



Preferences for street configuration and street tree planting in urban Hong Kong



Wai-Yin Ng, Chi-Kwan Chau*, Greg Powell, Tze-Ming Leung

Department of Building Services Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, Hong Kong Special Administrative Region

ARTICLE INFO

Article history:

Received 31 October 2013

Received in revised form

10 November 2014

Accepted 14 November 2014

Keywords:

Tradeoffs

Urban planning

Urban street configuration

Urban trees

Willingness-to-pay

ABSTRACT

This study aimed to explore people's perception of tree planting in street canyons and the perceived tree impacts through a questionnaire survey. Also, by using a discrete choice experiment, it aimed to reveal how people performed tradeoffs among three streetscape attributes: namely permeability (i.e. spacing between buildings), aspect ratio (i.e. ratio of street width to building height), and tree planting. A secondary aim was to determine respondent's willingness to pay for streetscape features and tree planting. Despite published research results that indicate tree planting can have a negative impact on air quality, the survey results from 509 respondents in Hong Kong indicated that the majority of them held positive views of tree planting in street canyons. The probability of having an overall positive view was found to be higher if an individual perceived that trees could improve air quality, provide shading or did not obstruct footpaths. The preferred streetscape was high permeability, regardless of whether respondents thought that trees could or could not contribute to improving air quality. However respondents who perceived that trees could improve air quality preferred tree planting at both sides of the street over lower aspect ratio whereas those who perceived that trees did not improve air quality preferred low aspect ratio over tree planting at both sides of the street. Both sets of respondents did however agree on the preferred order of tree planting options, namely planting on both sides of the street was preferred to planting at the center of the street which in turn was preferable to no tree planting at all. The overall willingness to pay was estimated to be HK\$163.4, HK\$132.4 and HK\$121.1 per month for high permeability, street-level tree planting and low aspect ratio, respectively. The study clearly identifies high permeability as the most preferred planning option. However, the perception held by the majority of respondents that trees can improve air quality is contrary to recent research findings. This poses a dilemma for urban planners in that schemes that may be more beneficial, i.e. low aspect ratio, may face more public opposition than less beneficial schemes involving tree planting. Although the study was conducted in Hong Kong the findings should be applicable to other modern metropolises characterized by high rise buildings.

© 2014 Elsevier GmbH. All rights reserved.

Introduction

Nowadays, urban greening is a popular program with an ultimate objective of improving the environmental quality within urban areas including roadside environments. Urban greening can mitigate the urban heat island (UHI) effect and improve thermal comfort by moderating micro-climatic conditions (Avissar, 1996; McPherson, 1992; Ng et al., 2012; Park et al., 2012; Shashua-Bar et al., 2009; Taha, 1997) and provide shading (Dimoudi and Nikolopoulou, 2003; Ali-Toudert and Mayer, 2007; Shahidan et al.,

2012). It can bring other benefits including the ability to attenuate noise levels (Ozer et al., 2008; Islam et al., 2012; Van Renterghem et al., 2012), improve air quality (Akbari et al., 2001; Jim and Chen, 2008; Nowak et al., 2006) and reduce urban storm water runoff (Bartens et al., 2008; Armson et al., 2012).

Trees can also help improve individuals' well-being by helping people reduce stress (Ulrich, 1983; Van den Berg et al., 2003; Gidlöf-Gunnarsson and Öhrström, 2007) and recover from stress (Kaplan and Kaplan, 1989; Ulrich et al., 1991; Hernandez and Hidalgo, 2005; Nielsen and Hansen, 2007; Mitchell and Popham, 2008; Grahn and Stigsdotter, 2010). Additionally, trees can help alleviate the sense of oppressiveness in crowded urban areas by bringing other benefits such as an aesthetic pleasing effect (Tyrväinen et al., 2003; Escobedo et al., 2011). For example, placement of trees in front of buildings could reduce the unpleasantness of the environment,

* Corresponding author. Tel.: +852 2766 7780; fax: +852 2765 7198.
E-mail address: chi-kwan.chau@polyu.edu.hk (C.-K. Chau).

especially when located in front of taller buildings (Asgarzadeh et al., 2012).

Trees do have some negative aspects such as allergies from pollen (Comtois and Schemenauer, 1991; D'Amato et al., 2007), and attracting insects (Jim, 1987; Nuckols and Connor, 1995) besides potential annoyances like obstructions in the footpath of urban streets and inconveniences due to fallen leaves. However, many urban residents held very positive overall views on street tree planting (Flannigan, 2005; Schroeder et al., 2006; Weber et al., 2014; Davis and Jones, 2014). Preferable features included tree planting on both sides of a street to produce a 'canopy closure effect' produced by the tree crowns (Sommer et al., 1990; Schroeder et al., 2006) which was found not to be achieved by planting along the centerline (Arnold, 1980). When planted at the roadside, trees could also act as barriers between pedestrians and moving cars in order to provide a more enjoyable walking environment (Fukahori and Kubota, 2003; Giles-Corti et al., 2005).

Contrary to the conventional perception that tree planting can improve air quality, both recent field experimental (e.g. Buccolieri et al., 2011; Mitchell and Maher, 2009; Vos et al., 2012; Wania et al., 2012) and numerical simulation studies (e.g. Amorim et al., 2013; Buccolieri et al., 2009; Gromke and Ruck, 2012; Gromke et al., 2008; Li et al., 2013; Salim et al., 2011) have discovered that street-level tree planting, especially planting in high pollution areas (i.e. 'hotspots') like traffic junctions and within street canyons, might actually result in an increase in ground-level pollutant concentrations. The effects were found to be even stronger for deeper canyons (i.e. with aspect ratio >2) (Ng and Chau, 2012). So there is a fundamental question of whether people would still favor tree planting in streets if they thought trees were likely to bring further detrimental impacts to air quality.

Nevertheless, the successful engagement of any planning option, including tree planting schemes, requires broad consent from stakeholders. Without soliciting a majority of people's support, it is difficult to seek public budgetary approval and subsequent fund allocation for a specific planning option. So understanding peoples' preferences or views is a key to the successful smooth implementation of planning decisions (Rydin and Pennington, 2000).

Besides soliciting people's attitudes toward street trees, it is also important to solicit their preferences for tree planting schemes in relation to other street and building configurations. Aspect ratios and building spacing are of particular interest as they also exert effects on shading provision (Ali-Toudert and Mayer, 2006; Takebayashi and Moriyama, 2012), urban air quality (Kastner-Klein et al., 2004; Liu et al., 2005; Ng and Chau, 2014; Vardoulakis et al., 2003) and oppressiveness (Asgarzadeh et al., 2012).

Preferences for different street and building configurations have been frequently studied. Building spacing is favored by people while enclosed settings or blocked views are disliked (Herzog, 1992) as unbroken blocks of building generate a sense of enclosure in the urban environment, which is created by having streets and sidewalks act as "floors" and the sky as a "ceiling" (Ewing and Handy, 2009). Wider spacing between buildings is preferred because it can alleviate the sense of oppressiveness created by tall buildings situated in narrow streets (i.e. high aspect ratio). With care, planners can create a people-focused street environment to increase the walkability of people within the neighborhood and thus enhancing their physical activity levels (Leslie et al., 2005; Southworth, 2005).

Yet as an important limitation, previous tree planting preference studies were largely confined to urban street configurations that do not represent deep urban canyons that are quite common in high rise high density cities. Also each of the proposed street and building configurations, namely tree planting, building spacing and aspect ratio have an associated cost which must be borne by public

funds. It is therefore of interest to elicit public's willingness to pay for improvements to the street canyon environment.

Accordingly, this study has four major objectives: it aims (i) to explore the general attitude of people toward street planting; (ii) to disclose preferences for planting schemes in relation to aspect ratios and building spacing, (iii) to determine whether people's perceptions of street tree planting affects the tradeoff between preferences on tree planting and canyon configurations, and (iv) to determine peoples' willingness-to-pay values for selected streetscape features. These objectives were investigated by using Hong Kong as an example for a compact city with deep street canyons.

Methodology

Questionnaire surveys were conducted via face-to-face interviews so as to reduce the chances of misunderstanding the content and methodology of the surveys. The questionnaire consisted of three parts: Part A was intended to elicit respondents' preferences for trees and other streetscape attributes that have been shown to be able to reduce oppressiveness, provide shading and improve the air quality in urban streets. Part B aimed at exploring respondents' perceptions toward the impacts of street trees. Part C embraced questions aimed at collecting personal details, including gender, age, income and education level from respondents.

Questionnaire surveys

Eliciting relative preferences for different streetscape attributes

Part A was designed to elicit respondents' preferences for different streetscape attributes using the discrete choice experiment method, of which the theoretical background and analysis will be discussed later. In identifying the major attributes, emphasis was placed on street and building configuration attributes which would influence oppressiveness, shading provision and air quality inside streets. Three major attributes selected for this study are: (i) aspect ratio (which is defined as the ratio of the average building height to street width); (ii) permeability of building (expressed in terms of the ratio of total distance of the building spacing to the overall length of street segment, which was measured at street level); and (iii) street tree planting. A fourth attribute for cost was included to determine the respondents' willingness to pay.

'Aspect ratio' was included as it displayed a strong relationship with oppressiveness and people's preferences (Jacobs, 1993; Stamps, 2005). For aspect ratio, two levels were defined: *low* for an aspect ratio of 2 and *high* for aspect ratio of 6. Aspect ratios in this experiment were obtained by varying the average building height on both sides of a street while keeping a constant road width.

'Permeability' was also included as it has been generally perceived as a factor which affects the perceived openness of a street. For permeability, two levels were also defined: *low* for a value of 10% and *high* for a value of 35%. These values were based on the input values used in one of our previous computational studies (Ng and Chau, 2014).

The attribute 'Tree planting' was included for representing the tree planting arrangement in streets. Three different types of settings were assigned for tree planting: (i) no trees in the street, (ii) trees located along the centerline of a street; and (iii) trees located at both sides of a street).

A cost attribute, which used environmental tax as a payment vehicle, was included to estimate the willingness-to-pay values for individual streetscape attributes. Three levels were defined for the cost attribute and they were expressed in terms of paying environmental tax for HK\$50, \$100 and \$200 per month. Table 1 shows the four studied attributes together with their associated levels.

Table 1
Streetscape attributes and their associated levels used in the survey.

Attributes	Attribute levels
Aspect ratio (AR)	Low (AR2); high (AR6)
Permeability	Low (10%); high (35%)
Tree planting setting	No trees; trees planted at both sides of a street; trees planted along the centerline of a street
Local environmental tax (WTP)	\$50; \$100; \$200 per month extra

The design codes '1', and '−1' were used to represent two different levels of an attribute. For example, a street with a low permeability value (i.e. 10%) and a street with a high permeability value (i.e. 35%) were represented by '−1' and '+1', respectively. A street with a high aspect ratio (value of 6, AR6) and a street with a low aspect ratio (value of 2, AR2) were represented by '−1' and '+1', respectively. For tree planting configuration, two dummy codes were used to represent three different levels where '1, 0' denotes tree planting at both sides of a street, '0, 1' denotes trees planting along the centerline of a street, and '−1, −1' represents a street without any tree planting.

With two levels assigned for two attributes (aspect ratio and permeability) and three levels for the two remaining attributes (tree planting setting and cost attribute), there were 36 possible choice profiles ($2 \times 2 \times 3 \times 3$). Applying the fractional factorial procedure within the statistical software SPSS enables the total number of choice sets to be reduced to a manageable level. As a result, eight choice profiles were generated using different combinations of performance levels of the attributes after performing a fractional factorial design together with an orthogonal array incorporating only the main effects. Table 2 shows the eight generated choice profiles, or scenarios.

A photographic image was created for each individual choice profile or scenario by using the photomontage technique. This technique has been applied in previous studies to improve the reliability of respondents' recognition of street or landscape design (Karjalainen and Tyrväinen, 2002; Fukahori and Kubota, 2003; Todorova et al., 2004). Although there have been concerns that respondents may have difficulty in choosing between the two-dimensional photos without a sense of a specific urban setting, other studies have presented a strong correlation between the perception of the environment on site and from photos (Stamps, 1990, 2010). Compared to computer graphics, photographs generated by the photomontage technique enable respondents to better recognize the street environment. In this study, the images for each scenario were composed by superimposing tree images on photographs of different streetscape images composed using photographs taken in real street environments in Hong Kong.

Respondents were required to choose between a pair of scenarios shown on individual choice cards. Fig. 1 shows a sample of a choice card.

Table 2
Fractional factorial matrix for the eight choice profiles.

Aspect ratio	Permeability	Tree planting setting	WTP
Low	High	At both sides of the street	HK\$50
Low	Low	No trees	HK\$100
High	Low	At both sides of the street	HK\$100
High	Low	Along the centerline of the street	HK\$50
High	High	No trees	HK\$200
Low	Low	At both sides of the street	HK\$200
Low	Low	No trees	HK\$50
Low	Low	Along the centerline of the street	HK\$200

WTP = willingness to pay.

In Fig. 1, Choice A represents a scenario for which the respondent needs to pay a monthly environmental tax of \$50 for a streetscape with a high aspect ratio (i.e. AR6), and a low permeability value (i.e. 10%) with trees being planted along the centerline of the street. Choice B represents a scenario for which the respondent needs to pay a monthly environmental tax of \$50 for a streetscape configuration of a low aspect ratio (i.e. AR2) and a high permeability value (i.e. 35%) with trees being planted at both sides of the street. Respondents were requested to choose which scenario they preferred or they could choose 'neither' if neither choice was preferred.

Eliciting the perception toward the impacts of street trees

Part B of the questionnaire aimed at revealing the people's perception toward the impacts of street trees and to explore whether laypeople were aware of the latest research findings on the impacts of street trees. An introductory question 'Do you like tree planting on streets?' was asked in the beginning of the survey. Eight Likert-scale questions were then used for eliciting respondents' perceptions of the impacts of street trees. Respondents were asked whether they agreed with the listed impacts of street trees (Scale 1–5, '1' – strongly disagree and '5' – strongly agree). The individual impacts were not disclosed to the respondents as either benefits or annoyances to avoid introducing interviewer biases. The investigated impacts were similar to those reported in the Lo and Jim study (2012) which included air purification, noise attenuation, temperature reduction, wind speed reduction, shading provision, annoyances caused by fallen leaves, insect attraction, and footpath space obstruction.

Data analysis procedures

The data analysis procedures used for analyzing the perception toward the impacts of street trees and relative preferences for street attributes are different as a result of different forms of questions were used for different parts.

Perception toward the impacts of street trees

First, the survey responses were analyzed to determine the extent to which the perception of different tree planting impacts would favor street tree planting. SPSS version 20.0 was applied for performing statistical analysis with an objective of analyzing the perception of respondents for tree planting in urban streets. Non-parametric tests were applied for analyzing categorical data and data with distorted distribution profiles while parametric tests were applied for analyzing normally distributed data.

Also, a binary logit model was constructed to predict the probability that an individual holding specific perceptions of the impacts of trees who would express a liking for trees. The binary logit model form was developed with the aid of the econometric software NLOGIT 4.0.

Relative preferences for different streetscape attributes

The second stage was focused on the analysis on the relative preferences of tree planting over different street configurations by discrete choice experiment, which has its roots in discrete choice theory, and has been successfully extended to the application of environmental economics (Hanley et al., 1998; Bennett and Blamey, 2001; Rambonilaza and Dachary-Bernard, 2007). The fundamental concept of discrete choice theory is to model choices as a function of the attributes of the alternative profiles relevant to a given choice problem (McFadden, 1974; Ben-Akiva and Lerman, 1985). It is assumed that the relative importance is reflected by the part-worth utilities associated with each of the attributes, and the choice

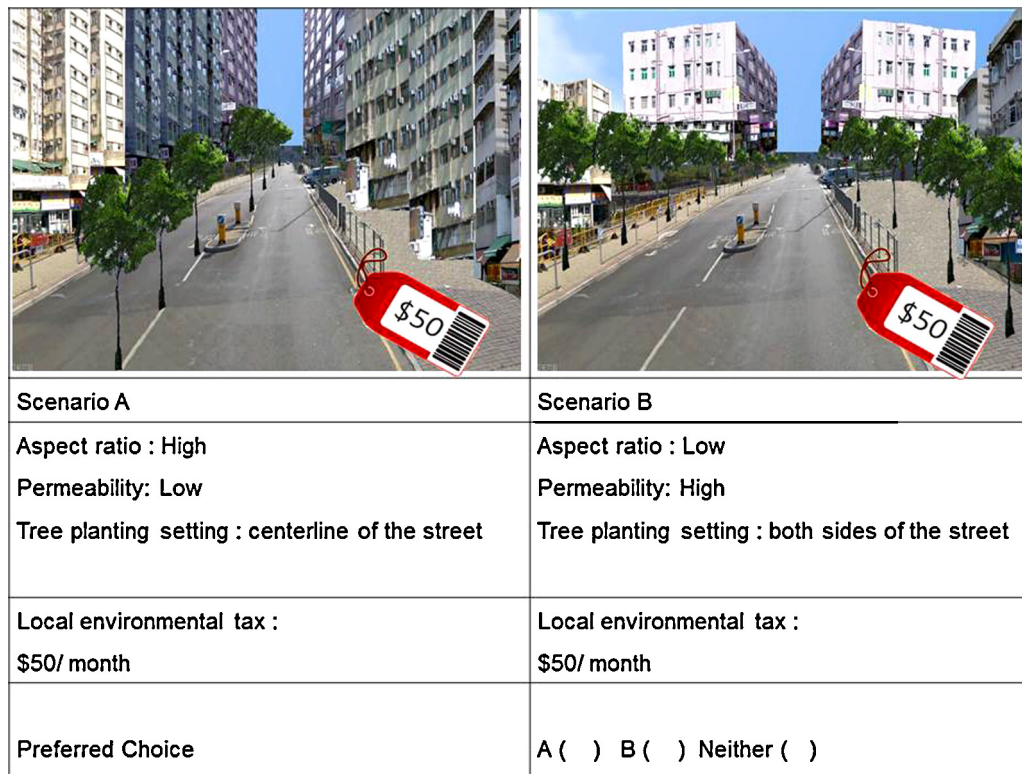


Fig. 1. Sample of a choice card.

selected by respondents will normally have the highest overall utility. Given that it is impossible to measure all characteristics of a choice objectively, the overall utility (U_i) of choice i is considered to embrace both a deterministic component (V_i) and a stochastic component (ε_i):

$$U_i = V_i + \varepsilon_i \quad (1)$$

The deterministic component (V_i) represents a vector of attributes of the choice that can be measured. The stochastic or random component relates to aspects that prevent choice from being a wholly deterministic process, as implied by the systematic component alone. It includes idiosyncratic, transitory, and a myriad of small influences on choice whose combined effects appear random over time, and can result in an individual's choice varying under identical circumstances.

If one assumes that the stochastic elements of the utilities follow a Gumbel distribution, whose errors are independently and identically distributed; the conditional logit model can be used and is specified as:

$$\text{Prob } \{i \text{ chosen}\} = \frac{e^{V_i}}{\sum e^{V_j}} \quad (2)$$

where the probability of choosing alternative i equals the exponent of all the measurable elements of alternative i over the sum of the exponent of all measurable elements of all alternatives j . The standard conditional logit model limits the systematic component V_i to linear-in-parameters functions, which are usually estimated with a maximum likelihood procedure (Ben-Akiva and Lerman, 1985). In this study, the conditional logit model form was developed with the aid of NLOGIT 4.0.

Data collection

Prior to full-scale surveys, a pilot study was conducted in October 2011 aimed at confirming the method of delivering the survey and removing any ambiguities on the content of the questionnaire design.

A full-scale survey was conducted between November 2011 and August 2012 in three streets in Tuen Mun, Hong Kong. Passers-by as well as people waiting for public transport near the surveying locations were randomly approached, and were invited to take part in the survey. Each survey interview took approximately 15 min to complete.

Results

In total, 2132 adult individuals were approached with 533 interviews being administered at the three sampling sites with a response rate of 25.0%. This is considered to be acceptable given the complexity of the choice experiment, and the similarity in response rates achieved in other studies using discrete choice experiments (Van der Pol and Cairns, 2001; Dia, 2002; Ratcliffe et al., 2009; Van Helvoort-Postulart et al., 2009; Chau et al., 2010). Of the 533 interviews, 509 interviewees provided sufficient information for analysis. With reference to the number of Hong Kong's population aged 15 and over of 6033,500 in mid-2012 (HKStatD, 2013), the confidence interval was determined to be better than $\pm 4.4\%$ for 95% confidence level using the 509 complete responses.

Respondents' characteristics

Table 3 shows the demographic characteristics of the 509 respondents. In comparing with the statistical data reported by the Census Department in Hong Kong in 2012 (HKStatD, 2013),

Table 3
Demographic characteristics of the survey respondents.

	Number of responders in each group	Percentage of the survey respondents in each group (%)	Percentage of the corresponding population subgroups in Mid-2012 Census ¹ (%)
<i>Sampling site</i>			
Vegetated street V1	116	22.8	–
Vegetated street V2	195	38.3	–
Non-vegetated street NV	198	38.9	–
<i>Gender</i>			
Male	235	46.2	48.0
Female	274	53.8	52.0
<i>Age</i>			
15–19 years	74	14.5	6.9
20–29 years	146	28.7	15.1
30–39 years	141	27.7	16.4
40–49 years	89	17.5	19.0
50 years and over	59	11.6	42.6
<i>Educational attainment</i>			
Elementary school	37	7.3	16.5
High school	203	39.9	51.0
Undergraduate degrees	238	46.7	28.7*
Master degrees	31	6.1	–
<i>Personal income level per month</i>			
No income	130	25.5	43.3
<HK\$10,000	89	17.5	18.2
HK\$10,001–HK\$20,000	200	39.3	20.9
HK\$20,001–HK\$30,000	64	12.6	7.8
>HK\$30,001	26	5.1	9.8
<i>Occupation</i>			
Working	352	69.2	–
Students	115	22.5	–
Home makers	30	5.9	–
Retirees	12	2.4	–

¹ Data extracted from Hong Kong Annual Digest of Statistics (2013).

* Figure represents all tertiary education Personal income level per month.

the surveyed respondents were considered to be a fair representation of the Hong Kong population aged 15 years and above.

Perceived impacts of street trees

A majority (94%) of the respondents indicated that they favored tree planting on streets, while only 6% either did not favor tree planting or expressed no opinion. Table 4 shows breakdown percentages of the respondents' opinions toward different impacts of street trees.

As seen in Table 4, the two most highly recognized impacts for the respondents who expressed a liking for trees were that trees could provide shading and lower air temperature with 88% and 82% agreement, respectively. In contrast, there were quite a number of actual impacts which were not fully recognized by a majority of the tree-liking respondents. Above all, the largest discrepancy in percentages between the actual and perceived impacts was found in air quality improvement.

Furthermore, 54% did not perceive trees would cause inconveniences as a result of fallen leaves, 48% perceived trees could reduce wind speed in streets, 47% perceived street trees could attenuate traffic noise, only 40% of the respondents perceived that trees would attract insects, and only 38% perceived that trees would obstruct the footpath space.

The respondents who either did not favor trees or had no opinion gave different opinions from those above. There were significant differences ($p < 0.05$) in the Likert scale mean scores for positive impacts such as providing shading (3.44 vs 4.06), and reducing wind in streets (2.85 vs 3.2) for the those that disliked trees or had no opinion and those that liked trees, respectively. Similarly, there were significant differences ($p < 0.05$) in the mean Likert scores for the negative impacts such as obstructing footpath space (3.37 vs 2.97) and inconvenience through fallen leaves (3.13 vs 2.69) for

those that disliked trees or had no preference compared with those that liked trees, respectively.

Interestingly, with regards to improving air quality the group that either disliked trees or had no preference for tree planting had a significantly lower ($p < 0.05$) mean Likert score (3.59) compared with the group that liked trees (mean Likert score 4.18). This suggested that there may be some awareness of trees' detrimental impact on air quality amongst this group, albeit they are a minority at only 6% of respondents.

Effect of different perceived impacts of trees on favoring street trees

A binary logit model was constructed to predict the probability that an individual holding specific perceptions of the impacts of trees who would express a liking for trees. Respondents were segmented into two groups – i.e. respondents who agreed with specific impacts, and those who disagreed or expressed no opinion on the specific impacts. The formulated model was

$$U_s = \lambda_1 \times N + \lambda_2 \times WS + \lambda_3 \times T + \lambda_4 \times AQ + \lambda_5 \times SH + \lambda_6 \times INS + \lambda_7 \times INCON + \lambda_8 \times OBS + \varepsilon \quad (3)$$

where U_s = utility value, λ_i refers to the coefficient value or of coefficients, N represents the view on impact of trees on noise attenuation, WS represents the view on impact of trees on reducing wind speed, T represents the view on impact of trees on lowering temperature, AQ represents the view on impact of trees on improving air quality, SH represents the view on the impact of trees on providing shading, INS represents the view on whether trees attracted insects, $INCON$ represents the view on whether trees caused inconveniences and OBS represents the type of perception held on the impact of trees on obstructing the footpath space.

Table 5 shows the estimated coefficients of the binary logit model. The McFadden's ρ^2 value was 0.151 indicating the model

Table 4

Mean ratings for the perceived impacts of street trees for groups who either expressed a liking for street trees or expressed dislike or no opinion toward trees.

Impacts of street trees		Percentage of total responses (%)		Mean rating (S.D.)	
		Like trees	Dislike trees or no opinion	Like trees	Dislike trees or no opinion
Improve street-level air quality**	Disagree	3.0	25.9	4.18 (0.76)	3.59 (1.03)
	No opinion	3.8	3.7		
	Agree	93.2	70.4		
Provide shading**	Disagree	7.0	33.3	4.06 (0.85)	3.44 (1.10)
	No opinion	5.1	3.7		
	Agree	87.9	63.0		
Lower air temperature	Disagree	10.3	14.8	3.85 (0.88)	3.63 (0.82)
	No opinion	7.5	14.8		
	Agree	82.2	70.4		
Reduce wind speed in streets**	Disagree	24.4	40.7	3.20 (0.90)	2.85 (0.85)
	No opinion	28.1	37.0		
	Agree	47.5	22.2		
Attenuate noise	Disagree	25.1	37.0	3.15 (0.89)	2.93 (0.81)
	No opinion	27.6	33.3		
	Agree	47.3	29.6		
Attract insects	Disagree	36.2	40.7	3.05 (1.02)	3.22 (1.13)
	No opinion	23.4	11.1		
	Agree	40.4	48.1		
Obstruct footpath space**	Disagree	45.2	18.5	2.97 (1.01)	3.37 (1.02)
	No opinion	17.3	37.0		
	Agree	37.5	44.4		
Cause inconveniences as a result of fallen leaves**	Disagree	54.4	40.7	2.69 (0.99)	3.19 (1.16)
	No opinion	22.4	7.4		
	Agree	23.4	51.9		

5 = Strongly agree, 4 = agree, 3 = no opinion, 2 = disagree, 1 = strongly disagree.

** Significant difference between two means at 95% confident interval.

was a reasonable fit to the data. It can be seen from Table 5 that different perceptions of the impacts of trees on improving air quality, providing shading and obstructing the footpath space significantly influences the probability that an individual favors street tree planting ($p < 0.05$). There is a higher probability of showing an overall liking viewpoint on street tree planting if one perceives that trees can improve air quality ($\lambda_1 = 0.677$), provide shading ($\lambda_2 = 0.595$) but do not obstruct the footpath space ($\lambda_3 = -0.632$). In contrast, the perceptions of the other impacts such as the ability to reduce wind in streets and to attenuate noise do not exert any significant influence on the probability value ($p > 0.05$). The remaining impacts were not fully recognized as shown by the small magnitude of the coefficients.

Relative preferences for tree planting and street configurations

In addition, people's preferences for street trees, aspect ratio and permeability were also compared by constructing a conditional logit model to fit all the 509 successful responses.

Table 5

Estimated coefficients for the binary logit model constructed for predicting the probability that an individual will express a liking for street trees.

Variable (code used in Eq. (3))	Coefficient value (λ)
Constant	2.186**
Attenuate noise (N)	0.348
Reduce wind speed in streets (WS)	0.383
Lower air temperature (T)	-0.215
Improve street-level air quality (AQ)	0.677**
Provide shading (SH)	0.595**
Attract insects (INS)	-0.227
Cause inconveniences as a result of fallen leaves (INCON)	-0.062
Obstruct footpath space (OBS)	-0.632**
McFadden's ρ^2	0.151

** Significant at 95% confidence level.

Quality assurance

Prior to the model formulation, tests were applied to evaluate the validity of the collected responses and ensure that the constructed model was suitable for portraying respondents' preferences for different streetscape attributes. The expected signs of all the coefficients are in line with our original expectation. For instance, positive signs were obtained for coefficients associated with aspect ratio and permeability as people are expected to have a higher preference for a street having a low aspect ratio or a high permeability value.

Model formulation

The model form for portraying the overall preferences of the respondents for different streetscape attributes can be represented by

$$U_{\text{overall}} = \beta_1 \times AR + \beta_2 \times BP + \beta_3 \times T_1 + \beta_4 \times T_2 + \beta_5 \times WTP + \varepsilon \quad (4)$$

where AR is aspect ratio, BP is permeability, T_1 and T_2 are the two dummy variables used for denoting three types of tree planting settings, WTP is the willingness to pay via monthly environment tax, and ε is the error term.

The magnitude of the coefficients estimated by NLOGIT reflects the relative importance of an individual attribute. The higher the coefficient value of an attribute, the more important the attribute is. Table 6 shows the estimated coefficient values for the four attributes.

The resulting McFadden's ρ^2 value is 0.193, which suggests that the constructed model is reasonably good in portraying the preferences of the sampled respondents for the streetscape attributes. Table 6 indicated that respondents had the highest preferences for a high permeability (coefficient = 0.735), which was preferred over tree planting at both sides of a street (coefficient = 0.596) and also a low aspect ratio (coefficient = 0.545). Generally, respondents did

Table 6

Estimated coefficient values for various streetscape attributes in a conditional logit model for predicting their preferences.

Conditional logit model			
Attribute	Coefficient (β)		p-value
Aspect ratio	β_1	0.5450**	0.0000
Permeability	β_2	0.7353**	0.0000
Tree planting at both side of a street	β_3	0.5957**	0.0000
Tree planting along the centerline of a street	β_4	−0.207**	0.0003
Without tree planting	β_{34}	−0.390**	0.0000
WTP (environment tax)	β_5	−0.0045**	0.0000
McFadden's ρ^2		0.193	

** Significant at 95% confidence level.

not prefer a street without any trees (coefficient = −0.390) or with trees being planted along its centerline (coefficient = −0.207).

Also, the importance of the attributes can be revealed by comparing the trade-off values between attributes. The relative ratio of β_i to β_j gives the relative importance of attribute i to attribute j . High permeability was considered to be the most important attribute which was considered to be 1.2 times important as planting trees along both sides of a street, and 1.3 times more important as a low aspect ratio.

Willingness-to-pay for specific streetscape attributes

As cost is involved as one of the attributes, the ratio of the value of the coefficient of one attribute to that associated with the cost term gives the amount of local environment tax that an individual was willing to pay per month for improving one unit of the attribute, i.e. β_i/β_4 ($i = 1, 2, 3$).

Assuming a linear utility function, the amount of willingness-to-pay can be estimated using the following equation

$$WTP = \frac{-\beta_i}{\beta_j} \quad (5)$$

where β_i is the coefficient of any attributes other than the cost attributes and β_j is the coefficient of the cost attribute.

People were willing to pay most for a high permeability (HK\$163.4 per month), but less for street-level tree planting (HK\$132.4 per month), and even less for a low aspect ratio (HK\$121.1 per month).

Also, it was revealed that respondents who belonged to different age groups or respondents having different personal income levels had significant differences in their willingness-to-pay values for tree planting or other streetscape attributes ($p < 0.05$). Younger respondents (aged below 29 years) were willing to pay more than their older counterparts, while higher income respondents (with monthly income level higher than HKD\$20,000) were willing to pay more than the lower income counterpart.

Effect of different perceived impacts of trees on preferences

Wald tests were applied to the response data segmented according to the respondents' perception for each of the specific impacts of trees so as to reveal any differences in preferences for different streetscape attributes. Significant differences in the estimated coefficient values for attributes were observed for the respondents holding different perceptions on the air quality impact of trees, but not for the other seven impacts. Accordingly, the responses were grouped according to whether the respondents perceived that trees could or could not improve air quality.

Consequently, the final model becomes:

$$U_1 = \beta_1 \times AR + \beta_2 \times BP + \alpha_3 \times TR1_{AQ_n} + \beta_3 \times TR1_{AQ_y} + \alpha_4 \times TR2_{AQ_n} + \beta_4 \times TR2_{AQ_y} + \alpha_5 \times WTP_{AQ_n} + \beta_5 \times WTP_{AQ_y} + \varepsilon \quad (6)$$

where AQ_y represents respondents who perceived that tree could improve air quality inside a street. AQ_n represents respondents who did not hold the perception that tree would improve street-level air quality.

Table 7 shows the resulting coefficient estimates for different attributes derived for the two groups.

The McFadden's ρ^2 value of 0.21 obtained for the final segmented model shown in Eq. (6) suggests that the data fit the constructed model reasonably well. Wald tests were applied to examine whether there were any significant differences in the coefficient values derived for the two segmented respondent groups. People having different perceptions on whether street trees could improve air quality showed different levels of preferences for the same attributes (Wald test results are significant, $p < 0.05$). Although both groups placed their highest preferences on permeability, the order of preferences differed for aspect ratio and street tree planting. People holding the perception that trees could improve street-level air quality had higher preferences for tree planting at both sides of a street than for a street having a low aspect ratio. Conversely, people who did not hold the perception that trees would bring air quality improvement had higher preferences for a low aspect ratio than for tree planting at both sides of a street.

In addition, people holding the perception that trees could improve street-level air quality had considerably higher willingness-to-pay values for tree planting at street levels than their counterparts (HKD\$110.5 per month vs. HKD\$24.4 per month). However, both groups did not prefer tree planting along the centerline of a street or to have a street without any tree planting.

Discussion

This study has revealed a number of important findings. First, 94% of the respondents held positive views on concerning street tree planting. This was probably linked to the majority of people's perception that trees were able to provide benefits which outweighed the annoyances caused. Most of the respondents in this study perceived that trees could improve the street-level air quality, block sunlight, provide shading, and lower the street-level air temperature. In contrast, they were quite divided on whether trees could attract insects and obstruct footpath space. However, 93% of the respondents perceived that trees could improve street-level air quality, which is contrary to the latest research findings on the detrimental effects of trees on the air quality of a canyon with an aspect ratio 1 or higher (Buccolieri et al., 2011; Gromke and Ruck, 2008, 2007; Ng and Chau, 2012; Salim et al., 2011). People holding the perception that street trees could improve street-level air quality were found to have much higher preferences and be willing to pay significantly more for tree planting inside urban streets than their counterparts. Accordingly, it is postulated that people's preferences for street trees will become lower once they recognize the

Table 7

Estimated coefficient values for various streetscape attributes for respondents holding different perceptions on the impacts of trees on street-level air quality.

Attribute		Coefficient (α)		Coefficient (β)
Aspect ratio		0.626**	β_1	0.626**
Permeability		0.759**	β_2	0.759**
Tree planting at both sides of a street	α_3	0.268**	β_3	0.663**
Tree planting along the centerline of a street	α_4	−0.100	β_4	−0.283**
Without tree planting	α_{34}	−0.168*	β_{34}	−0.380**
WTP (environment tax)	α_5	−0.011*	β_5	−0.006*
Wald test for α_3 and β_3				0.000
Wald test for α_4 and β_4				0.047
Wald test for α_5 and β_5				0.000
McFadden's ρ^2		0.210		

 α : Respondents did not perceive trees to be able to improve street-level air quality; β : respondents perceived trees to be able to improve street-level air quality.

* Significant at 90% confidence level.

** Significant at 95% confidence level.

detrimental air quality impact brought by street trees in canyons. Further studies should be conducted to verify this.

Second, tree planting was not the most preferable streetscape attribute in urban streets. Permeability was found to be the most preferable attribute for both those who perceived that trees could improve air quality and those who did not perceive that trees could improve air quality. Those respondents who perceived trees could improve air quality then expressed their preferences for tree planting at both sides of the street followed by low aspect ratio whereas those who did not consider that trees could improve air quality expressed their preferences as low aspect ratio followed by tree planting at both sides of the street.

Finally, it was discovered that people preferred a specific type of tree planting scheme on streets. They preferred planting trees on both sides of a street over planting trees along the centerline of a street even though most of them supported the tree planting program.

The finding that most people perceive trees to be beneficial to improving air quality poses a dilemma for urban planners. Whereas increased permeability is the main preference, this group would prefer tree planting at both sides of the street over lower aspect ratios. Based on recent research identifying the detrimental effects of trees on air quality it appears that reducing the aspect ratio would be a better option, as borne out by the preferences expressed by those who did not consider that trees improved the air quality. There may be public opposition to planning schemes recommending lower aspect ratios over tree planting until there is greater awareness of the detrimental impacts of tree planting.

The foregoing findings can provide some important implications for urban planners and policymakers on tree planting in an urban street environment. Nevertheless, our findings may suffer from some potential errors which may undermine the representativeness of our sample and results.

First, the absence of tree pits or planters in the display choice cards might lead respondents to underestimate the impacts of tree planting in terms of additional spaces required for planters and reduced spaces for vehicle traffic or pedestrians, which might have resulted in more respondents having voted 'neither'.

Second, the proportion of respondents who thought that trees did not contribute to improving air quality was relatively small. This is probably a consequence of relatively recent research results not yet being in the public domain or they were not aware that the question was specifically related to tree impacts in street canyons.

This work provides a reference mark for public perceptions of tree planting schemes that should be revisited when the findings that trees can have a detrimental effect on air quality become more widely disseminated. Although the data was collected in Hong Kong the findings should be applicable to other modern metropolises characterized by high rise buildings.

Acknowledgement

The authors would like to thank the Hong Kong Polytechnic University for the funding support through the Central Allocation Grants No:4-ZOEX.

References

- Akbari, H., Pomerantz, M., Taha, H., 2001. Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. *Sol. Energy* 70, 295–310.
- Ali-Toudert, F., Mayer, H., 2006. Numerical study on the effects of aspect ratio and orientation of an urban street canyon on outdoor thermal comfort in hot and dry climate. *Build. Environ.* 41, 94–108.
- Ali-Toudert, F., Mayer, H., 2007. Effects of asymmetry, galleries, overhanging façades and vegetation on thermal comfort in urban street canyons. *Sol. Energy* 81, 742–754.
- Amorim, J.H., Rodrigues, V., Tavares, R., Valente, J., Borrego, C., 2013. CFD modelling of the aerodynamic effect of trees on urban air pollution dispersion. *Sci. Total Environ.* 461–462, 541–551.
- Armson, D., Stringer, P., Ennos, A.R., 2012. The effect of tree shade and grass on surface and globe temperatures in an urban area. *Urban For. Urban Green.* 11, 245–255.
- Arnold, H.F., 1980. *Trees in Urban Design*. Van Nostrand Reinhold Co. Ltd, New York.
- Asgarzadeh, M., Lusk, A., Koga, T., Hirate, K., 2012. Measuring oppressiveness of streetscapes. *Landscape Urban Plann.* 107, 1–11.
- Avissar, R., 1996. Potential effects of vegetation on the urban thermal environment. *Atmos. Environ.* 30, 437–448.
- Bartens, J., Day, S.D., Harris, J.R., Dove, J.E., Wynn, T.M., 2008. Can urban tree roots improve infiltration through compacted subsoils for stormwater management? *J. Environ. Qual.* 37, 2048–2057.
- Ben-Akiva, M.E., Lerman, S.R., 1985. *Discrete Choice Analysis: Theory and Application to Travel Demand*. MIT Press, Cambridge, MA.
- Bennett, J., Blamey, R., 2001. *The Choice Modelling Approach to Environmental Valuation*. Edward Elgar, Cheltenham, UK.
- Buccolieri, R., Gromke, C., Di Sabatino, S., Ruck, B., 2009. Aerodynamic effects of trees on pollutant concentration in street canyons. *Sci. Total Environ.* 407, 5247–5256.
- Buccolieri, R., Salim, S.M., Leo, L.S., Di Sabatino, S., Chan, A., Ielpo, P., de Gennaro, G., Gromke, C., 2011. Analysis of local scale tree-atmosphere interaction on pollutant concentration in idealized street canyons and application to a real urban junction. *Atmos. Environ.* 45, 1702–1713.
- Chau, C.K., Tse, M.S., Chung, K.Y., 2010. A choice experiment to estimate the effect of green experience on preferences and willingness-to-pay for green building attributes. *Build. Environ.* 45, 2553–2561.
- Comtois, P., Schemenauer, R.S., 1991. Tree pollen viability in areas subject to high pollutant deposition. *Aerobiologia* 7, 144–151.
- D'Amato, G., Cecchi, L., Bonini, S., Nunes, C., Annesi-Maesano, I., Behrendt, H., Liccardi, G., Popov, T., Van Cauwenberge, P., 2007. Allergic pollen and pollen allergy in Europe. *Allergy* 62, 976–990.
- Davis, K.L., Jones, R.E., 2014. Modeling environmental concern for urban tree protection using biophysical and social psychological indicators. *Soc. Natl. Resour.* 27, 1–17.
- Dia, H., 2002. An agent-based approach to modelling driver route choice behaviour under the influence of real-time information. *Transp. Res., C: Emerg. Technol.* 10, 331–349.
- Dimoudi, A., Nikolopoulou, M., 2003. Vegetation in the urban environment: micro-climatic analysis and benefits. *Energy Build.* 35, 69–76.
- Escobedo, F.J., Kroeger, T., Wagner, J.E., 2011. Urban forests and pollution mitigation: analyzing ecosystem services and disservices. *Environ. Pollut.* 159, 2078–2087.
- Ewing, R., Handy, S., 2009. Measuring the unmeasurable: urban design qualities related to walkability. *J. Urban Des.* 14, 65–84.
- Flannigan, J., 2005. An evaluation of residents' attitudes to street trees on Southwest England. *Arboric. J.* 28, 219–241.

- Fukahori, K., Kubota, Y., 2003. The role of design elements on the cost-effectiveness of streetscape improvement. *Landscape Urban Plann.* 63, 75–91.
- Gidlöf-Gunnarsson, A., Öhrström, E., 2007. Noise and well-being in urban residential environments: the potential role of perceived availability to nearby green areas. *Landscape Urban Plann.* 83, 115–126.
- Giles-Corti, B., Broomhall, M.H., Knuiaman, M., Collins, C., Douglas, K., Ng, K., Lange, A., Donovan, R.J., 2005. Increasing walking: how important is distance to, attractiveness, and size of public open space? *Am. J. Prev. Med.* 28, 169–176.
- Grahn, P., Stigsdotter, U.K., 2010. The relation between perceived sensory dimensions of urban green space and stress restoration. *Landscape Urban Plann.* 94, 264–275.
- Gromke, C., Buccolieri, R., Di Sabatino, S., Ruck, B., 2008. Dispersion study in a street canyon with tree planting by means of wind tunnel and numerical investigations – evaluation of CFD data with experimental data. *Atmos. Environ.* 42, 8640–8650.
- Gromke, C., Ruck, B., 2007. Influence of trees on the dispersion of pollutants in an urban street canyon – experimental investigation of the flow and concentration field. *Atmos. Environ.* 41, 3287–3302.
- Gromke, C., Ruck, B., 2008. Aerodynamic modelling of trees for small-scale wind tunnel studies. *Forestry* 81, 243–258.
- Gromke, C., Ruck, B., 2012. Pollutant concentrations in street canyons of different aspect ratio with avenues of trees for various wind directions. *Boundary Layer Meteorol.* 144, 41–64.
- Hanley, N., Wright, R.E., Adamowicz, V., 1998. Using choice experiments to value the environment. *Environ. Resour. Econ.* 11, 413–428.
- Hernandez, B., Hidalgo, M.C., 2005. Effect of urban vegetation on psychological restorativeness. *Psychol. Rep.* 96, 1025–1028.
- Herzog, T.R., 1992. A cognitive analysis of preference for urban spaces. *J. Environ. Psychol.* 12, 237–248.
- HKStatD, 2013. Hong Kong Annual Digest of Statistics, 2013 ed. Census and Statistics Department, HKSAR.
- Islam, M., Rahman, K., Bahar, M., Habib, M., Ando, K., Hattori, N., 2012. Pollution attenuation by roadside greenbelt in and around urban areas. *Urban For. Urban Green.* 11, 460–464.
- Jacobs, A.B., 1993. *Great Streets*. MIT Press, Cambridge, MA.
- Jim, C.Y., 1987. The status and prospects of urban trees in Hong Kong. *Landscape Urban Plann.* 14, 1–20.
- Jim, C.Y., Chen, W.Y., 2008. Assessing the ecosystem service of air pollutant removal by urban trees in Guangzhou (China). *J. Environ. Manage.* 88, 665–676.
- Kaplan, R., Kaplan, S., 1989. *The Experience of Nature: A Psychological Perspective*. Cambridge University Press, New York, NY.
- Karjalainen, E., Tyrväinen, L., 2002. Visualization in forest landscape preference research: a Finnish perspective. *Landscape Urban Plann.* 59, 13–28.
- Kastner-Klein, P., Berkowicz, R., Britter, R., 2004. The influence of street architecture on flow and dispersion in street canyons. *Meteorol. Atmos. Phys.* 87, 121–131.
- Leslie, E., Saelens, B., Frank, L., Owen, N., Bauman, A., Coffee, N., Hugo, G., 2005. Residents' perceptions of walkability attributes in objectively different neighbourhoods: a pilot study. *Health Place* 11, 227–236.
- Li, J.F., Zhan, J.M., Li, Y.S., Wai, O.W.H., 2013. CO₂ absorption/emission and aerodynamic effects of trees on the concentrations in a street canyon in Guangzhou, China. *Environ. Pollut.* 177, 4–12.
- Liu, C., Leung, D., Barth, M., 2005. On the prediction of air and pollutant exchange rates in street canyons of different aspect ratios using large-eddy simulation. *Atmos. Environ.* 39, 1567–1574.
- Lo, A.Y.H., Jim, C.Y., 2012. Citizen attitude and expectation towards greenspace provision in compact urban milieu. *Land Use Policy* 29, 577–586.
- McFadden, D., 1974. The measurement of urban travel demand. *J. Public Econ.* 3, 303–328.
- McPherson, E.G., 1992. Accounting for benefits and costs of urban greenspace. *Landscape Urban Plann.* 22, 41–51.
- Mitchell, R., Maher, B.A., 2009. Evaluation and application of biomagnetic monitoring of traffic-derived particulate pollution. *Atmos. Environ.* 43, 2095–2103.
- Mitchell, R., Popham, F., 2008. Effect of exposure to natural environment on health inequalities: an observational population study. *Lancet* 372, 1655–1660.
- Ng, E., Chen, L., Wang, Y., Yuan, C., 2012. A study on the cooling effects of greening in a high-density city: an experience from Hong Kong. *Build. Environ.* 47, 256–271.
- Ng, W.Y., Chau, C.K., 2012. Evaluating the role of vegetation on the ventilation performance in isolated deep street canyons. *Int. J. Environ. Pollut.* 50, 98–110.
- Ng, W.Y., Chau, C.K., 2014. A modeling investigation of the impact of street and building configurations on personal air pollutant exposure in isolated deep urban canyons. *Sci. Total Environ.* 468–469, 429–448.
- Nielsen, T.S., Hansen, K.B., 2007. Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators. *Health Place* 13, 839–850.
- Nowak, D.J., Crane, D.E., Stevens, J.C., 2006. Air pollution removal by urban trees and shrubs in the United States. *Urban For. Urban Green.* 4, 115–123.
- Nuckols, M.S., Connor, E.F., 1995. Do trees in urban or ornamental plantings receive more damage by insects than trees in natural forests? *Ecol. Entomol.* 20, 253–260.
- Ozer, S., Irmak, M.A., Yilmaz, H., 2008. Determination of roadside noise reduction effectiveness of *Pinus sylvestris* L. and *Populus nigra* L. in Erzurum, Turkey. *Environ. Monit. Assess.* 144, 191–197.
- Park, M., Hagishima, A., Tanimoto, J., Narita, K., 2012. Effect of urban vegetation on outdoor thermal environment: field measurement at a scale model site. *Build. Environ.* 56, 38–46.
- Rambonilaza, M., Dachary-Bernard, J., 2007. Land-use planning and public preferences: what can we learn from choice experiment method? *Landscape Urban Plann.* 83, 318–326.
- Ratcliffe, J., Bekker, H.L., Dolan, P., Edlin, R., 2009. Examining the attitudes and preferences of health care decision-makers in relation to access, equity and cost-effectiveness: a discrete choice experiment. *Health Policy* 90, 45–57.
- Rydin, Y., Pennington, M., 2000. Public participation and local environmental planning: the collective action problem and the potential of social capital. *Local Environ.* 5, 153–169.
- Salim, S.M., Buccolieri, R., Chan, A., Di Sabatino, S., Cheah, S.C., 2011. Large eddy simulation of the aerodynamic effects of trees on pollutant concentrations in street canyons. *Procedia Environ. Sci.* 4, 17–24.
- Schroeder, H., Flannigan, J., Coles, R., 2006. Residents' attitudes toward street trees in the UK and US communities. *Arboric. Urban For.* 32, 236–246.
- Shahidan, M.F., Jones, P.J., Gwilliam, J., Salleh, E., 2012. An evaluation of outdoor and building environment cooling achieved through combination modification of trees with ground materials. *Build. Environ.* 58, 245–257.
- Shashua-Bar, L., Pearlmutter, D., Erell, E., 2009. The cooling efficiency of urban landscape strategies in a hot dry climate. *Landscape Urban Plann.* 92, 179–186.
- Sommer, R., Guenther, H., Barker, P.A., 1990. Surveying householder response to street trees. *Landscape J.* 9, 79–85.
- Southworth, M., 2005. Designing the walkable city. *J. Urban Plann. Dev.* 131, 246–257.
- Stamps, A.E., 1990. Use of photographs to simulate environments: a meta-analysis. *Percept. Mot. Skills* 71, 907–913.
- Stamps, A.E., 2005. Visual permeability, locomotive permeability, safety, and enclosure. *Environ. Behav.* 37, 587–619.
- Stamps, A.E., 2010. Use of static and dynamic media to simulate environments: a meta-analysis. *Percept. Mot. Skills* 111, 355–364.
- Taha, H., 1997. Urban climates and heat islands: albedo, evapotranspiration, and anthropogenic heat. *Energy Build.* 25, 99–103.
- Takebayashi, H., Moriyma, M., 2012. Relationships between the properties of an urban street canyon and its radiant environment: Introduction of appropriate urban heat island mitigation technologies. *Sol. Energy* 86, 2255–2262.
- Todorova, A., Asakawa, S., Aikoh, T., 2004. Preferences for and attitudes towards street flowers and trees in Sapporo, Japan. *Landscape Urban Plann.* 69, 403–416.
- Tyrväinen, L., Silvennoinen, H., Kolehmainen, O., 2003. Ecological and aesthetic values in urban forest management. *Urban For. Urban Green.* 1, 135–149.
- Ulrich, R.S., 1983. Aesthetic and affective response to natural environment. In: Altman, I., Wohlwill, J.F. (Eds.), *Behavior and the Natural Environment*. Springer US, Boston, MA, pp. 85–125.
- Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., Zelson, M., 1991. Stress recovery during exposure to natural and urban environments. *J. Environ. Psychol.* 11, 201–230.
- Van den Berg, A.E., Koole, S.L., Van der Wulp, N.Y., 2003. Environmental preference and restoration: (how) are they related? *J. Environ. Psychol.* 23, 135–146.
- Van der Pol, M., Cairns, J., 2001. Estimating time preferences for health using discrete choice experiments. *Soc. Sci. Med.* 52, 1459–1470.
- Van Helvoort-Postulat, D., van der Weijden, T., Dellaert, B.G.C., de Kok, M., von Meyenfeldt, M.F., Dirksen, C.D., 2009. Investigating the complementary value of discrete choice experiments for the evaluation of barriers and facilitators in implementation research: a questionnaire survey. *Implementation Sci.* 4, 10.
- Van Renterghem, T., Botteldooren, D., Verheyen, K., 2012. Road traffic noise shielding by vegetation belts of limited depth. *J. Sound Vib.* 331, 2404–2425.
- Vardoulakis, S., Fisher, B.E., Pericleous, K., Gonzalez-Flesca, N., 2003. Modelling air quality in street canyons: a review. *Atmos. Environ.* 37, 155–182.
- Vos, P.E.J., Maiheu, B., Vankerkom, J., Janssen, S., 2012. Improving local air quality in cities: to tree or not to tree? *Environ. Pollut.* 183, 113–122 (Barking, Essex: 1987).
- Wania, A., Bruse, M., Blond, N., Weber, C., 2012. Analysing the influence of different street vegetation on traffic-induced particle dispersion using microscale simulations. *J. Environ. Manage.* 94, 91–101.
- Weber, F., Kowarik, I., Säumel, I., 2014. A walk on the wild side: perceptions of roadside vegetation beyond trees. *Urban For. Urban Green.* 13, 205–212.