample, generally supported hypothesis 1 that attributes relating to the openness character of pine barrens would more strongly predict preferences for restoration treatment designs than fire-related characteristics (Table 2, Fig. 4). Spatial configuration was by far the most important predictor, accounting for 74.8% of total importance of all six attributes ($p < .001$),

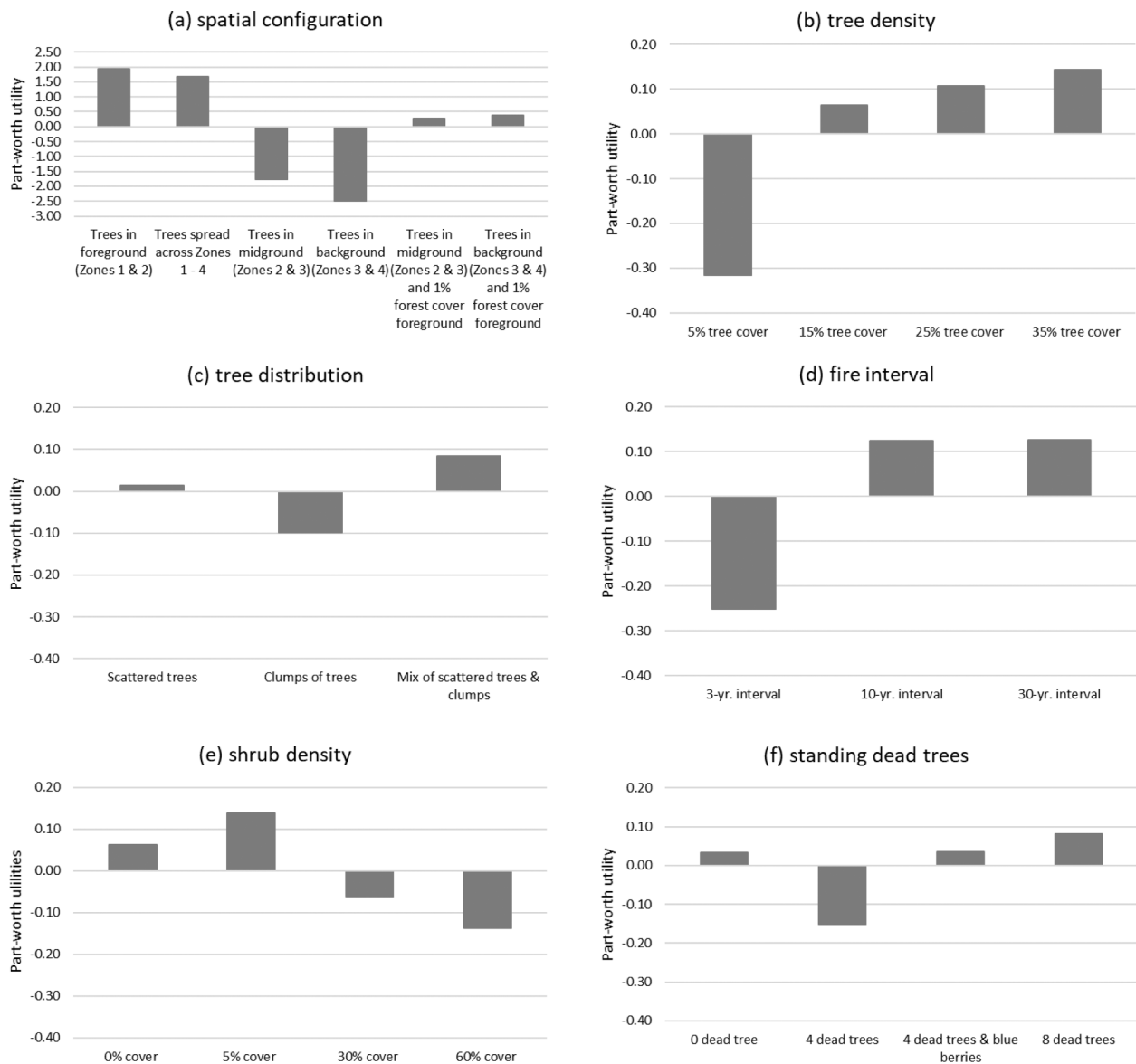


Fig. 4. a–f. Attribute levels for the overall respondent sample (N = 542). Please note that the vertical scales differ.

while tree density accounted for the next most at 7.8% ($p < .001$). The other openness characteristic, tree distribution, accounted for 2.5% but was not statistically significant in the model. Of the fire-dependent attributes, fire interval was the most important attribute, accounting for 6.4% of total importance ($p < .001$), followed by shrub density (4.6%, $p < .01$) and standing dead trees (3.9%, $p < .05$).

Specific attribute level findings further clarified and strengthened support for hypothesis 1 and its two sub-hypotheses, with respondents preferring less-open spatial configurations showing higher densities of trees in the foreground or distributed throughout the distance zones (H1.1; Fig. 4a–b). Likewise, respondents preferred moderate and low fire intervals, and while a small amount of shrub cover was seen as desirable, higher densities reduced preferences (H1.2; Fig. 4d–e). No clear directional preference was seen for the presence of standing dead trees (Fig. 4f), with small but positive values indicated for no trees, eight dead trees, and four dead trees with blueberry bushes in the foreground.

Fig. 5 provides examples of scenarios highest, lowest, and somewhat highly preferred by the entire sample of respondents. The two high-preference images (top) show attribute level combinations resembling typical closed-forest Northwoods scenery, while the two low-preference images (middle) resemble wide-open pine barrens restoration sites.

There were some cases, however, where the attribute level combinations resulted in scenarios that were somewhat highly preferred (bottom two images) yet resulted in semi-open conditions that would still be equated with a restored pine barrens.

4.3. Preference differences

A priori segmentations using the information intervention and knowledge and experience measures somewhat weakly supported hypothesis 2.1. For the information intervention, one attribute differed—spatial configuration ($p < .01$, data not shown)—but this difference was only because of the magnitude of parameter values. Otherwise, differences were found for three attributes for the experience measure (Table 3). Respondents who had previously visited a pine barrens preferred a moderate tree density (marginally significant, $p < .10$), a 10-year fire interval, and a 5% shrub cover, while those with no previous experience expressed a preference for a high tree density, a 30-year fire interval, and no shrub cover. While a priori segmentation analyses using the knowledge and information intervention measures showed no differences between groups (data not shown), knowledge was a significant covariate of experience (Table 3, bottom), indicating that landowners

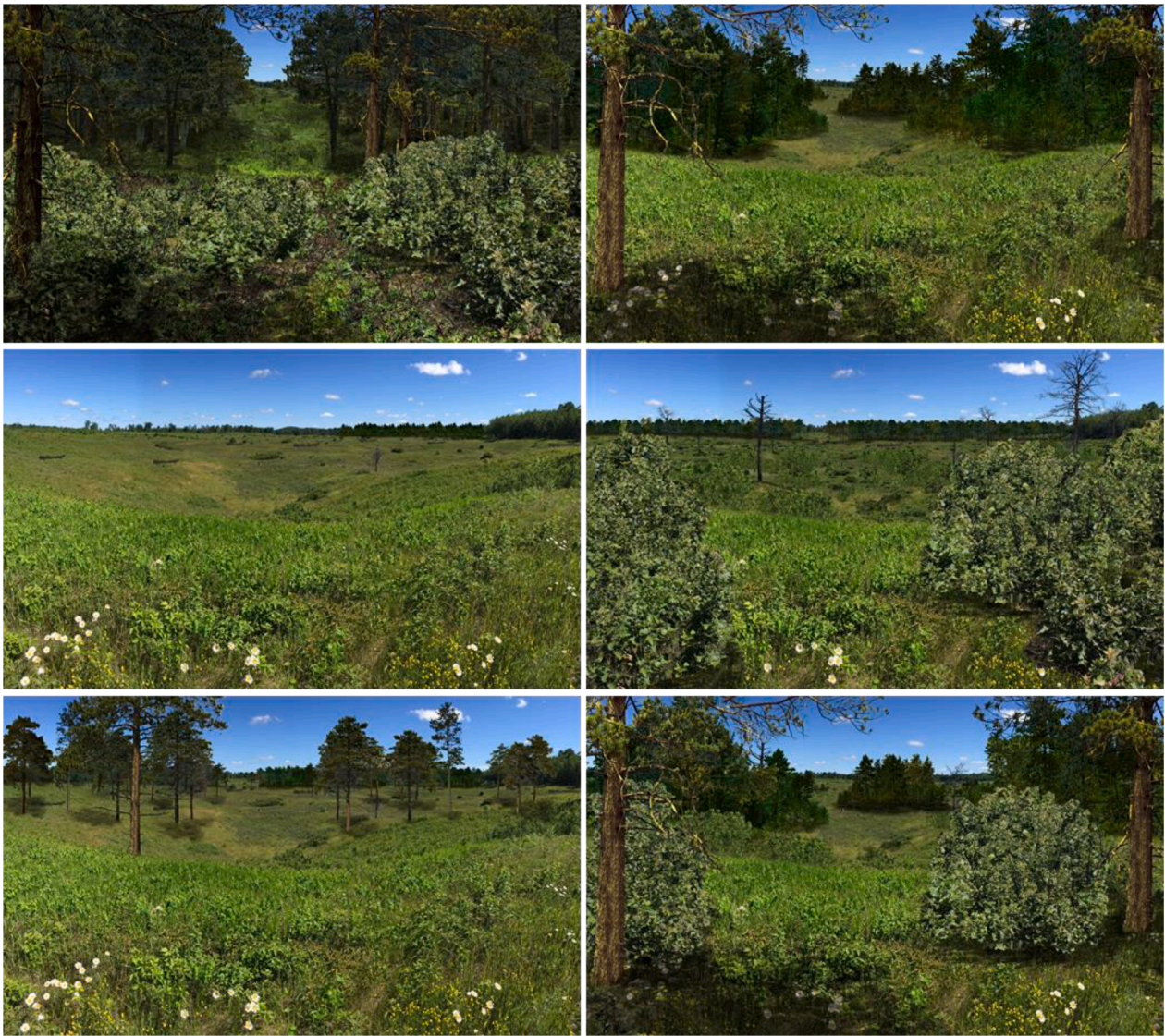


Fig. 5. Examples of attribute combinations that were most, least, and somewhat highly preferred by the entire sample of respondents. Top row images were among the most preferred and featured attribute level combinations resulting in conditions reminiscent of typical Northwoods scenery. Middle row images were among the least preferred and depict characteristics resembling a wide-open pine barrens restoration. Bottom row images scenarios were somewhat highly preferred and depict semi-open conditions that would still be equated with a restored pine barrens.

who did not know what pine barrens are were unlikely to report that they had visited one.

For the latent class analysis, the BIC-value indicated heterogeneity and had its optimum solution with two segments while the optima of the AIC and AIC3 criteria resulted in unstable segmentation models. Using the BIC-value solution, the pseudo- R^2 statistic increased from 0.28 for the 1-segment solution to 0.41 for the 2-segment solution, indicating good model fit (Louviere et al., 2000). All attributes except standing dead trees varied by segment, with the division between segments showing partial support for hypothesis 2.2 that a majority of respondents would favor attribute levels relating to a closed-forest scenic aesthetic while a minority would prefer more open scenes tending toward an ecological aesthetic (Table 3, Fig. 6). Segment 1 (“Northwoods scenic aesthetic”) included 68% of respondents and indicated preferences for spatial configurations with trees in the foreground or spread across the zones, a high tree density, scattered tree distribution, 30-year fire interval, higher shrub density, and (at a $p < .10$ level) 8 standing dead trees. In contrast, Segment 2 (“Pine barrens ecological aesthetic”) included 32% of respondents and indicated preferences for spatial configurations with trees in the foreground or the two relatively open

attribute levels with trees in the mid- or background zones and a 1% foreground forest cover, a 10-year fire interval, a low shrub density, and (at a $p < .10$ level) 0 standing dead trees. Tree density and distribution were not significant for Segment 2. The relative importance analysis showed spatial configuration and tree density attributes played a more important role for Segment 1, while fire interval and shrub density were more important for Segment 2. Covariates included for prior knowledge and experience did not differ between the two latent class segments (data not shown). Socio-demographic or acceptability measures, forest industry employment, reasons for owning property, recreation activity, and social group affiliation measures had too little variation or too many missing values to include as covariates. The only significant covariate was length of ownership ($p < .01$), where long-term owners were more likely to be Segment 2 members. However, because missing values impacted the class solution, we did not include the item in the final model.

Fig. 7 illustrates examples of high-preference scenarios for the two latent class segments, with the two upper images showing attribute level combinations preferred highly by the Northwoods scenic aesthetic segment and the two lower images preferred highly by the pine barrens

Table 3

Parameter estimates and standard errors for attribute levels of the DCE segmentation analysis based on past experience with pine barrens (N = 535).

Have you ever visited pine barrens? Attributes and attribute levels	Yes Parameter estimates	s.e.	No Parameter estimates	s.e.	Don't know Parameter estimates	s.e.	Segment differences Wald test
a) Spatial configuration	$\hat{64\%}$		$\hat{73\%}$		$\hat{73\%}$		11.3
1) Trees in foreground (Zones 1 & 2)	***1.752	0.161	***2.138	0.118	***1.876	0.137	
2) Trees spread across Zones 1–4	***1.492	0.157	***1.864	0.110	***1.666	0.134	
3) Trees in midground (Zones 2 & 3)	***−2.117	0.393	***−1.823	0.226	***−1.585	0.260	
4) Trees in background (Zones 3 & 4)	***−1.781	0.296	***−2.939	0.294	***−2.639	0.320	
5) Trees in midground (Zones 2 & 3) and 1% forest cover foreground	(*)0.316	0.163	**0.304	0.109	*0.266	0.133	
6) Trees in background (Zones 3 & 4) and 1% forest cover foreground	(*)0.339	0.176	***0.455	0.123	**0.416	0.146	
b) Tree density	$\hat{13\%}$		$\hat{6\%}$		$\hat{10\%}$		(*)11.6
1) 5% tree cover	**−0.445	0.136	**−0.262	0.085	**−0.314	0.105	
2) 15% tree cover	**0.352	0.127	−0.001	0.083	−0.056	0.104	
3) 25% tree cover	0.186	0.140	0.120	0.090	0.065	0.113	
4) 35% tree cover	−0.093	0.140	(*)0.142	0.084	**0.304	0.106	
c) Tree distribution	$\hat{3\%}$		$\hat{6\%}$		$\hat{2\%}$		7.0
1) Scattered trees	−0.071	0.141	0.046	0.093	0.054	0.113	
2) Clumps of trees	0.017	0.121	**−0.226	0.082	−0.019	0.103	
3) Mix of scattered trees and clumps	0.055	0.131	*0.180	0.085	−0.035	0.105	
d) Fire interval	$\hat{6\%}$		$\hat{7\%}$		$\hat{8\%}$		*13.5
1) 3-yr. interval	*−0.243	0.121	***−0.269	0.078	*−0.222	0.097	
2) 10-yr. interval	0.181	0.117	0.075	0.076	(*)0.162	0.095	
3) 30-yr. interval	0.062	0.114	**0.194	0.071	0.060	0.090	
e) Shrub density	$\hat{6\%}$		$\hat{6\%}$		$\hat{4\%}$		*12.7
1) 0% cover	−0.092	0.119	**0.234	0.073	−0.086	0.096	
2) 5% cover	(*)0.196	0.115	0.112	0.077	0.121	0.093	
3) 30% cover	−0.142	0.139	−0.137	0.091	0.117	0.111	
4) 60% cover	0.038	0.122	**−0.209	0.080	−0.153	0.102	
f) Standing dead trees	$\hat{9\%}$		$\hat{3\%}$		$\hat{2\%}$		5.3
1) 0 dead tree	0.170	0.107	−0.001	0.069	−0.021	0.087	
2) 4 dead trees	**−0.381	0.132	−0.105	0.081	−0.075	0.105	
3) 4 dead trees & blueberries	0.115	0.139	0.001	0.091	0.062	0.116	
4) 8 dead trees	0.096	0.120	0.105	0.081	0.033	0.104	
Covariate: Knowledge of pine barrens							***126.1
Never heard of them	***−2.327	0.381	**1.577	0.598	*0.750	0.359	
Heard of them but know nothing about	*−0.805	0.338	0.645	0.594	0.160	0.352	
Heard of and have some knowledge	*0.862	0.335	0.089	0.601	*−0.951	0.375	
Know a lot about them	*2.270	0.916	−2.311	1.752	0.041	0.996	
Pseudo-R ² : 0.29							
Observations: Yes: 416; No: 1084; Don't know: 636							
Log-likelihood: −2498.4							

Significant influence of the attribute levels on respondents' choices: (*)p < .10; *p < .05; **p < .01; ***p < .001.

ecological aesthetic segment.

5. Discussion

In this study, we sought to understand how key visual characteristics of pine barrens might be manipulated through different treatment designs to address landowner preferences, and whether preference differences existed among respondents. Using a DCE, we presented visual scenarios of restoration treatment designs to landowners near a pine barrens restoration project in northern Wisconsin. In support of hypothesis 1 and consistent with the literature (e.g., Ribe, 1990), we found highest preferences for scenarios with smaller openings and higher tree densities more closely resembling the scenic aesthetic of the Northwoods. However, we also found that some scenarios portraying more open characteristics of a pine barrens garnered relatively high preferences, hinting that certain treatment designs might help achieve an ecological aesthetic that aligns people's visual preferences with restoration goals (Gobster, 1999). Further evidence of an ecological aesthetic for pine barrens restoration was borne out by our segmentation analyses, which in partial support for hypothesis 2 found higher preferences for more intensive types of pine barrens treatment designs retaining fewer

trees among those who had previously visited pine barrens (H2.1) and for a minority segment of individuals identified by latent class analysis (H2.2).

5.1. Study limitations

Photo-based DCEs are an attractive way to present complex visual information to stakeholders, and digitally-manipulated visualizations can be effective in determining the relative importance of key visual characteristics related to landscape preferences (Ebenberger & Arnberger, 2019). We feel the principal spatial attributes of pine barrens landscapes were effectively captured visually, but a few attribute levels such as the ten-year fire interval and the blueberry bushes that co-occurred with four standing dead trees may have been less noticeable to respondents, particularly if viewing them on a small screen. This could have led to inaccuracies in the attribute level weights in the DCE model.

Our response rate of 23.4% was slightly below average (SurveyAnyPlace, 2019) though not unusually low (Massey & Tourangeau, 2013). Cost constraints precluded a non-response bias survey, and while our sample was older, more highly educated, and had more males than

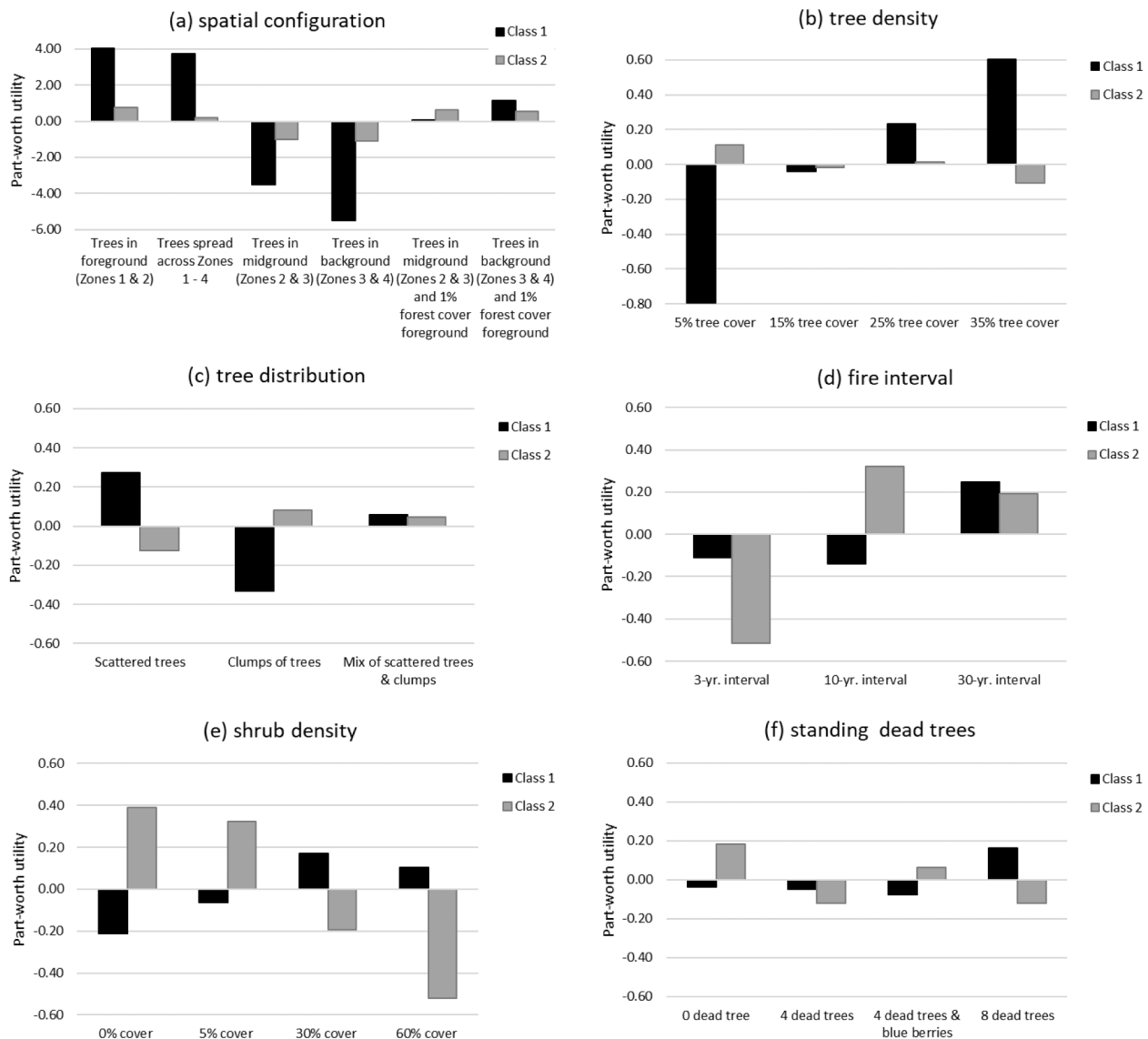


Fig. 6. a–f. Attribute levels for “Northwoods scenic aesthetic” (Class1) and “pine barrens ecological aesthetic” (Class2) latent class segments. Please note that the vertical scales differ.

census figures for the region, it was comparable to our earlier landowner survey where we obtained a response rate of 43% (Floress et al., 2018). It is likely these demographic differences reflect those interested in the research topic, while the lower response could reflect the more demanding DCE task (Watson et al., 2016) and online survey (Campbell et al., 2018), neither of which were used in our earlier work. Future research with more resources should consider more persuasive messaging along with additional reminders.

Our sample of 542 landowners assigned at least 67 respondents to each of the 8 survey versions needed to complete the DCE research design. While these numbers exceeded accepted standards (Louviere et al., 2000; Rose & Bliemer, 2013), a larger respondent sample would have allowed us to vary choice scenarios by incorporating text descriptions along with the images and test their effects on responses (Shr et al., 2019). An expanded sample would also allow us to test more questionnaire items as potential covariates to help explain the latent class segmentations, which was not possible with the existing sample due to missing or low variability of responses. Finally, nearby landowners are key stakeholders of pine barrens restorations and our sample was broadly representative of non-industrial, private woodland owners who prioritize recreation and aesthetics over economic goals in

ownership (Floress et al., 2018). Still, a more broadly drawn sample including other residents and visitors would have helped to better approximate the general public and allow for intergroup comparisons.

Contrary to hypothesis 2.1, our information intervention had a negligible effect on respondent preferences, nor did prior knowledge of barrens as identified by a self-report measure. These results may have been due to the limited nature of our intervention, a one-paragraph description presented just prior to the rating task, and because respondents' prior knowledge and experience of barrens was also quite limited. Past research has found inconsistent results on how such measures affect preferences for ecologically managed landscapes (e.g., Gundersen & Frivold, 2011; Hill & Daniel, 2008), and one argument against knowledge-based approaches is they fail to account for psychological bases of preferences, which are thought to be more strongly tied to emotion than cognition (Gobster et al., 2007).

5.2. Research and management implications

Our findings have implications for research and theoretical development on landscape preferences. Evolutionary landscape theories (Heerwagen & Orians, 1993) posit a preference for more semi-open

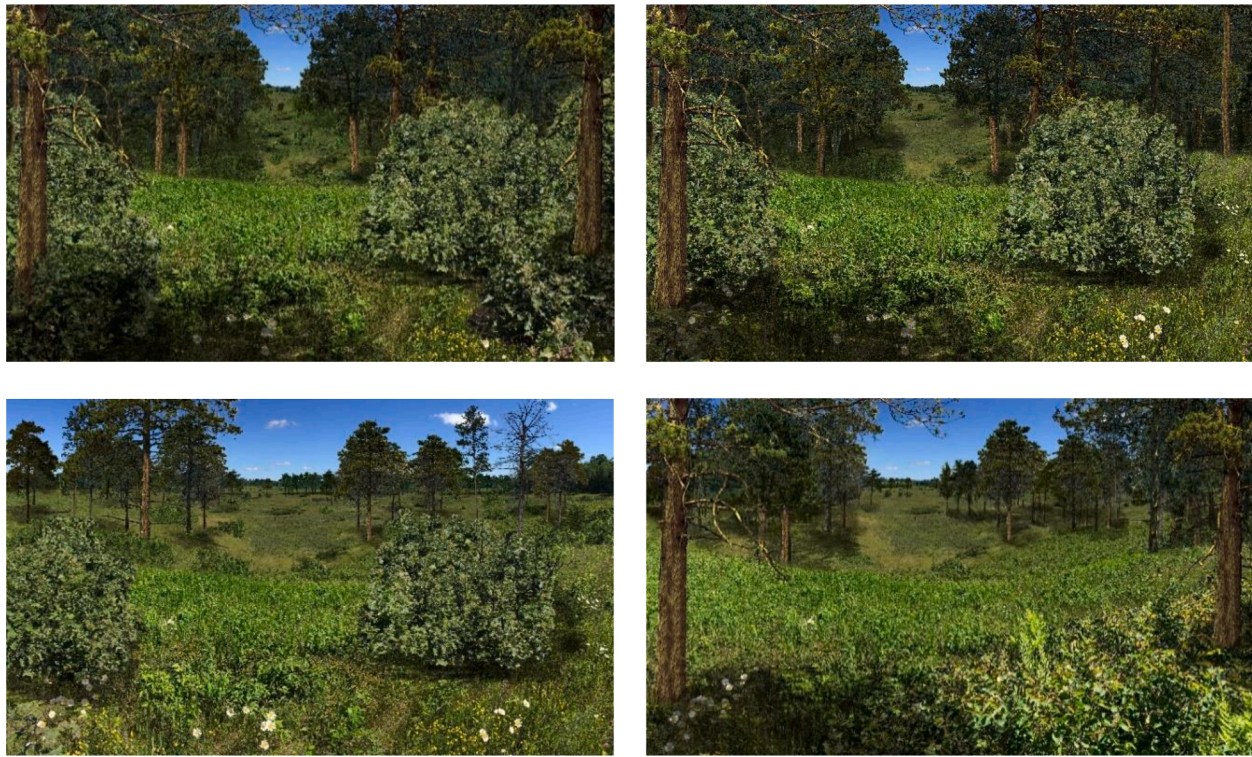


Fig. 7. Examples of high-preference scenarios for two latent class segments, with the two upper images showing attribute level combinations preferred highly by the Northwoods Scenic Aesthetic segment and the two lower images given the same preference rating by the Pine Barrens Ecological Aesthetic segment.

savanna-like landscapes. However, the majority of respondents preferred a rather dense forest condition that could be tied to a dominant cultural preference (Van den Berg & Koole, 2006) consistent with the Northern European heritage of many residents of northern Wisconsin along with more recent Northwoods cultural viewpoints. These theories are not necessarily mutually exclusive as an individual's landscape preferences are likely an amalgamation of experiences, some of which are hardwired, others learned culturally, and still others that may be uniquely acquired via new knowledge and experiences (Gobster et al., 2007). Further research is needed on how landscape preferences are expressed by individuals, how they differ and align across groups and cultures, how they differ by geographical regions and ecological community types, and how they relate to different theories.

These results also suggest two complementary management strategies to balance social and ecological goals. One is by working on the ecological side through design, where manipulating key visual attributes of pine barrens can impact how they are perceived by the public. For example, spatial configurations of openings that leave a small number of mature trees in the foreground view, such as along road and trail corridors, can frame the open landscape beyond. These foreground features, along with leaving low densities of trees across other distance zones, can help reduce the appearance of otherwise large openings. By the same token, fire-related features such as standing dead trees, blueberry bushes, and low density shrub cover can introduce greater variety in vegetative heights, colors, and textures, adding visual interest to the scene. These familiar scenic conventions, along with other cues to care such as nesting boxes for grassland birds and colorful flowers and other seasonal vegetation, can help local residents and visitors to more easily “read” the beauty of pine barrens and similar open landscape types (Nassauer, 1995; Li & Nassauer, 2020).

Another strategy is by working on the social side, where interventions through knowledge and experience may help increase people's familiarity and understanding of pine barrens ecosystem, leading to greater appreciation. Although our brief information intervention did not show any significant change in landscape preferences, other studies

have (e.g., Gundersen & Frivold, 2011), and it may be that different knowledge-based approaches such as formal education, guided tours, or self-guided tours using on-site signage or brochures could help shift how people think and feel about pine barrens. Of the various types of knowledge interventions, experiential learning approaches often provide a more immediate and potent means for appreciating unfamiliar landscapes as they more directly engage the emotions (Berleant, 2012; Williams & Harvey, 2001). Our work found those who had previously visited pine barrens had higher preferences for scenarios with somewhat more open landscape conditions. Visiting pine barrens allows for exploration, multisensory immersion, and an intimate connection with the landscape and its non-human inhabitants—ways of interactive learning that may be important in landscapes such as pine barrens that lack the spectacular qualities commonly regarded as scenically beautiful (Gobster, 1999; Williams & Cary, 2001).

Further work is needed to more clearly understand how ecological design and knowledge-based approaches can aid landscape managers in balancing social and ecological goals. Visual DCEs can be complex to design and implement, but with appropriate software the resulting models can be made reasonably user-friendly so managers can explore how different attribute levels and combinations affect stakeholder preferences (Schroeder, 1990). Similarly, connecting managers with residents and visitors through field tours, publicizing when and where berry-picking patches are ripe for harvest, and promoting other leisure-learning activities such as restoration workdays and wildlife monitoring can build constituencies for scenically challenging landscapes.

6. Conclusions

Like other open ecological communities, pine barrens do not conform to culturally dominant standards of landscape beauty and thus their restoration can challenge public land managers responsible for balancing social and ecological goals. We sought to better understand how individuals who own forest land near a major pine barrens restoration project on public lands viewed ecological design alternatives that



Fig. 8. Photo shown to respondents prior to the choice task that depicts typical closed forest conditions in the study area.

aim to balance these goals. While a dominant Northwoods scenic aesthetic continues to drive forest landscape preferences for these landowners, an emerging ecological aesthetic identified through our work helps reveal how ecological design and on-the-ground experience can lead to greater acceptance of scenically challenging landscapes such as pine barrens. These different aesthetic perspectives need not conflict with one another, and by managing public lands for multiple values and engaging citizens through experiential learning opportunities, land managers can help their stakeholders better appreciate the unique beauty inherent across all types of landscapes.

Author contributions

PHG and IES were co-principal investigators and led the overall study. AA led the development and analysis of the discrete choice experiment (DCE) and preparation of the visual choice scenarios. IES led the implementation and analysis of the on-line landowner survey with CB (research assistant) and the other authors. All authors collaborated in writing and editing the manuscript.

Acknowledgments

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Appendix. Informational intervention

PLEASE READ THIS DESCRIPTION BEFORE ANSWERING THE NEXT SET OF QUESTIONS

Restoring the Pine Barrens of Northeastern Wisconsin

A Pine Barrens is a forest type that occurs in dry, sandy regions of the Upper Great Lakes, including land near your property in Northeastern Wisconsin. Periodic fire kept Pine Barrens in their natural state, with scattered pine trees, grassy groundcover, and low shrubs. Historically, Pine Barrens covered more than 2 million acres of Wisconsin, but due to fire suppression and other forestry activities, today only a few thousand acres remain.

Forest managers are now working to restore additional Pine Barrens on a few public forests in Northeastern Wisconsin by using prescribed burning, cutting brush and timber, and other methods. Their goals are to reduce wildfire risk, improve habitat for plants and animals, and increase recreation like berry-picking, hunting, and wildlife viewing. Periodic burning would have some short-term effects including smoke and blackened areas and there would be a long-term change in the typical “look” of the current landscape such as the one pictured here (Fig. 8).

Because of these issues, managers want to know what landowners like you think about different Pine Barrens management options. In the next section, we would like you to view four sets of photos showing different options. In each set, we will ask you to choose which photo you most visually prefer and which ones would be acceptable to you as management options.

Control (no information)

Picture instructions

The photo shown here (Fig. 8) is typical of many public forestlands near your property in Northeastern Wisconsin. Forest managers are working to manage a few public forests like these to accomplish various forestry goals, and want to know what landowners like you think about different management options.

In the next section, we would like you to view four sets of landscape photos. In each of those sets, we will ask you to choose which photo you most visually prefer and which ones would be acceptable to you as

management options.

References

- Addelman, S. (1962). Symmetrical and asymmetrical fractional factorial plans. *Technometrics*, 4(1), 47–58. <https://doi.org/10.1080/00401706.1962.10489986>.
- Anderson, L. M., Levi, D. J., Daniel, T. C., & Dietrich, J. H. (1982). The esthetic effects of prescribed burning: A case study. Research Note RM-413. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Arnberger, A., Ebenberger, M., Schneider, I. E., Cottrell, S., Schlueter, A. C., Ruschkowski, E., et al. (2018). Visitor preferences for visual changes in bark beetle-impacted forest recreation settings in the United States and Germany. *Environmental Management*, 61(2), 209–223. <https://doi.org/10.1007/s00267-017-0975-4>.
- Becerra, T. A., Engle, D. M., Elmore, R. D., & Fuhlendorf, S. D. (2013). Contrasting preference for grassland landscape among population groups in the central and southern Great Plains. *Rangeland Ecology and Management*, 66(5), 529–538. <https://doi.org/10.2111/REM-D-12-00174.1>.
- Becerra, T. A., Engle, D. M., Fuhlendorf, S. D., & Elmore, R. D. (2017). Preference for grassland heterogeneity: Implications for biodiversity in the Great Plains. *Society & Natural Resources*, 30(5), 601–612. <https://doi.org/10.1080/08941920.2016.1239293>.
- Bell, S. (2001). Landscape pattern, perception and visualization in the visual management of forests. *Landscape and Urban Planning*, 54, 201–211. [https://doi.org/10.1016/S0169-2046\(01\)00136-0](https://doi.org/10.1016/S0169-2046(01)00136-0).
- Berleant, A. (2012). Ideas for an ecological aesthetics. In A. Berleant (Ed.), *Aesthetics beyond the arts: New and recent essays* (pp. 193–217). Surrey, UK: Ashgate.
- Brush, R. O. (1979). The attractiveness of woodlands: Perceptions of forest landowners in Massachusetts. *Forest Science*, 25, 495–506.
- Campbell, R. M., Venn, T. J., & Anderson, N. M. (2018). Cost and performance tradeoffs between mail and internet survey modes in a nonmarket valuation study. *Journal of Environmental Management*, 210, 316–327. <https://doi.org/10.1016/j.jenvman.2018.01.034>.
- Carlson, A. (1999). Admiring the mirelands: The difficult beauty of wetlands. In K. Hakala (Ed.), *Suo on Kaunis* (pp. 173–181). Helsinki: Maakenki Oy.
- Cook, P. S., & Cable, T. T. (1995). The scenic beauty of shelterbelts on the Great Plains. *Landscape and Urban Planning*, 32, 63–69. [https://doi.org/10.1016/0169-2046\(94\)00171-x](https://doi.org/10.1016/0169-2046(94)00171-x).
- De Valck, J., Vlaeminck, P., Broekx, S., Liekens, I., Aertsens, J., Chen, W., et al. (2014). Benefits of clearing forest plantations to restore nature? Evidence from a discrete choice experiment in Flanders, Belgium. *Landscape and Urban Planning*, 125, 65–75. <https://doi.org/10.1016/j.landurbplan.2014.02.006>.
- Dhakal, B., Yao, R. T., Turner, J. A., & Barnard, T. (2012). Recreational users' willingness to pay and preferences for changes in planted forest features. *Forest Policy and Economics*, 17, 34–44. <https://doi.org/10.1016/j.forpol.2011.11.006>.
- Dobbie, M., & Green, R. (2013). Public perceptions of freshwater wetlands in Victoria, Australia. *Landscape and Urban Planning*, 110, 143–154. <https://doi.org/10.1016/j.landurbplan.2012.11.003>.
- Eagan, D., & Howell, E. (Eds.). (2005). *The historical ecology handbook: A restorationist's guide to reference ecosystems*. Washington, DC: Island Press.
- Ebenberger, M., & Arnberger, A. (2019). Exploring visual preferences for structural attributes of urban forest stands for restoration and heat relief. *Urban Forestry & Urban Greening*, 41, 272–282. <https://doi.org/10.1016/j.ufug.2019.04.011>.
- Edwards, D., Jay, M., Jensen, F., Lucas, B., Marzano, M., Montagne, C., Peace, A., & Weiss, G. (2012). Public preferences for structural attributes of forests: Towards a pan-European perspective. *Forest Policy and Economics*, 19, 12–19. <https://doi.org/10.1016/j.forpol.2011.11.006>.
- Epstein, E. (2017). Natural communities, aquatic features, and selected habitats of Wisconsin. PUB-SS-1131H. *The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management*. Madison, WI: Wisconsin Department of Natural Resources.
- Erickson, D. L., Ryan, R. L., & De Young, R. (2002). Woodlots in the rural landscape: Landowner motivations and management attitudes in a Michigan case study. *Landscape and Urban Planning*, 58, 101–112. [https://doi.org/10.1016/S0169-2046\(01\)00213-4](https://doi.org/10.1016/S0169-2046(01)00213-4).
- Evernden, N. (1983). Beauty and nothingness: Prairie as a failed resource. *Landscape*, 27, 1–8.
- Falk, J. H., & Balling, J. D. (2010). Evolutionary influence on human landscape preference. *Environment and Behavior*, 42(4), 479–493. <https://doi.org/10.1177/0013916509341244>.
- Flores, K., Haines, A., Usher, E., Gobster, P., Dockry, M., et al. (2018). *Landowner and visitor response to forest landscape restoration: the Chequamegon-Nicolet National Forest Lakewood Southeast Project*. Stevens Point, WI: University of Wisconsin-Stevens Point, Center for Land Use Education and University of Wisconsin-Extension.
- Gobster, P. H. (1999). An ecological aesthetic for forest landscape management. *Landscape Journal*, 18(1), 54–64. <https://doi.org/10.3368/lj.18.1.54>.
- Gobster, P. H., Nassauer, J. I., Daniel, T. C., & Fry, G. (2007). The shared landscape: What does aesthetics have to do with ecology? *Landscape Ecology*, 22, 959–972. <https://doi.org/10.1007/s10980-007-9110-x>.
- Gobster, P. H., Schneider, I. E., Flores, K. M., Haines, A. L., Arnberger, A., Dockry, M., & Benton, C. (2021). Understanding the key characteristics and challenges of pine barrens restoration: Insights from a Delphi survey of forest land managers and researchers. *Restoration Ecology*, 29(1), e13273, pp. 1–12. <https://doi.org/10.1111/rec.13273>.
- Gundersen, V., & Frivold, L. H. (2011). Naturally dead and downed wood in Norwegian boreal forests: Public preferences and the effect of information. *Scandinavian Journal of Forest Research*, 26(2), 110–119. <https://doi.org/10.1080/02827581.2010.536567>.
- Gundersen, V., Stange, E. E., Kaltenborn, B. P., & Vistad, O. I. (2017). Public visual preferences for dead wood in natural boreal forests: The effects of added information. *Landscape and Urban Planning*, 158, 12–24. <https://doi.org/10.1016/j.landurbplan.2016.09.020>.
- Hammit, W. E. (1980). Managing bog environments for recreational experiences. *Environmental Management*, 4(5), 425–431. <https://doi.org/10.1007/BF01869653>.
- Heerwagen, J. H., & Orians, G. H. (1993). Humans, habitats, and aesthetics. In S. R. Kellert, & E. O. Wilson (Eds.), *The biophilia hypothesis* (pp. 138–172). Washington, DC: Island Press.
- Hill, D., & Daniel, T. C. (2008). Foundations for an ecological aesthetic: Can information alter landscape preferences? *Society & Natural Resources*, 21, 34–49. <https://doi.org/10.1080/08941920701655700>.
- Johnston, R. J., Boyle, K. J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T. A., et al. (2017). Contemporary guidance for stated preference studies. *Journal of the Association of Environmental and Resource Economists*, 4(2), 319–405. <https://doi.org/10.1086/691697>.
- Kaplan, R. (1985). The analysis of perception via preference: A strategy for studying how the environment is experienced. *Landscape Planning*, 12(2), 161–176. [https://doi.org/10.1016/0304-3924\(85\)90058-9](https://doi.org/10.1016/0304-3924(85)90058-9).
- Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. New York: Cambridge University Press.
- Kemperman, A. D. A. M., & Timmermans, H. J. P. (2006). Heterogeneity in urban park use of aging visitors: A latent class analysis. *Leisure Sciences*, 28(1), 57–71. <https://doi.org/10.1080/01490400500332710>.
- Lampereur, J. (2013). *Forest vegetation resource report for the Lakewood Southeast Project, Chequamegon-Nicolet National Forest*. Rhinelander, WI: USDA Forest Service.
- Li, J., & Nassauer, J. I. (2020). Cues to care: A systematic analytical review. *Landscape and Urban Planning*, 201, 103821. <https://doi.org/10.1016/j.landurbplan.2020.103821>.
- Lindemann-Matthies, P., Junge, X., & Matthies, D. (2010). The influence of plant diversity on people's perception and aesthetic appreciation of grassland vegetation. *Biological Conservation*, 143(1), 195–202. <https://doi.org/10.1016/j.biocon.2009.10.003>.
- Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated choice methods – Analysis and application*. London: Cambridge University Press.
- Massey, D., & Tourangeau, R. (2013). Where do we go from here? Nonresponse and social measurement. *Annals of the American Academy*, 645, 222–236.
- McFadden, D. (1973). Conditional logit analysis of qualitative choice behavior. In P. Zarembka (Ed.), *Frontiers in Econometrics* (pp. 105–142). New York: Academic Press.
- Nassauer, J. I. (1995). Messy ecosystem, orderly frames. *Landscape Journal*, 14, 161–170. <https://doi.org/10.3368/lj.14.2.161>.
- Nielsen, A. B., Gundersen, V. S., & Jensen, F. S. (2018). The impact of field layer characteristics on forest preference in Southern Scandinavia. *Landscape and Urban Planning*, 170, 221–230. <https://doi.org/10.1016/j.landurbplan.2017.10.005>.
- Norden, A., Coria, J., Jönsson, A. M., Lagergren, F., & Lehsten, V. (2017). Divergence in stakeholders' preferences: Evidence from a choice experiment on forest landscapes preferences in Sweden. *Ecological Economics*, 132, 179–196. <https://doi.org/10.1016/j.ecolecon.2016.09.032>.
- Palmer, J. F., Shannon, S., Harrilchak, M. A., Gobster, P. H., & Kokx, T. (1993). Long-term visual effects of alternative clearcutting intensities. In G. A. Vander Stoep (Ed.), *Proceedings of the 1993 Northeastern recreation research symposium. General Technical Report NE-185* (pp. 84–88). Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station.
- Patterson, Z., Darbani, J. M., Rezaei, A., Zacharias, J., & Yazdizadeh, A. (2017). Comparing text-only and virtual reality discrete choice experiments of neighbourhood choice. *Landscape and Urban Planning*, 157, 63–74. <https://doi.org/10.1016/j.landurbplan.2016.05.024>.
- Radeloff, Volker C., Mladenoff, David J., & Boyce, Mark S. (2000). A historical perspective and future outlook on landscape scale restoration in the Northwest Wisconsin pine barrens. *Restoration Ecology*, 8(2), 119–126. <https://doi.org/10.1046/j.1526-100x.2000.80018.x>.
- Ribe, R. G. (1990). A general model for understanding the perception of scenic beauty in Northern hardwood forests. *Landscape Journal*, 9(2), 86–101. <https://doi.org/10.3368/lj.9.2.86>.
- Ribe, R. G. (1991). The scenic impact of key forest attributes and long-term management alternatives for hardwood forests. In L. H. McCormick, & K. W. Gottschalk (Eds.), *Proceedings, 8th Central Hardwood Forest Conference. General Technical Report NE-148* (pp. 34–54). Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station.
- Rose, J. M., & Bliemer, M. C. J. (2013). Sample size requirements for stated choice experiments. *Transportation*, 40(5), 1021–1041. <https://doi.org/10.1007/s11116-013-9451-z>.
- Ryan, R. L. (2005). *Social science to improve fuels management: A synthesis of research on aesthetics and fuels management. General Technical Report NC-261*. St. Paul, MN: USDA Forest Service, North Central Research Station.
- Saito, Y. (1998). The aesthetics of unscenic nature. *Journal of Aesthetics and Art Criticism*, 56, 101–111.
- Scarpa, R., & Thiene, M. (2005). Destination choice models for rock climbing in the Northeastern Alps: A latent-class approach based on intensity of preferences. *Land Economics*, 81(3), 426–444.
- Schroeder, H. W. (1990). *RS-PREF: Recreation site preference and choice model users guide*. Chicago: USDA Forest Service, North Central Forest Experiment Station.

- SFI Implementation Committee. (2014). *Wisconsin's forests: The private landowner's handbook*. Madison, WI: Wisconsin Department of Natural Resources, Sustainable Forestry Initiative.
- Shapiro, A. (2013). *The lure of the north woods: Cultivating tourism in the Upper Midwest*. Minneapolis: University of Minnesota Press.
- Shelby, B., Thompson, J. R., Brunson, M., & Johnson, R. (2005). A decade of recreation ratings for six silviculture treatments in Western Oregon. *Journal of Environmental Management*, 75(3), 239–246. <https://doi.org/10.1016/j.jenvman.2004.12.004>.
- Sherren, K., Fischer, J., Clayton, H., Hauldren, A., & Dovers, S. (2011). Lessons from visualising the landscape and habitat implications of tree decline and its remediation through tree planting in Australia's grazing landscapes. *Landscape and Urban Planning*, 103(2), 248–258. <https://doi.org/10.1016/j.landurbplan.2011.08.004>.
- Shr, Y.-H., Ready, R., Orland, B., & Echols, S. (2019). How do visual representations influence survey responses? Evidence from a choice experiment on landscape attributes of green infrastructure. *Ecological Economics*, 156, 375–386. <https://doi.org/10.1016/j.ecolecon.2018.10.015>.
- Sorice, M. G., Kreuter, U. P., Wilcox, B. P., & Fox, W. E. (2012). Changing landowners, changing ecosystem? Land-ownership motivations as drivers of land management practices. *Journal of Environmental Management*, 133, 144–152. <https://doi.org/10.1016/j.jenvman.2013.11.029>.
- SurveyAnyplace. (2019). What's the average survey response rate? (2019 benchmark). <<https://surveyanyplace.com/average-survey-response-rate/>> (Last accessed 02/25/2021).
- Van den Berg, A. E., & Koole, S. L. (2006). New wilderness in the Netherlands: An investigation of visual preferences for nature development landscapes. *Landscape and Urban Planning*, 78(4), 362–372. <https://doi.org/10.1016/j.landurbplan.2005.11.006>.
- Van der Wal, R., Miller, D., Irvine, J., Fiorini, S., Amar, A., Yearley, S., et al. (2014). The influence of information provision on people's landscape preferences: A case study on understorey vegetation of deer-browsed woodlands. *Landscape and Urban Planning*, 124, 129–139. <https://doi.org/10.1016/j.landurbplan.2014.01.009>.
- Vermunt, J. K., & Magidson, J. (2005). *Technical guide for Latent Gold Choice 4.0: Basic and advanced*. Belmont, MA: Statistical Innovations Inc.
- Vodak, M. C., Roberts, P. L., Wellman, J. D., & Buhyoff, G. J. (1985). Scenic impacts of Eastern Hardwood management. *Forest Science*, 31, 289–301.
- Watson, V., Becker, F., & De-Bekker-Goob, E. (2016). Discrete choice experiment response rates: A meta-analysis. *Health Economics*, 26(6), 810–817. <https://doi.org/10.1002/hec.v26.610.1002/hec.3354>.
- WDNR. (1995). *Interim forest management plan for Spread Eagle Barrens State Natural Area*. Madison, WI: Wisconsin Department of Natural Resources.
- Williams, K., & Cary, J. (2001). Perception of native grassland in southeastern Australia. *Ecological Management and Restoration*, 2(2), 139–144. <https://doi.org/10.1046/j.1442-8903.2001.00077.x>.
- Williams, K., & Harvey, D. (2001). Transcendent experience in forest environments. *Journal of Environmental Psychology*, 21, 249–260. <https://doi.org/10.1006/jevp.2001.0204>.