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Stated preferences for the colours, smells, and sounds of biodiversity

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ABSTRACT

Forest creation and restoration are embedded in global policy. Both result in landscape changes that have far-reaching socioeconomic consequences. However, there is limited evidence on public preferences for the biodiversity these forests contain. Here we used a choice experiment to explore the British public's willingness to pay (WTP) for different forest biodiversity attributes. We began with a multiple-step deliberative participatory process. This revealed that participants conceptualised forest biodiversity through visual, aural and olfactory senses. We subsequently developed and pre-tested sensory attributes based on colours, smells and sounds. Depending on the size of the proposed change, participants ($N = 1711$) were willing-to-pay for a greater variety of sensory attributes and for an indicator of improved ecological functioning (deadwood for decomposition). WTP for sensory attributes was influenced by participants' having related sensory impairments or visiting forests frequently. Our wider contribution highlights the importance of participatory methods to unearth novel and uncommon attributes that can then be used in stated preference studies. Ensuring that we evaluate stated preferences in a manner that reflects how the public conceives biodiversity is important if we are to improve the alignment between forest creation/restoration and public views, which could thus help bolster public support for the planning and implementation of landscape changes.

1. Introduction

Ecosystem transformations, such as restoration projects, land-use conversions, and changes in species distributions and/or abundance, unfold against a policy backdrop (Stanturf and Mansourian, 2020). For instance, we are currently midway through the United Nations (UN) Decade on Ecosystem Restoration (United Nations, 2019), and the need for widespread ecosystem protection and rehabilitation has been highlighted by the Convention on Biological Diversity (CBD) agreement to protect 30 % of the world's terrestrial and marine area by 2030 (Convention on Biological Diversity (CBD), 2022). Given that ecosystem transformations can affect large numbers of people (Erbaugh et al., 2020), understanding the preferences and values held by local communities should be a central concern (Löfqvist et al., 2023). Despite growing recognition of the need to proactively understand people's social and cultural perspectives (Pritchard, 2021), they remain largely overlooked in valuation studies, representing a substantial knowledge gap (Erbaugh et al., 2020).

Forests provide a vast array of ecosystem goods and services that underpin benefits to humanity (Zhang et al., 2021). To secure these benefits, many national and international policy initiatives have been established, such as the Bonn Challenge and New York Forest Declaration that aim to restore 350 million hectares of degraded forest by 2030 (Stanturf and Mansourian, 2020). Forest creation and restoration initiatives are typically supported by a range of economic, specifically financial, measures such as taxation or incentive payments (Ryan et al., 2018). The economic valuation of non-market environmental goods associated with ecosystem transformations has, therefore, become a mainstay of environmental economics (Bartkowski et al., 2015). Stated preference techniques, including choice experiments (CE), can be used

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to generate robust monetary values for environmental goods that may otherwise not be included in the cost-benefit analyses that underpin many policy decisions (Christie et al., 2006; Rambonilaza and Brahic, 2016; Sagebiel et al., 2017). Stated preference studies tend to demonstrate that participants' preferences underpin their WTP for forest creation and restoration through taxes (Sagebiel et al., 2017) or financial contributions (Rambonilaza and Brahic, 2016). Participant preferences for forest creation and restoration are influenced by the characteristics of the forests (Czajkowski et al., 2017). However, some stated preference studies have understated the multifaceted roles, and experiences, of biodiversity. For example, many previous CEs have used a single biodiversity attribute (e.g., one attribute labelled 'diversity'; Filyushkina et al., 2017; Toledo-Gallegos et al., 2021), or focussed on the conservation/management of individual species (Steven et al., 2017). Others have highlighted tree species diversity and stand height variation (Filyushkina et al., 2017), percentage of trees protected (Czajkowski et al., 2017), public familiarity with species and their rarity (Christie et al., 2006), species and habitat diversity (e.g., Bakhtiari et al., 2018; Czajkowski et al., 2009), and ecological functions such as deadwood for decomposition (Rambonilaza and Brahic, 2016).

The values that are elicited for creating, conserving, or restoring forest ecosystems depend on what is valued, by whom and to what end (Bartkowski et al., 2015; Sagebiel et al., 2017). Thus, attribute selection (i.e. what is valued) is a foundation for any stated preference study. Attributes that have been used previously suggest that they may have been selected as they are: (i) associated with use values (e.g., relevant to the provision or value of recreational experiences; Schaafsma et al., 2013; Filyushkina et al., 2017); (ii) directly linked to potential ecosystem transformations (e.g., management of or increases/decreases in certain land cover types; Sacher et al., 2022); and/or (iii) specific metrics that may be relevant to experts concerned with ecological management (e.g., numbers of species, abundance of species, presence or quality of ecological functions; Filyushkina et al., 2017). Best-practice guidelines (e.g., Johnston et al., 2017; Mariel et al., 2021) suggest that attributes be derived and defined through a careful balance of focus groups with the affected communities and scientific consultation (Bakhtiari et al., 2014). While many studies acknowledge this design step (e.g., Nielsen et al., 2007; Jacobsen et al., 2008; Jacobsen et al., 2012), the detail on the process and findings therein is often limited. While more stated preference studies are engaging with communities earlier in the design and derivation of attributes (e.g., Bakhtiari et al., 2018; Falk et al., 2021; Martin-Ortega et al., 2021), embedding people's perceptions throughout the pre-testing process will help to further unpack the diversity of ways by which people value interactions with nature (Elwell et al., 2018; Jones et al., 2018; Martin-Ortega et al., 2017).

A wide variety of locally, culturally, and contextually specific factors influence people's biodiversity preferences, including childhood memories, historical meaning, popular culture, colours, and soundscapes and whether they live in urban or rural environments (Austen et al., 2021, 2023; Nawrath et al., 2022). Consequently, people generally conceive biodiversity and associated ecosystem services differently to experts (e.g., Christie et al., 2006; Le and Campbell, 2022; Maund et al., 2020; c.f., Bakhtiari et al., 2014), and the language that people use to describe biodiversity differs from scientific expert descriptions (Fish et al., 2024). The concepts and preferences articulated by the public in relation to biodiversity thus move well beyond the widely used metrics in environmental economics literature, such as the population sizes of individual species, numbers of species or individuals, or the extent and quality of particular habitat types or ecological functions.

The ways in which people interact with biodiversity are highly diverse. Nonetheless, one commonality is that people experience biodiversity through their senses. This can be particularly important because sensory experiences of natural environments may also be linked to an individual's health and wellbeing. For instance, mood and anxiety are negatively affected by blocking participants' visual, olfactory, and auditory senses of the natural environment (Wooller et al., 2016), while exposure to natural green colours (Akers et al., 2012) and sounds in natural settings (e.g., birdsong) can contribute positively to stress recovery (Alvarsson et al., 2010) and are perceived to offer restoration from stress and cognitive fatigue (Ratcliffe et al., 2018). The potential human health and wellbeing benefits of smells have been recognised through aromatherapy, forest bathing and modern retail marketing approaches (Schloss et al., 2015; Spence et al., 2014). Moreover, smells may interact with memory formation and retrieval (Camps et al., 2014; Fisher et al., 2023). Despite this, there is scarce knowledge about people's willingness to pay (WTP) for changes in the sensory experiences associated with biodiversity, aside from some studies on the marginal value of noise pollution reduction (Calleja et al., 2017; Merchan et al., 2014).

The diverse ways in which people interact with biodiversity requires us to consider how to more fully incorporate this into stated preference studies. Here we aim to fill this conceptual gap and show how participant-derived aspects of the use value of biodiversity can be integrated into a CE. We design the CE via a multiple-step participatory process that builds on qualitative understandings of how people interact with, experience and gain wellbeing from British forests (Austen et al., 2021, 2023; Fisher et al., 2023; Irvine et al., 2023). By doing so we uncover that sensory experiences of biodiversity (sights, smells and sounds) are salient and uniquely include these as attributes within a CE. We also include deadwood for decomposition, an attribute that is frequently used (Sacher et al., 2022) in CEs to assess public preferences for an indicator of forest ecological function. We thus highlight the importance of participatory methods in designing attributes in a manner that reflects how the public relate to and experience biodiversity. Aligning forest creation and public preferences may help ensure public support for forest restoration initiatives.

2. Methods

2.1. Study system

Temperate forests, although less biodiverse than their tropical counterparts, comprise 16 % of global forest area (FAO, 2020). Often temperate forests are less intact in regions of high population density and intensive agriculture (FAO, 2020), so are frequently the focus of forest creation and restoration initiatives. For instance, the UK government aims to deliver 30,000 ha of new woodland creation per year by 2025 as part of its net-zero strategy (HM Government, 2023). If this is achieved, it would increase national forest coverage in England from 14.53 to 16.57 % by 2050. We also decided to focus on British forests because they are distributed across the country, occurring both inside and outside of urban areas (Forest Research, 2020). Moreover, they tend to be accessible to the public and are the third most visited type of environmental space behind 'urban parks' and 'paths, cycleways, and bridleways' (Natural England, 2019). Forests encompass young thicket copses to old growth woodlands with mature trees, therefore representing a wide range of ecological conditions and supporting a varied array of biodiversity.

2.2. Survey development

CEs follow Lancaster's (1966) theory of economic value, which assumes that individual utility from consuming a good is a composite of utilities for the individual attributes of that good. In a CE, participants are asked to choose between alternatives, which vary in the levels of certain attributes. Preferences for the different attributes can be expressed in WTP-terms. The distribution of the estimated attribute specific marginal WTP is then informative of respondents' preferences. However, as the estimates are specific to the attributes included in the CE, researchers must carefully consider how and what exactly is valued.

We undertook three phases of survey development: (i) identifying suitable biodiversity attributes; (ii) choice experiment and survey design; and (iii) survey piloting and design efficiency. Our approach combined an extensive deliberative participatory process to generate the biodiversity attributes and their levels, as well as more traditional methods to test survey comprehension and CE design efficiency.

2.2.1. Identifying suitable biodiversity attributes

We embedded attribute development within a multi-stage participatory process. We held four weekend-long workshops, one per season (winter, February; spring, April; summer, June; autumn, October), during 2019. A total of 194 individuals from the target population (adults aged 18 years old or older, resident in England, Scotland, and Wales) attended one of four workshops (Irvine et al., 2023). Each workshop followed the same process design, consisting of a range of in situ (within a forest) and ex situ (indoor) activities, followed by facilitated ex situ discussions to prompt further insight about participant experiences of forest biodiversity. The activities and discussions were audio recorded, transcribed verbatim and anonymised. Transcripts were imported into, and coded within, NVivo Version 12 (QSR, 2009). We carried out a thematic analysis (Braun and Clarke, 2006). The findings provided a rich and deep understanding of how people conceptualise their experiences of biodiversity, including if/how they might prefer and/or value different aspects of it. The various aspects of their experiences emerged from the analysis, rather than being hypothesised a priori. This workshop stage of the process yielded an initial set of biodiversity attributes that could be included in the CE including sounds, colours, shapes, textures, smells, and behaviours alongside other biodiversity metrics; see Irvine et al. (2023) for further details. Throughout the CE we replaced the word forest with 'woodland' as this word is in more common usage in Britain and was readily understood by participants.

Biodiversity attributes were then explored in more depth during nine, hour-long, online focus groups, each with up to seven individuals invited from the target population. In total, 59 individuals participated. The approach to the workshops and focus groups was guided by the environmental psychology literature, particularly research investigating restorative effects of outdoor recreation, with further details on the participatory procedures available in Irvine et al. (2023). From the focus group stage of the process, we chose three biodiversity attributes, from the initial 17, that elicited the greatest range of responses across the activities with participants: (i) variety of colours; (ii) variety of smells; and (iii) variety of sound. This approach ensures that we used attributes that were salient to the public. Three levels ('low', 'medium', 'high') were generated for each biodiversity attribute. Low, medium, or high variety of colours were visualised using exemplar colour palettes typical of a British forest in the season the survey was run. Our use of palettes to describe the variety of colours reduced the likelihood that participants had different interpretations of this attribute. The survey text informed participants that colours could be varied in a forest through *"changes to the management [that] could create a woodland with a higher variety of colours within it."*. For instance, trees could be planted that retain colour all year, with tree cover/density managed (e.g., via traditional coppicing practices) to encourage forest floor flowering plants.

It was more challenging to develop attribute levels for smells as people generally struggle to describe smell verbally (Fisher et al., 2023). We, therefore, represented the increasing variety of smells in each level using words that resonated with participants' workshop transcripts: 'fresh', 'clean', 'woody', 'damp', 'earthy', 'floral', 'herbal', 'spice', 'floral' and 'fungi'. Participants were informed that the woodland would always have a "low" variety of smells which we described as 'fresh' and 'clean' (Fig. 1). While "fresh" and "clean" were derived from our workshop transcripts and may have positive valence, they are credible descriptions for a "low" variety of smells; similar to how shades of green were used in all the colour palettes. We described changes to the 'medium' or 'high' variety of smells as they "*[would] add an additional three smells from the list. A high variety of smells would add six smells from the list.*". To describe how variation could arise, participants were informed

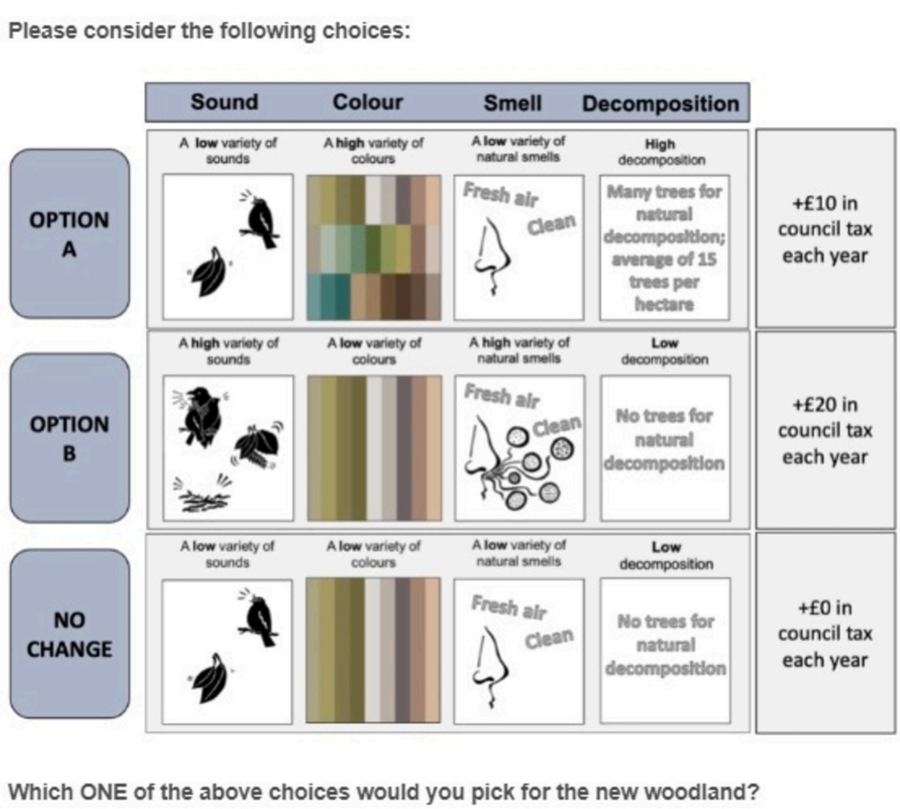

Fig. 1. Example choice card completed by participants in a study of WTP for improvements in sensory experiences associated with forest biodiversity. Four biodiversity attributes (colours, smells, sounds, and deadwood for decomposition) were presented and linked with proposed changes in annual local tax.

that a *"wider variety of natural smells could be promoted by planting vegetation such as wild herbs or flowers.*", and management could encourage flowering plants.

To represent the variety of sounds, we recorded three audio clips corresponding to the three levels of variety of sounds, each one correctly representing seasonal biodiversity sounds, and required participants to play these before they answered the CE tasks. The mechanism for changes in the variety of sounds was described as *"changes to the management in the new woodland [that] could promote a greater variety of sounds, for example, more bird sounds. It could also include having more trees with broad leaves to increase rustling noises in the wind."* explicitly referencing types of sounds discussed in the focus groups. The low, medium, and high variety were represented on the choice card pictorially with an increasing amount of leaves rustling, bird sounds, and twigs snapping.

Given the novel nature of our sensory experience biodiversity attributes, we wished to include an additional attribute that is routinely included in CEs that assess public preferences for forest quality. By doing this we were able to demonstrate that the CE had convergent validity to other valuation exercises, as well as benchmark WTP for sensory experience attributes against an attribute that is already well characterised in the literature. We chose to include deadwood for decomposition as a fourth biodiversity attribute because: (i) it is commonly used in CEs (e.g., Bakhtiari et al., 2018; Sacher et al., 2022); and (ii) during our workshops, participants responded heterogeneously to it. For instance, discussion considered both negative: "*…rotting trees, rotting down and things"*, and positive aspects: "*the decay is a vital part of the forest. Without decay the forest would die eventually"*. We represented this attribute as the amount of deadwood for decomposition that could be present in the forest.

2.2.2. Choice experiment and survey design

After selecting relevant attributes, the next stage of the process involved holding three pre-testing focus groups with the target population, each with six individuals, to develop the wording for the management scenario and introductory text, explore the wording of the CE, and the comprehensibility of the choice cards, attributes, and their levels. The management scenario presented participants with a hypothetical situation in which a new forest was to be created near to where they lived ("*…in your local area*"), although the exact location was not specified. We did not describe potential accessibility of this forest to allow the scenario to generalise across participants. To ensure that participants perceived the policy to be consequential, the final description of the scenario noted that it would be "*managed by Forestry England, Natural Resources Wales or Scottish Forestry, depending on where you live. The woodland will be established following best practice and the UK Forestry Standard Guidelines.*". The scenario was considered realistic due to increased publicity regarding forest creation and restoration, as well as UK government targets to expand tree cover. In the introductory text, participants were informed that, at an additional cost, biodiversity could be enhanced to ameliorate the sensory experiences *"There is an opportunity for the local community to change the levels of these elements, increasing the variety of sounds, colours, and smells, as well as the decomposition that will be present in the woodland. Any change to management to deliver these changes would require additional funds.*". This change would not be immediate as participants were informed that "*creating a new woodland successfully requires a lot of work in the early years to balance different management objectives.*".

When creating new forests, deadwood would be unlikely to occur naturally for several decades, although the ecological function can be enhanced through management (Hekkala et al., 2016; Müller and Bütler, 2010; Sandström et al., 2019). Participants were told that this is the case prior to being shown the choice cards: *"When establishing a new woodland, this [deadwood for decomposition] would not be expected to happen for decades. However, management techniques can be used to start the process early, by bringing deadwood into the new woodland. The deadwood brought into new woodland would be completely disease/pest free. Currently, no deadwood would be brought into the new woodland."*. The number of trees per hectare was specified for each attribute level (0 for 'low', 7 for 'medium', 15 for 'high') as a more accessible way of expressing amount of deadwood than the volumes per hectare used in the ecological literature. Participants were also told that the benefits of deadwood for decomposition included improved carbon storage, soil biodiversity, and soil quality: "*… dying or dead trees can promote natural decomposition in woodlands. Doing this supports numerous living processes-improving soil quality, storing carbon and increasing biodiversity.*".

The pre-testing focus group stage helped to agree on a suitable payment vehicle. Participants were informed that increasing the different attribute levels required a change in management of the forest that had to be funded through an additional tax payment. We used council tax, which is a local tax in Britain that is based on property value. Participants in these focus groups believed this was the most credible payment vehicle for our context. Payments were additional British Pounds (GBP) per household per year for ten years. The survey text added that this would apply to the entire local area and described a credible reason for the ten-year time limit: "*This increase would apply to everyone in your local council area. After ten years the woodland would continue to establish naturally and there would be no further cost to you.*". Seven levels (£0, £2, £4, £10, £20, £35, and £60) were used in the design, following the values used by previous studies (Colombo et al., 2009; Dallimer et al., 2014) and modified based on the focus group discussions. The zero-tax level was only used for the 'No Change' status quo alternative.

In the final survey design, each participant was asked to complete nine choice cards. Each choice card had three alternative options, including one that was 'No Change' (the status quo, with no payment and the biodiversity attributes [colours, smells, sounds, and deadwood for decomposition] at their lowest levels), and two others labelled 'Option A' and 'Option B' that differed on each card (Fig. 1). The three alternatives were described using all four biodiversity attributes and annual local council tax. Each attribute was described individually to avoid implying any links or correlations between them.

In addition to the CE, the survey included questions on sociodemographic factors (gender, age, ethnicity, income, urban), and other variables known to influence values and preferences for forests (Agimass et al., 2018; Koppen et al., 2014): distance to nearby forest, membership of environmental charities, forest visit frequency (within the season of surveying and prior seasons), and forest biodiversity perceptions (e.g., Czajkowski et al., 2017; Irvine et al., 2023), although not all variables were used in all models. Most variables were dichotomised and dummy coded for ease of inference, but we preserved the continuous coding where meaningful to do so. Coding and summary statistics for all variables used are described in Table B1. To investigate how preferences for the sensory experience of biodiversity was affected by impairments, we also asked whether participants had any sensory (sight, hearing, and/or smell) impairment (Table B1). These three sensory experience dummy variables were used as interactions with the ASC in selected mixed logit models. For robustness, we also demonstrate an alternative specification where we interacted each attribute with its associated sensory impairment responses to understand how the effect of impairments depended on the sense, although we avoid over interpreting the results of this model given the potential for endogeneity issues between the interaction terms and the preference parameters for each attribute. Finally, two-tailed Mann-Whitney tests were used to examine whether mean conditional WTP was different between participants with and without one of three sensory impairments.

We collected data on frequency of forest visits as a measure of time spent in nature which can have notable health and wellbeing benefits (e.g., Dallimer et al., 2012; Marselle et al., 2021). Consistent with the work of Taye et al. (2019) on childhood forest experiences, we collected data on historical visit frequency. However, childhood visit frequency (correlation = 0.319; $p < 0.001$), teenage visit frequency (correlation =

0.345; $p < 0.001$) and adult visit frequency (correlation = 0.351; $p < 0.001$) were correlated with forest visit frequency in the most recent season, so were omitted from the modelling to avoid collinearity. While we collected data on forest visit frequency in each of the four prior seasons, visit frequency in winter 2021 was highly correlated with visit frequency in the previous autumn (correlation = 0.865; $p < 0.001$), summer (correlation = 0.759; $p < 0.001$), and spring (correlation = 0.787; $p < 0.001$). Forest visit frequency in the season of surveying (winter 2021) was chosen as the most recent and thus accurate and salient measure of visit frequency. Visit frequency was treated as a continuous variable such that higher scores meant more frequent forest visits.

Stated preference studies commonly elicit participant income (Johnston et al., 2017). This can remind participants about their budget constraints and reduce hypothetical bias, as well as being used to evaluate income effects on WTP, explain spatial patterns in WTP, and subgroup preference heterogeneity (Toledo-Gallegos et al., 2021). Here, we elicited gross annual household income before the CE questions as a reminder of participants' budget constraints (Mariel et al., 2021). The income variable was dichotomised as above or below sample median income to examine how preferences differed between these subgroups (Faccioli et al., 2020).

Motivated by the rich literature on distance-decay effects on WTP, we assessed the distance between participants and a forest nearby them (Bakhtiari et al., 2018; Czajkowski et al., 2017; Glenk et al., 2020; Schaafsma et al., 2013). In our survey, participants indicated the location of their household and forest nearby them on a map. For verification, participants were also asked to provide the first part of their postcode, and as corroboration also asked to select how far in miles (converted to km for analysis): "*the approximate distance as the crow flies (one way) between your home and your nearby woodland.*". Distance was coded as a continuous variable of increasing distance from the nearby forest to the participant.

To measure perceptions of their nearby forest, participants were asked to evaluate the variety of colours, smells, sounds, and the amount of deadwood for decomposition from 0 ('very low') to 100 ('very high'). We used the individual-level mean of these four measures as each participant's overall perceived biodiversity score. To facilitate comparisons between attributes we used this average measure across all models rather than investigating attribute-specific perceptions.

Although perceived and objective measures of biodiversity are often uncorrelated (Dallimer et al., 2012; Hoyle et al., 2018), perceived biodiversity can be correlated with wellbeing (Dallimer et al., 2012; Fisher et al., 2021). We used perceived measures as objective measures relevant to our attributes did not exist. Objective biodiversity measures, such as species richness, may not capture the variety of sensory experiences, and our participatory processes indicate that participants may not relate to them as strongly as variety of colours, smells, and sounds. Future work to benchmark sensory experiences both to field-based metrics (e.g., colour, smell, and sound diversity) associated with those senses andobjective measures of biodiversity may be valuable.

2.2.3. Survey piloting and design efficiency

The CE design that combined the biodiversity attributes and levels was created using the software Ngene (ChoiceMetrics, 2012), and consisted of 18 choice cards that were divided into two blocks. An initial design was generated using approximate priors for the utility weights based on similar research and experience. The final stage of our process was testing the design in a pilot survey with the target population, comprising 200 participants in total (100 per block). Based on the pilot survey findings, no changes were made to the payment levels. Utility weights were estimated using a simple multinomial model (MNL-optimised), resulting in a new design from updated priors. The choice cards were then manually checked for realism and dominating alternatives were removed, resulting in a final design with a D-error of 0.0186. This process is crucial to ensure the theoretical validity of the final WTP estimates (Mariel et al., 2021).

2.3. Data collection

Data were collected January to March 2021 using the online survey platform Qualtrics (www.qualtrics.com). Our participant sample quotas, which were recruited by a social research company, were: a balance of gender across people who identify as a man or woman; age balance across three brackets (18–29 years; 30–59 years; 60+ years old); a mix of White British and other ethnicities (>20 %); a mix of individuals from different socioeconomic groups (ABC1 [higher income]; C2DE [lower income]; based on employment of chief income earner); a diversity of people resident in different government regions of England, plus individuals from Wales and Scotland; and a mix of urban and rural (>20 %) dwellers. We tested (Table B2) whether the sample was sufficiently similar to the population using G tests, a more reliable alternative to the common Chi^2 test (Hoey, 2012). We report the test statistic and *p* value against the null hypothesis that there is no difference in the frequency of different groups between our sample and the wider population. We deliberately oversampled individuals of non-White British ethnicity, as our previous work had demonstrated differences in the non-market values people hold for forests according to ethnicity (Maund et al., 2020). Ethical approval for data collection was granted by the School of Anthropology and Conservation Research Ethics Committee, University of Kent (Ref: 009-ST-19).

2.4. Data analysis

Data analysis was undertaken using RStudio 4.4.1 with Apollo version 0.3.3 (R Core Team, 2021; Hess and Palma, 2019). Replication materials including Ngene design, survey design, R code and data are available at doi:10.22024/UniKent/01.01.480.

2.4.1. Preference heterogeneity

CE data are typically analysed using the Random Utility Model (RUM) (Train, 2009). The RUM assumes that participants choose the alternative in a CE that maximises their utility (Eq. (1)). The utility U (Eq. (1)) of individual n conditional on alternative i is composed of a deterministic component V_{in}, and a stochastic component ε_{in} independently and identically distributed extreme value (Train, 2009). A commonly used and highly flexible method of modelling preferences in the RUM is a random-parameters mixed logit (MXL) model (Mariel et al., 2021).

$$U_{in} = V_{in} + \varepsilon_{in} = \beta_n' X_{in} + \varepsilon_{in} \quad (1)$$

$$U_{in} = ASC_{in} + \beta_n^{Tax}\left(WTP_n' X_{in}^{Attributes} + Tax_{in}\right) + \varepsilon_{in} \quad (2)$$

The deterministic component V_{in} includes a vector X_{in} containing the monetary and non-monetary CE attributes that are individual and alternative-specific, and the β_n parameters representing individual preferences for each attribute.

The conditional probability of an individual n choosing alternative i is the probability that the utility of alternative i is greater than the utility of any other available alternatives j in the set C_n (Eq. (3)). The mixed logit probability integrates this probability over a density of parameters (Train, 2009).

$$P_{in} = Pr\left(U_{in} > U_{jn,\forall j \neq i}\right) = \left\{\frac{exp\left(\beta_n' X_{in}\right)}{\sum_{j \in C_n} exp\left(\beta_n' X_{jn}\right)}\right\} \quad (3)$$

The β_n are assumed to be drawn from a known distribution depending on estimable parameters, the mean and standard deviation for the normal distribution for example (Toledo-Gallegos et al., 2021). In Eq. (2) we delineate between our monetary attribute, β_n^{Tax}, and non-monetary attributes in the CE (colours, smells, sounds, and deadwood for decomposition), $X_{in}^{Attributes}$, where attribute specific WTP is given by

WTP_n (Czajkowski et al., 2017) because we parameterise the utility function in WTP-space. The parameterisation of our utility function in WTP-space ensures that the distributions of WTP have finite moments, thus making further inference possible (Daly et al., 2012). We assume a distribution for the vector $\left(WTP_n, \beta^{Tax}\right)$ and then estimate the associated parameters.

The likelihood (Eq. (4)) for individual n choices ($Choice_n$) is an integral of the choice probabilities. Further derivation of the probabilities and log-likelihood is widely available in the literature (e.g., Czajkowski et al., 2017; Colombo et al., 2009; Train, 2009).

$$L(Choice_n|X_n,\theta) = \int_{WTP_n}\int_{\beta_n^{Tax}}\prod_t\sum_i Choice_{ijn}\frac{exp\left(\beta_n' X_{in}\right)}{\sum_k exp\left(\beta_n' X_{jn}\right)} f\left(WTP_n, \beta_n^{Tax}|\theta\right) d\alpha_n d\beta_n^{Tax} \quad (4)$$

We assumed that preferences for our four non-monetary attributes were normally distributed, which allowed for both negative and positive preferences. The mean and standard deviation were estimated for the distribution of preferences for each attribute. The tax attribute was specified as negative log-normally distributed to impose the theoretically appropriate sign (Czajkowski et al., 2017). Although our pretesting focus groups did not indicate that preferences for attributes were correlated, we followed best practice (Mariel et al., 2021) in allowing correlations to exist between each non-monetary attribute and each level given that one element of a forest could contain several attributes (e.g., new deadwood for decomposition would have a variety of colours and a woody smell). While there were three levels for each biodiversity attribute, the status quo level was held at zero to permit identification. We thus estimate WTP for two levels ('medium' and 'high') of each non-monetary attribute, which provides insight into nonlinear preferences and scope sensitivity (Czajkowski et al., 2017; Lew and Wallmo, 2011). This approach means we could examine whether participant WTP was scope sensitive to changes in attribute levels. This sensitivity of valuations to the scope of the good being valued is an important check on whether the elicited WTP is theoretically valid (Dugstad et al., 2021; Rakotonarivo et al., 2016). A further test of internal validity concerns the individual specific WTP estimates recovered from the MXL and then used throughout our analysis. Given the challenges of recovering theoretically valid WTP from mixed logit models (e.g., Daly et al., 2012), we computed the three tests suggested by Sarrias (2020): (i) whether the average of the conditional mean WTP per attribute is at least 90 % of the estimated μ value; (ii) whether the variance for the WTP represents at least 60 % of the estimated σ^2 value; and (iii) whether the conditional distribution is sufficiently similar to the unconditional distribution using the Kolmogorov-Smirnov test. Combining these three tests yields an important insight into whether the individual-specific WTP we estimate is internally and theoretically valid for further inference (Rakotonarivo et al., 2016; Toledo-Gallegos et al., 2021).

We estimated one alternative specific constant (ASC), representing the 'No Change' alternative (Train, 2009), and held ASCs for the two other alternatives constant at zero. We used a fixed, rather than random, ASC to: (i) avoid convergence issues that can and did arise when all the attributes are randomly distributed (c.f., Revelt and Train, 1998; Toledo-Gallegos et al., 2021); (ii) allow us to focus on the heterogeneity in preferences for the CE attributes; and (iii) permit easier interpretability of our control variables. As the ASC is confounded with the 'low' level of our attributes, we cannot truly interpret it as status quo bias, rather an indication of preferences for choosing the status quo option. A negative (positive) sign of the estimated ASC can be interpreted as preferences against (for) the 'No Change' alternative in the CE with associated 'low' levels of each attribute. In one model ("Model One"), we include just the attributes, while in "Model Two" we interacted the ASC with sociodemographic covariates (age, ethnicity, country of residence, gender, household income, urbanicity) to control for heterogeneity in preferences towards the status quo and improve model fit (Mariel et al., 2021; Toledo-Gallegos et al., 2021). A third model ("Model Three") was estimated (Appendix B only) to demonstrate the robustness of our results to including further covariates.

We first estimated a simple multinomial logit (MNL) model (Table B3) to recover the parameter estimates as starting values for our preference-space (Table B4) and WTP-space mixed logit models (Table B5). The WTP-space results were then used as starting values for the WTP-space models with correlations (Table B6); a consecutive approach to avoid convergence to an inferior model fit (Mariel et al., 2021). The WTP-space model with correlations is our preferred specification as it allows a flexible and heterogenous representation of participants' preferences and avoids issues with recovering WTP. We also estimated a final specification with interactions in the utility functions for Options A and B between each attribute with associated sensory impairment responses (Table B7). For completeness, each model was estimated using 1000 Pseudo Monte-Carlo draws for the random parameters, although results were robust to alternatives using Sobol or modified Latin hypercube sampling (MLHS) draws (Hess and Palma, 2019; Mariel et al., 2021). Further details on the specification are available in the Appendix A.

2.4.2. Individual preferences

Individual preferences for attributes of forest biodiversity were evaluated by recovering individual specific WTP estimates from the MXL models. In Model Two we controlled for sociodemographic variables by interacting them with the alternative-specific coefficient. We recovered the conditional and unconditional distributions of individual specific WTP values for each attribute level from Model Two, which facilitated tests of differences in WTP between subgroups. We used the Mann-Whitney non-parametric test of means (e.g., Matthews et al., 2017) to test whether impairment of senses among participants influenced their WTP for any of our three sensory attributes. Lastly, to examine how individual welfare changes with the different attribute levels, we calculated consumer surplus using the WTP elicited from Model One (Mariel et al., 2021; Rambonilaza and Brahic, 2016).

3. Results

1901 respondents started the survey, from which we collected 1711 completed responses (190 were excluded for not completing all the CE choice cards or providing insufficient location responses), equating to a completion rate of 90 %. We do not have information on how many participants were sent the survey but did not start it. Our sample closely matched the wider population, except where we deliberately oversampled minority ethnicities (19.75 % versus 13 %) (Table B2).

We found that both the mean and standard deviation parameters for all sensory attributes were highly statistically significant (Table 1A). The small standard errors indicate relatively precisely estimated means, while the large estimated standard deviations indicate sample heterogeneity. We further report statistically significant correlations between each level of the sensory attributes (Table B6), suggesting that preferences for each sensory attribute were inter-linked. The WTP is statistically different between different attributes and levels (Table B8) with

Table 1A
Results from the two MXL models ($N = 1711$) estimated in WTP-space with attribute correlations. The estimated mean and standard deviation parameters refer to the distribution of WTP across the sample in GBP per household per year terms. We report the absolute value of the standard deviations. The estimate-specific standard errors are reported in parentheses. *P* values are represented by stars (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$). Note, the column labels "mean", and "standard deviation" labels do not apply for the ASC. Model One diagnostics in Table 1B. Results for the sociodemographic covariates are elaborated in Table 2, and the results for the correlation terms are available in Table B6.

	Model One (Attributes only)		Model Two (Attributes and covariates)	
Attribute	Mean	Standard deviation	Mean	Standard deviation
ASC	−2.254*** (0.064)		−1.612*** (0.203)	
Tax	−3.490*** (0.109)	2.876*** (0.128)	−3.720*** (0.131)	3.336*** (0.141)
Colours: high	14.000*** (0.844)	4.032*** (0.308)	11.873*** (0.445)	0.081 (0.207)
Colours: medium	9.616*** (0.571)	1.685*** (0.247)	6.738*** (0.416)	0.650*** (0.141)
Smells: high	8.478*** (0.514)	6.470*** (0.356)	8.023*** (0.271)	4.263*** (0.195)
Smells: medium	1.223*** (0.307)	0.360 (0.289)	1.812*** (0.387)	3.949*** (0.147)
Sounds: high	7.130*** (0.626)	5.105*** (0.178)	4.545*** (0.248)	4.650*** (0.150)
Sounds: medium	−3.266*** (0.475)	0.601* (0.316)	−3.387*** (0.289)	0.830*** (0.195)
Deadwood for decomposition: high	−2.891*** (0.534)	6.461*** (0.429)	−4.198*** (0.251)	4.085*** (0.160)
Deadwood for decomposition: medium	5.778*** (0.522)	7.074*** (0.439)	4.631*** (0.293)	3.763*** (0.297)

Table 1B
Diagnostic results from the two MXL models (N = 1711) estimated in WTP-space with attribute correlations. The addition of the sociodemographic covariates marginally improved model fit according to lower AIC and final log-likelihood.

Measure	Model One (Attributes only)	Model Two (Attributes and covariates)
AIC	25,257.872	25,244.647
Adj.R^2	0.249	0.249
Log-likelihood	−12,561.936	−12,549.324

summary statistics for each attribute's WTP (Table B9), and theoretical validity tests (Table B10) available in Appendix B. The model fit and diagnostics are presented in Table 1B.

Variety of colour was the most preferred forest biodiversity attribute (Table 1A), with participants willing to pay the most for marginal improvements from 'low' to 'medium' and 'low' to 'high' levels. The results in Table 1A were consistent with scope sensitivity, in that participants were willing to pay for more variety of colours.

For the variety of smells, participants were willing to pay a positive amount for both a medium and a high variety of smells, given the positive (and statistically different from zero) coefficients in Model Two (Table 1A). There were larger standard deviations for 'high' suggesting more variety had a more heterogeneous response. By contrast, there were opposing preferences for the variety of sounds; negative WTP for changes from a 'low' to a 'medium' level, but positive for changes from 'low' to 'high. Again, standard deviations were greater for 'high'. The mean WTP was statistically different between each attribute and level (Table B8). Although the sign of the medium level was different in our preference-space model, we follow the WTP-space model as the internally valid method of recovering WTP estimates.

Table 2
Estimated parameters from Model Two for each variable interacted with the ASC parameter with standard errors reported in parentheses and statistical significance against the null hypothesis. The null hypothesis is that the coefficient is equal to zero. *P* values are represented by stars (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$). Positive (negative) parameter estimates indicate that participants preferred (not) choosing the status quo option in the CE.

Variable	Coding	Reference category	Parameter Estimate	Sample Mean	Sample standard deviation
Age (Younger than sample median age)	Dummy	Older than median	−0.819*** (0.136)	0.52	0.50
Country of residence (Wales or Scotland)	Dummy	England	−0.133 (0.127)	0.62	0.49
Ethnicity (White)	Dummy	All other ethnicities	−0.026 (0.161)	0.80	0.40
Gender (Man)	Dummy	Woman	0.066 (0.133)	0.50	0.50
Household income (Greater than or equal to sample median income)	Dummy	Less than sample median income	−0.308** (0.127)	0.52	0.50
Urbanicity (Urban)	Dummy	Rural	−0.105 (0.141)	0.76	0.43

Mann-Whitney non-parametric two-tailed tests of whether conditional mean WTP was different for participants with and without relevant impairments found statistical differences in WTP for increased variety of colours ($p = 0.041$ and 0.036), smells ($p = 0.042$ and 0. 006), but not sounds ($p = 0.387$ and 0.445) for the 'medium' and 'high' levels respectively. Thus, having any sensory impairment may affect WTP for these attributes, although the effect size was small (Fig. B1; Table B11). Despite the insignificant effect on WTP, a revised Model Two, interacting the sensory attributes and their related impairments in the utility function for Options A and B, indicated that having a hearing impairment may have positively influenced the utility gained from increased varieties of sounds (Table B7).

We found a statistically significant effect of visit frequency on choices (coefficient estimate: −0.132, standard error: 0.044; Table B6), indicating that participants who visit more frequently were less likely to choose the status quo option. We found mixed results on the effect of visit frequency on WTP. Mann-Whitney non-parametric two-tailed tests of whether conditional mean WTP was different for participants at each level of visit frequency found significant differences in WTP (Table B12; Fig. B2) between participants who never visited and those who had visited at least once that season.

We found that seven of our eight levels of the non-monetary attributes passed all three of the internal validity tests, with the mean and variance of the conditional distribution of the individual-level WTP being sufficiently close to the estimated population values (Table B10). Although the conditional WTP for the remaining attribute level, the high variety of sounds, failed the mean test (the mean was 87 % of the estimated parameter, rather than ≥ 90 %), it passed the variance and distribution tests. This indicates that the distributions of WTP were theoretically valid for further inference. For example, using the WTP estimates from Model One for simplicity, across all four biodiversity attributes we calculated a positive consumer surplus (status quo to 'medium' = £15.61; status quo to 'high' = £28.97) showing that welfare improves with the changes in attribute levels.

Participants reported positive mean WTP to pay for a small rise (from 'low' to 'medium' levels) in the amount of deadwood for decomposition in a forest (Table 1A). However, the mean WTP for an increase in the amount of deadwood for decomposition from a 'low' to a 'high' level was negative. Participants therefore reported significant sharply diminishing marginal utility for 'medium' to 'high' levels, suggesting that a high level of deadwood for decomposition being brought into the new forest was considered a disamenity.

Further results from the MXL models revealed a significant negative effect for income (Table 2), as higher-income participants were more likely to support changes to forest management to increase biodiversity attributes levels, while lower-income households may have supported the status quo to minimise their costs, indicating survey internal validity. However, many sociodemographic covariates (gender, urban, ethnicity) had no significant effect on choices. In our extended specification (Table B6), perceived biodiversity, distance to nearby forests, and charity involvement also had no significant effect on choices, while greater frequency of forest visits statistically influenced participant's choices.

4. Discussion

Forest restoration is one of twelve targets associated with Sustainable Development Goal (SDG) 15 ("Life on Land"; FAO and UNEP, 2020) and has become a priority for policy globally. However, the suite of international initiatives that at least partly intend to help countries meet their commitments to SDG 15, such as the Bonn Challenge (Stanturf and Mansourian, 2020) and the UN Strategic Plan for Forests 2017–2030 (United Nations, 2017), fail to deliver on promised outcomes (Duguma et al., 2020). Such initiatives will transform the landscapes in which people live and work, eliciting strong views from the communities and publics that are affected, linked to their values and preferences (c.f., Ihemezie et al., 2023; Austen et al., 2023). Indeed, the efficacy of forest creation initiatives depend on the support and insight provided by local communities and stakeholders (Elwell et al., 2018; Zhang et al., 2021). Although forest management can deliver benefits for climate, biodiversity, and human wellbeing, wellbeing benefits are dependent on the support and involvement of local groups (Pritchard, 2021; Ihemezie et al., 2023). Understanding how public preferences for forest biodiversity vary between attributes and between different stakeholders is thus an important aspect of forest creation initiatives. Here, we shed light on the heterogeneous range of preferences for forest biodiversity attributes. The in-depth participatory process that we undertook prior to CE development indicated that participants strongly related to attributes of forest biodiversity described in sensory terms. Given that the multi-sensory experience of biodiversity is an important factor in delivering wellbeing benefits (Fisher et al., 2023), our findings indicate that although planting large monocultures may satisfy tree planting objectives, they are likely to deliver only limited wellbeing benefits if they feature a low variety of colours, smells, and sounds.

The strongest preferences were for increases in the variety of colours. The statistically significant WTP indicates that visual stimuli and variety is an important component of forest recreational experiences and value. This finding is consistent with other studies in different environments (e.g., colour diversity in meadows and urban green infrastructure; Hoyle et al., 2018; Hoyle et al., 2017). These results may be linked to the social and cultural importance of vision and sight (Austen et al., 2021) and how colours may act as indicators of things such as danger or seasonal change (Austen et al., 2023). We found that preferences for colours were scope sensitive as higher variety of colours was valued more highly (Dugstad et al., 2021). Given the scope sensitivity of this attribute, the implication for management is that trees with a more diverse variety of colours may have widespread public support for their planting. Further, preferences for a variety of colours may correspond with preferences for species diversity, suggesting that preferences for the sensory experience of biodiversity may ultimately align with similar management priorities.

We found negative mean WTP for a medium variety of sounds and positive mean WTP for a high variety of sounds. The mean WTP was statistically different between the medium and high varieties of sounds but did not fulfil strict scope-sensitivity. Failing scope-sensitivity may be expected given that prior studies found preferences for sounds to be heterogeneous and often dependent on context. Bakhtiari et al. (2014) noted their focus groups' preference for "quietness" in forests, and Merchan et al. (2014) found that participants may be willing to pay for programmes to reduce anthropogenic sounds in urban parks. These two findings imply that anthropogenic sounds disturbing a tranquil green space may be considered a disutility, and that different types, and contexts, of sounds may elicit different responses. For example, Calleja et al. (2017) found that anthropogenic sounds, such as running machines necessary to maintain natural landscapes, were perceived as noise and rated negatively by participants. However, the resulting landscapes supported more tree and bird sounds, which were positively rated. Further, Ratcliffe et al. (2018) found that participants perceived restorative potential in forests was higher with a variety of natural sounds including bird sounds. To limit variation in how participants interpreted our variety of sounds attribute, our study provided audio clips that featured natural, not anthropogenic sounds, and encompassed a shift from relatively simple to more diverse sounds. Introducing more diverse sounds in the "high" variety audio clips, may have led to greater heterogeneity in preferences for this level, as evidenced by the larger standard deviations for the high variety in both the preference-space and WTP-space models. Given the heterogeneous preferences for changes in the variety of sounds, forest managers should be cautious when using these findings to inform management decisions. While there may be public support for increasing the variety of natural sounds, such as bird song in forests, managers must also consider the perceived value of tranquillity, given the large standard deviations of the distribution of preferences.

We found a small, but positive WTP for a medium and high variety of smells; indicating that the variety of forest smells was an important component of the use value of experiencing biodiversity. Although we found that participants reported a broadly positive WTP for increases in the variety of smells, the large standard deviations for both the medium and high varieties suggest that a subset of participants preferred a low variety of smells over a change to medium or high variety. This could be due to our survey describing some management actions as introducing "*species that have a more distinctive smell [that] could enrich the variety of smells you may encounter*", with the resulting estimates indicating heterogenous preferences around distinctive smells. The observed negative preferences could alternatively be attributed to the difficulties that people have describing smells, despite the evidence that smell is both important in underpinning preferences, and has implications for wellbeing (Fisher et al., 2023). For both the medium and high variety, the positive mean WTP is indicative of scope sensitivity (Dugstad et al., 2021; Lew and Wallmo, 2011). Our results imply that forest management to introduce vegetation and species that change the variety of forest smells from just "fresh" and "clean" to include 'woody', 'damp', 'earthy', 'floral', 'herbal', 'spice', 'floral' and/or 'fungi' smells, may have public support.

How people experience and interact with biodiversity is multifaceted and influenced by many of the senses (Austen et al., 2023). We know that sensory occlusion, including of the olfactory sense, can affect the benefits of green exercise (Wooller et al., 2016). However, stated preference studies on biodiversity rarely include information that is not either descriptive or visual. This potentially omits an important aspect of how people value and experience the natural world and, therefore, how people might make decisions on WTP within stated preference studies. Framing the three sensory attributes as varieties of colours, smells, and sounds that the participants would experience in the proposed forests clearly linked our attributes to recreational use value. However, we did not inform participants that they would visit the forests, and indeed some of our participants reported that they never visited, suggesting that part of non-use value may be the variety of sensory attributes that others who do visit forests can experience. While Austen et al. (2021) suggested that commonly used ecological metrics may not be best for assessing public support for biodiversity, our study did not directly test whether sensory or other metrics are more reflective of public preferences. Instead, our findings highlight the importance of sensory interactions with biodiversity in influencing participants' values.

Notwithstanding heterogeneity in the distributions of preferences for sensory experiences of biodiversity within forests, in general, participants preferred more diverse colours, smells, and sounds, although higher levels of variety were associated with greater preference heterogeneity. The variation in preferences for sensory attributes indicates that generic evaluations of "green space" obfuscate important variation in the personal experiences of forest biodiversity (Austen et al., 2023). Nevertheless, the heterogeneity that underpins these broad patterns further highlights the range of views on forest biodiversity. Diverse perspectives on the value of forests (e.g., Austen et al., 2023; Ihemezie et al., 2023) are commonly found. However, for stated preference work that is intended to inform the creation and management of forests (Pritchard, 2021), including such diverse views on environmental goods remains a key challenge (Elwell et al., 2018).

The link between biodiversity and wellbeing has been explored in the ecology and health literatures (e.g., Bennett et al., 2015; Dallimer et al., 2012; Marselle et al., 2021). This has included investigations of how visual, auditory, and olfactory interactions with biodiversity may be important. For instance, a higher variety of colours underpins perceived restorative effects (Akers et al., 2012), and diverse natural sounds are linked to perceived wellbeing benefits (Ratcliffe et al., 2018), especially through stress recovery and restoration (Alvarsson et al., 2010). Incorporating wellbeing metrics into the analysis of CE data may improve our understanding of heterogeneity in preferences (e.g., Vondolia et al., 2021; Faccioli et al., 2020). The generally positive preferences for more variety in the colours, smells, and sounds associated with forest biodiversity may therefore be indirectly linked to participants' perceived health and wellbeing benefits.

When compared to the sensory experience of forests, the ecological function of deadwood for decomposition was valued less. This does not mean that the attribute did not matter to participants; given the pretesting responses and the statistical significance of both levels, deadwood for decomposition was evidently an important component of forest use value. There was also no indication that participants objected to bringing in deadwood for decomposition rather than allowing it to form naturally. Indeed, relatively homogenously across the sample, participants report a positive WTP for the change to a medium level of deadwood for decomposition (an increase from 0 to 7 trees per hectare); a finding common to the literature (e.g., Sacher et al., 2022; Bakhtiari et al., 2018; Rambonilaza and Brahic, 2016). However, for a high variety (up to 15 trees per hectare), we found a sharp decrease in WTP across the whole distribution.

The empirical evidence on the scope sensitivity of preferences for deadwood is mixed. Although many studies reported that participants' WTP positively increased with the proposed number of dead trees (e.g., Camps et al., 2014; Bakhtiari et al., 2018), others only found positive WTP for a 'medium' level of deadwood for decomposition, with negative (Giergiczny et al., 2015) or not significant (Nielsen et al., 2007) preferences for higher levels. Gundersen et al. (2017) speculated that the preference for lower levels of deadwood to be present may be related to prospect refuge theories, which argue that people prefer a landscape with both views and enclosures (Dosen and Ostwald, 2016), although they did not explicitly test whether this was a salient influence on participants. A further argument for the negative WTP for a high level of deadwood could be reduced perceived recreational values; sites with more deadwood for decomposition may be less preferred for recreational use given untidiness or lower aesthetic values (Giergiczny et al., 2015; Sacher et al., 2022). Hence, a landscape with a medium level of deadwood for decomposition may be preferred over a landscape with a lower level. The implication for forest management is that although the presence of some deadwood for decomposition would have public support, this may be sensitive to the number of trees. Although people may generally support forest creation for its role in mitigating climate change and enhancing natural habitats (Baur et al., 2016; Peterson St-Laurent et al., 2018), measures that further enhance ecological functions in and of themselves may not be as important to participants as the sensory experience of a biodiverse forest.

One plausible reason that deadwood for decomposition was the least preferred attribute was a lack of familiarity with the role that deadwood plays within forests. Rambonilaza and Brahic (2016) observed that participants who were well-informed about the ecological benefits of more deadwood for decomposition reported higher WTP, speculating that low WTP may be explained by lack of familiarity and salience, especially when compared to aesthetic attributes. This argument is consistent with Gundersen et al. (2017) who found that preference scores increased when participants were given in-depth information about the ecological role of deadwood. In general, the positive WTP we find for a medium level of deadwood for decomposition, and potential for WTP to increase with familiarity, echoes Sacher et al. (2022) in suggesting that the presence of deadwood for decomposition in new forests is unlikely to significantly alter WTP for forest creation.

Despite our study indicating that values for sensory experiences of biodiversity do not always adhere to strict scope sensitivity, other results do align with well-accepted patterns within the stated preference literature. For instance, our data on the frequency of forest visits align with those of Taye et al. (2019), showing a positive relationship between visit frequency as a child, a teen, and then as an adult. We found that participants who visited forests less frequently or not at all in the season of surveying had statistically significant differences in: (i) the likelihood of choosing the status quo option ('No Change'); and (ii) the mean WTP for each attribute. Our finding that participants who visited more frequently were less likely to have chosen the status quo option aligns with previous CE research (Rambonilaza and Brahic, 2016; Schaafsma et al., 2013; Toledo-Gallegos et al., 2021). We also found that the mean WTP for each attribute was significantly different between participants who did not visit at all versus those who did (c.f., Czajkowski et al., 2017), indicating that preferences for changes to attributes of forest biodiversity may vary significantly between those who visit forests frequently and those who do not. However, there were no statistically significant differences in mean WTP between any other levels of visit frequency in any of our attributes. This finding suggests that the difference in choices and WTP is limited to those who did not visit at all versus those who did, even infrequently. Our results are consistent with Gundersen et al. (2017), who found no variation in preference scores for forest scenes with and without deadwood between participants with different frequency of visits, although their study evaluated preferences using ratings of forest photographs rather than monetary terms. In our third model specification, we included a measure of perceived biodiversity in the participants' nearby forests, rated from 0 to 100, but the marginal effect of a one-point increase in perceived biodiversity on status quo choices was not statistically different from zero.

Our results on income effects were also broadly consistent with previous literature. The negative interaction of the income dummy with the ASC suggests that higher-income participants were more likely to support policy options that featured increases in the attributes of forest biodiversity. This is consistent with Schaafsma et al. (2013), Johnston and Ramachandran (2014), and Toledo-Gallegos et al. (2021), who all found that higher-income respondents were less likely to choose the status quo options in their CEs. Our estimated effect of income on preferences for the status quo option are larger than that reported in Toledo-Gallegos et al. (2021), which may be due to us dummy-coding income above or below the sample median (c.f., Faccioli et al., 2020) rather than estimating the log or linear effect. Both Czajkowski et al. (2017) and Toledo-Gallegos et al. (2021) speculate that higher-income respondents are more able to spatially sort into areas with preferred characteristics, closer to forests or lower flood risk, respectively. The extent to which preferences for sensory attributes are spatially variable or clustered is an avenue for further investigation.

5. Conclusion

Forest creation and restoration initiatives are essential for biodiversity conservation, as well as mitigating climate change, but their long-term success depends on public support and stewardship. Therefore, understanding which attributes people prefer is imperative. Our contribution is to demonstrate that in-depth participatory approaches can allow for attributes that participants relate to even if they are uncommonly used or harder to describe, such as the sensory experience of biodiversity, to be included in internally valid stated preference work. We found that participants' use value of biodiversity, represented through sensory experience, was heterogeneous with the size and sign of WTP for changes in the variety of colours, smells, and sounds in nearby forests dependent on the size of the change. While we found no significant effect of levels of perceived biodiversity in existing forests on choices or WTP, there was evidence that participants with impairments, or who had higher frequency of forest visits, may be more likely to support policies to increase the variety of sensory experiences present in forests. Although our work centred on one country and habitat type, using in-depth participatory processes should become further normalised in stated preference studies. Ensuring that public preferences and forest creation/restoration goals are aligned may increase public support for the implementation and management of far-reaching landscape changes.

CRediT authorship contribution statement

Peter King: Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Martin Dallimer:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. **Thomas Lundhede:** Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Gail E. Austen:** Investigation, Writing – review & editing, Project administration. **Jessica C. Fisher:** Investigation, Data curation, Writing – review & editing. **Katherine N. Irvine:** Investigation, Writing – review & editing, Funding acquisition. **Robert D. Fish:** Investigation, Writing – review & editing, Funding acquisition. **Zoe G. Davies:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data available at doi:10.22024/UniKent/01.01.480

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Appendix A. Supplementary data

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