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Heterogeneous Preferences for Urban Forest Attributes: A Latent Class Approach §

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Abstract: The increasing pace of urbanization worldwide makes urban forests key providers of a wide range of ecosystem services that contribute to human well-being in multiple ways. The United Nations estimates that 54 percent of the world's population already lives in urban areas, and by 2050 two-thirds of the globe's people will be living in cities. Forests in the urban and peri-urban landscape provide many services that directly and indirectly benefit human beings, such as carbon sequestration, air quality improvements through particulate deposition, wildlife habitat, and aesthetic benefits that improve land and home values as well as human health outcomes, among many others. The importance and contribution of urban forests to human well-being will only increase as societies worldwide become more urbanized. In this study, we use data from a discrete choice experiment implemented through an online survey of 724 Florida residents, to estimate a series of latent class models of preferences for urban forest attributes. Our results reveal multiple preference groups, each with different willingness-to-pay values for the four forest attributes evaluated: type of trees (native vs. exotic), number of trees (many vs. few), size of trees (fully grown vs. mix of ages), and maintenance costs. Thus, our study estimates the public's willingness-to-pay for different attributes of urban forests and provides further evidence of the ubiquity of heterogenous preferences for non-market goods and services.

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1. Introduction

Research on people's preferences for attributes of goods, services, and policies can inform public decision-making on a variety of problems and issues. In the realm of natural resources and the environment, preferences for policies and policy attributes have been explored using discrete choice models, where the stated or revealed choices of individuals are analyzed using logit models in a random utility framework. This type of research can inform public policies dealing with fish consumption advisories (Morey et al. 2006), compensation to outdoor recreationists impacted by oil spills (Alvarez et al. 2014), drinking water supply (Thiene et al. 2015), and wetland management (Birol et al. 2006; Milon and Scrogin 2006), among other issues.

Discrete choice models can be used to forecast demand for environmental assets and policies impacting them, as well as to estimate individuals' willingness to pay for these assets and their attributes. However, early methods used to analyze discrete choice data had several shortcomings, key among them the assumption that the coefficients that describe preferences are the same for all individuals (Train 1998). Hence, policies informed by these models would be designed to serve the average respondent but would ignore the diversity of preferences in the population, thereby unintentionally creating winners and losers.

Advances in computing power and statistical methods now allow researchers to account for diversity or heterogeneity in preferences inherent in people's choices and captured in discrete choice data. With the random parameters logit, researchers can assume a distribution for the preference parameter and recover its mean and standard deviation. With the latent class logit, researchers can determine the number of available classes and recover a preference parameter for each latent class. While both methods account for heterogeneity in preferences expressed through individual's choices, they are not equally useful for policy decision making, as their practicality can be expected to hinge on the specificity of their results.

In this paper we use stated preference data from an online choice experiment to examine people's preferences for urban forests and their attributes, while exploring the presence of preference heterogeneity and the usefulness of results from different logit approaches to provide policy-relevant information. We contribute to the literature on urban forests by examining public preferences and willingness to pay for key forest attributes such as native and exotic trees, forest diversity, and overall quantity of trees in urban forested landscapes, and provide evidence that preferences for these attributes are heterogeneous. Similarly, we contribute to the literature on preference heterogeneity for natural resources by providing a framework to explore heterogeneity in stated preference discrete choice experiments and the usefulness of results from different estimation approaches for supporting policy decision making.

2. Trees and Forests in Urban Areas

The increasing pace of urbanization worldwide makes urban forests key providers of a wide range of ecosystem services that contribute to human well-being in multiple ways. The United Nations estimates that 54 percent of the world's population already lives in urban areas, and by 2050 two-thirds of the globe's people will be living in cities. North America is the world's most heavily urbanized region, with an estimated 82 percent of people currently living in urban areas (United Nations 2014). Forests in the urban and peri-urban landscape provide many services that directly and indirectly benefit human beings, such as carbon sequestration, air quality improvements through particulate deposition, wildlife habitat, and aesthetic benefits that improve land and home values as well as human health outcomes, among many others (Donovan et al. 2011; Donovan et al. 2013; Escobedo et al. 2015; Livesley et al. 2016). The importance and contribution of urban forests to human well-being will only increase as societies worldwide become more urbanized.

3. Data

Data used in this study were obtained through an online survey of Florida residents. The objective of the survey was to investigate the preferences of Florida residents towards forested landscapes in their homes and neighborhoods as well as individuals' willingness to pay for prevention of forest pests. The survey was developed during the first months of 2016. For pre-testing, we sought input from 15 individuals ranging from experts in the field of forestry to members of the lay public. Following careful pre-testing the survey was soft-launched in late July 2016 through a Qualtrics online panel. After two days of data collection, the survey was taken offline for a preliminary results review. After deeming that the online platform was performing appropriately, the survey was fully launched in early August. The survey was closed in late August after 724 respondents submitted completed surveys, exceeding our target of 500 completed surveys.

During soft and full launch, Qualtrics sent a total of 14,386 email invitations to members of their online panel. A total of 3,210 individuals started the survey, but 2,413 individuals were screened out due to ineligibility. In addition, 73 individuals dropped out after beginning the survey. Therefore, the 724 completed surveys resulted in a completion rate of 24.82% (DiSogra and Callegaro 2008; Callegaro and DiSogra 2016).

The survey was composed of four major sections. The first section introduced the subject matter of the survey and contained a series of demographic and socioeconomic questions. Respondents were told that the survey had to do with the importance of urban forests and included two major components: preferences for urban forests including different forest settings and costs, and invasive pest prevention options for protecting urban forests. The demographic section consisted of multiple choice questions about household income, gender, age, education, employment status, race and ethnicity, relationship status, and number of children. The section finalized with an attention check question prompting respondents to select a particular number from a list.

The second section contained the discrete choice experiment, which was modeled after the scenario used by Garrod (2002). Respondents were asked to imagine that they were going to move to a new home in Florida, and a series of questions followed this visioning exercise. First, they were asked about the factors that are important to them when selecting a new home, such as proximity to work, low crimes rates, and quality of schools, among others. They were then asked if they prefer living in urban areas, suburban areas, or rural areas. Given that Florida experiences tropical force winds on a regular basis, respondents were also asked about their main concerns with storm damage. Respondents were then asked about their level of concern due to pollen from trees or other sources, as well as the region of the state that they would prefer to live in. These warm-up questions lead respondents into the discrete choice experiment task, in which they were told to imagine that after searching for their prospective new home they had found their top three options. Respondents are also told to imagine that the main difference between the three options are related to the type of shrubs, trees, and landscaping in the home and the surrounding neighborhood. They are also told that landscaping differs in terms of four attributes: the types or species of trees (native vs. exotic), the ages and sizes of trees (only tall, large, and fully grown trees vs. trees of different ages, sizes, and heights), the number of tree and shrub species (few species vs. many species), and the monthly costs to maintain the landscape ($1, $4, $7, or $10). At this point, the sample was split in two, with roughly half being asked to answer questions about their preferred landscape in their favorite home yard, and the other half being asked about their preferred landscape in the public areas around their favorite home. The choice experiment itself included eight choice tasks consisting of three options plus a status quo or opt-out option. In addition, each choice task was followed by a question asking respondents how certain they were of their response in the preceding task.

The third section contained the double-bounded contingent valuation experiment, which began with an overview of the impacts of invasive forest pests on urban forests. Respondents were told that pest invasions can result in the death of trees—sometimes by the thousands—resulting in expensive removal and replacement costs that are borne by landowners and local governments. Respondents were also told that if pests are detected in a timely manner trees can usually be treated and saved, and in addition, reducing the amount of host material transported between regions could also prevent outbreaks of forest pests. This information led the respondent into a scenario where the state of Florida is considering a program that would deploy thousands of insect and spore traps throughout the state to enhance early detection of pests. Respondents were also told that experts estimated the effectiveness of such a program percentage terms, with the effectiveness shown to each respondent varying randomly among 3 levels (50%, 70%, 90%). The respondent was then asked a referendum style question on a ballot initiative that would raise monthly utility fees to cover the costs of the program. The initial bid offered had 4 levels ($3, $5, $7, $9). Respondents were then asked a similar follow-up with the same effectiveness level but a different bid depending on whether the first question had been answered positively or negatively. There were 6 bid levels on the follow-up question ($1, $3, $5, $7, $9, $11), with respondents seeing the next higher or lower level as in the initial referendum question, depending on if they answered 'yes' or 'no' to the first bid.

The fourth section contained a series of attitudinal and psychometric questions on several topics. Respondents were first asked about their level of concern for water pollution and invasive species in Florida. Then they were asked if they think that climate change is resulting in more extreme weather, followed by a question asking if they believe climate change is caused by human activity or natural changes in the environment, or both. Respondents were also asked if they recycle, and if they are willing to change their lifestyle to reduce environmental damage. Then, respondents were asked how important outdoor recreation is to them, as well as the types of outdoor recreation activities they have engaged in the past 12 months. Finally, respondents were asked if they agree more with republicans, democrats, independents, or somebody else.

4. Methods

Discrete choice experiments are essentially repeated choice occasions by the same individuals, in which each individual chooses one from among a set of available choices. We analyze this choice data in a random utility framework, where individual *n* gets utility U_{nit} from selecting alternative *i* in choice occasion *t*:

$$U_{nit} = V_{nit} + E_{nit}, \quad (1)$$

where V_{nit} is a deterministic component of utility and E_{nit} is a stochastic component. If choice occasion t includes a set of J alternatives, individual n will choose alternative i if $U_{nit} > U_{njt}$; for all $j \neq i$. Hence, the probability that individual n chooses alternative i is given by:

$$P_{nit} = \Pr(V_{nit} + E_{nit} > V_{njt} + E_{njt}; \text{ for all } j \neq i). \tag{2}$$

The deterministic component of utility takes the form $V_{nit} = \beta' X_{nit}$, where β' is a vector of random parameters that represent individual preferences, and X_{nit} is the vector of attributes found in alternative i. Assuming that the stochastic terms (E_{nit}) are i.i.d. extreme value yields McFadden's (1974) conditional logit, where the probability of choice is given by:

$$P_{nit} = \frac{\exp(\beta' X_{nit})}{\sum_j \exp(\beta' X_{njt})} . \tag{3}$$

The conditional logit yields point estimates for the preference parameters (β'), implicitly assuming that preferences are homogeneous.

Heterogeneous preferences can be accommodated using either a random parameters logit (Train 1998) or a latent class logit (Boxall and Adamowicz 2002). In the random parameters logit, the choice probability is given by:

$$P_{nit} = \int \frac{\exp(\beta' X_{nit})}{\sum_j \exp(\beta' X_{njt})} f(\beta) d\beta \ , \tag{4}$$

where $f(\beta)$ is the density function of the preference parameters. In the LCL, heterogeneity in preferences is assumed to occur in discrete classes. The N individuals in the sample are sorted into S discrete classes, each composed of individuals with homogeneous preferences. In that case, the choice probability is given by:

$$P_{nit} = \sum_{s=1}^{S} \frac{\exp(\beta_s' X_{nit})}{\sum_j \exp(\beta_s' X_{njt})} R_{ns}, \tag{5}$$

where β_s' is the specific parameter vector for class *s*, and R_{ns} is the probability that individual *n* belongs to class *s*. In turn, the class membership probability (R_{ns}) can be modeled as:

$$R_{ns} = \frac{\exp(\theta_s' Z_n)}{\sum_r \exp(\theta_r' Z_n)}, \tag{6}$$

where Z_n is a set of observable individual characteristics that affect class membership, and θ_s is the parameter vector for individuals in class *s*.

5. Results

We estimate a series of conditional, random parameters, and latent class logits using the split sample data from the online choice experiments. Having the split sample allows us to estimate preference parameters and willingness to pay for attributes of urban forests in people's private yards as well as those in public areas in neighborhoods, such as parks and street medians. We also estimate a series of latent class logits by increasing the number of allowed classes from two to five. This allows us to explore the existence of preference heterogeneity in our data, as well as to find the best fitting latent class logit model and thereby exposing the number of latent preference classes in the sample.

Results for the models estimating preferences for urban forests in private yards and public areas in neighborhoods are shown in Figures 1 and 2, respectively. The Figures shows estimated willingness to pay for each of the examined attributes, and willingness to pay is reported as zero for attributes whose estimated preference parameters were not statistically significant. Willingness to pay values estimated with the random parameters logit are shown at the top of the Figures, and models with an increasing number of latent classes are shown from top to bottom. Models with up to five latent class logits were estimated. Latent class participation probabilities are shown at the top of each set of latent class results.

The random parameters logit estimating preferences for urban forests in private yards shows that the average respondent prefers native trees and is willing to pay $5.05 a month to have native trees in their property. Similarly, the average respondent prefers to have a mix of tree sizes in their yard, as opposed to just large fully grown trees, and is willing to pay $2.61 a month for this attribute. The average respondent, however, does not have a strong preference for the number of tree species that make up their forested yard, and the model estimates a preference parameter for this attribute that is not statistically different from zero.

The two-class model results in two classes with membership probabilities of 79% and 21%. The first class, composed by a majority of respondents (79%) prefers native trees in their yards and is willing to pay $3.58 a month for them. This group also prefers a mix of tree sizes and is willing to pay $2.49 per month for this type of forested yard. The second class, composed by just 21% of the sub-sample, expressed preferences for the same two attributes, but is willing to pay more for each ($7.61 a month for native trees and $2.52 a month for a mix of tree sizes). Neither of these two classes appears to have a strong preference either way for many or few species of trees in their yards.

The three-class model results in classes composed of 34%, 13% and 52% of the sub-sample. The first class, composed of nearly one-third (34%) of the sub-sample, expressed strong preferences for native trees and a mix of tree sizes. Members of this class are willing to pay a hefty $28.86 a month to have native trees, and $11.05 a month to have a mix of tree sizes in their yards. The second class, composed of 13% of the sub-sample, prefers native trees and is willing to pay $3.17 a month for these types of trees in their yards, but is indifferent about the other attributes examined. Lastly, the third class, composed of 52% of the sub-sample, prefers exotic trees and is willing to pay $3.10 a month to have them in their yards, as well as $1.10 a month for a mix of tree sizes, and is indifferent about the number of tree species.

The four-class model results in classes composed of 39%, 25%, 22%, and 13% of the sub-sample. The first class, with 39% of the sub-sample, prefers exotic trees and is willing to pay $4.20 a month to have them in their yards. Members of this class also prefer to have few species of trees in their yards, expressing a willingness to pay of $1.47 a month for this attribute, and a mix of tree sizes, expressing a willingness to pay of $1.92 for this attribute. The second class, composed of 25% of the sub-sample, prefers native trees, few tree species, and a mix of tree sizes, and is willing to pay $9.36, $4.70, and $7.31

per month, respectively, for these attributes in their yards. The third class, composed of 22% of the sub-sample, has an estimated payment coefficient that is not significantly different from zero, which makes their willingness to pay for all examined attributes equal to zero. The fourth class, composed of 13% of the sub-sample, prefers native trees and is willing to pay $3.94 to have them in their yards, but is indifferent about the other urban forest attributes examined.

The five-class model results in classes comprised of 33%, 17%, 24%, 13%, and 13% of the sub-sample. The first class, composed by 33% of the sample, prefers exotic trees and is willing to pay $22.31 a month for them, as well as trees of many species and is willing to pay $4.06 for these types of landscapes in their yards. The second class, composed of 17% of the sample, prefers native trees, few species of trees, and a mix of tree sizes, and is willing to pay $1.46, $1.27, and $1.21, respectively, for these attributes in their forested yards. The third class, composed of 24% of the sample, prefers native trees and is willing to pay $34.52 a month for them, but is indifferent about other attributes examined. The fourth class, composed of 13% of the sub-sample, prefers native trees, few species of trees, and a mix of tree sizes, and is willing to pay $10.54, $2.52, and $12.69 a month for forested yards with these attributes. Lastly, the fifth class, composed of 13% of the sample, prefers native trees and is willing to pay $5.47 a month for yards with native trees, but is indifferent about the other attributes examined.

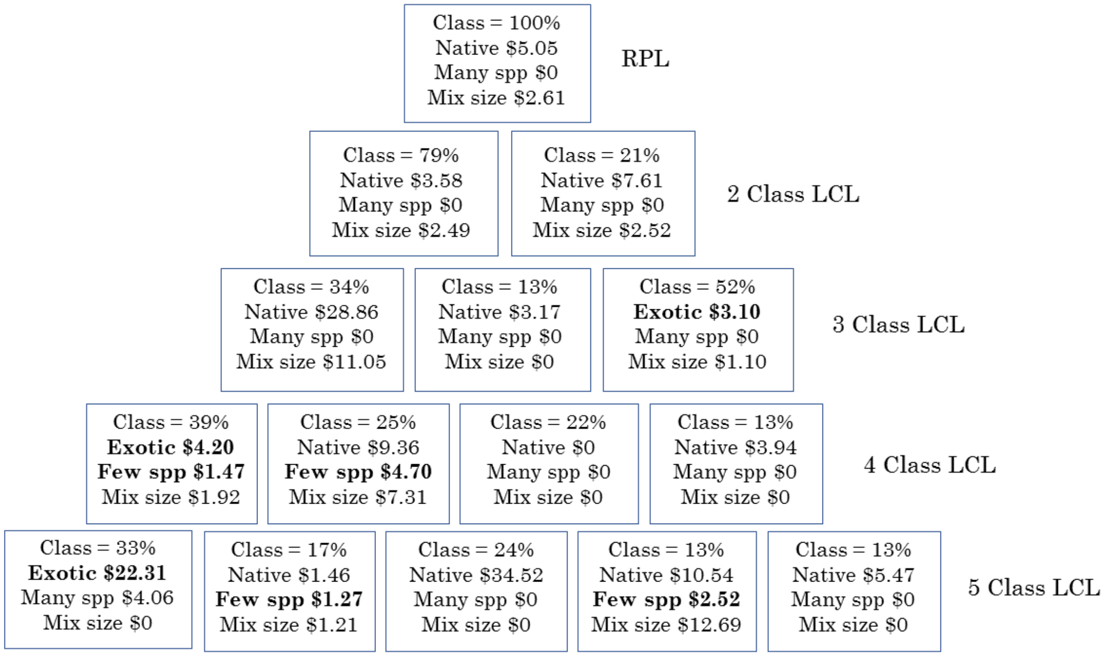

Figure 1. Willingness to pay for private yard forest attributes. Parameter estimates for the Random Parameters Logit (RPL) and Latent Class Logits (LCL) are presented increasing the number of classes from top to bottom.

The random parameters logit estimating preferences for urban forests in public areas within residential neighborhoods, such as parks and street medians, shows that the average respondent prefers native trees and is willing to pay $5.47 a month to have native trees in their property. Similarly, the average respondent prefers to have many species of trees in these areas, and is willing to pay $1.23 a month for public areas with many species of trees. Finally, the average respondent also prefers a mix of tree sizes in public areas of their neighborhoods, as opposed to just large fully grown trees, and is willing to pay $2.10 a month for this attribute.

The two-class model results in classes with membership probabilities of 86% and 14%. The first class, composed by a majority of respondents (86%) prefers native trees in public areas of their neighborhood and is willing to pay $4.98 a month for them. This group also prefers many species of trees and a mix of tree sizes, and is willing to pay $1.47 and $1.80 per month, respectively, for forested public spaces with these attributes. The second class, composed by just 14% of the sub-sample, expressed preferences for native trees and a mix of tree sizes, but is willing to pay more for each ($5.12 a month for native trees and $4.02 a month for a mix of tree sizes). The second class does not appear to have a strong preference either way for many or few species of trees in public areas within their neighborhoods.

The three-class model results in classes composed of 63%, 12% and 25% of the sub-sample. The first class, composed of nearly two-thirds (63%) of the sub-sample, did not express a strong preference for native or exotic trees. Members of this class are willing to pay a meager $0.70 a month to have many species of trees, and $1.88 a month to have a mix of tree sizes in neighborhood public spaces. The second class, composed of 12% of the sub-sample, prefers native trees and is willing to pay $3.75 a month for these types of trees in their parks and medians. This class is also willing to pay $2.76 for a mix of tree sizes, but is indifferent to the number of species in their neighborhood public spaces. Lastly, the third class, composed of 25% of the sub-sample, prefers native trees and is willing to pay a hefty $35.29 a month to have them in their parks and medians, as well as $3.74 a month for many species of trees, and $3.50 for a mix of tree sizes.

The four-class model results in classes composed of 27%, 30%, 12%, and 31% of the sub-sample. The first class, with 27% of the sub-sample, prefers native trees and is willing to pay a hefty $32.87 a month to have them in public areas of their neighborhoods. Members of this class also prefer to have many species of trees in public areas in their neighborhoods, expressing a willingness to pay of $3.75 a month for this attribute, and a mix of tree sizes, expressing a willingness to pay of $4.48 for this attribute. The second class, composed of 30% of the sub-sample, does not exhibit a preference for native or exotic trees, but prefers few tree species and a mix of tree sizes, and is willing to pay $1.74 and $2.62 per month, respectively, for these attributes in public spaces of their neighborhoods. The third class, composed of 12% of the sub-sample, is indifferent to the number of tree species, but prefers native trees and a mix of tree sizes, and is willing to pay $5.08 and $5.23, respectively, for these attributes in forested public areas in their neighborhoods. The fourth class, composed of 31% of the sub-sample, has an estimated payment coefficient that is not significantly different from zero, which makes their willingness to pay for all examined attributes equal to zero.

The five-class model results in classes comprised of 28%, 2%, 11%, 30%, and 29% of the sub-sample. The first class, composed by 28% of the sample, prefers native trees and is willing to pay a hefty $33.47 a month for them, as well as trees of many species and a mix of tree sizes, and is willing to pay $3.88 and $5.00 for these types of landscapes in parks and medians of their neighborhoods. The second class, composed of just 2% of the sub-sample, is indifferent about native or exotic trees and the number of tree species, but prefers to have large trees only in public areas of their neighborhoods and is willing to pay $4.46 for these attributes. The third class, composed of 11% of the sample, prefers native trees and a mix of tree sizes, and is willing to pay $5.36 and $3.66 a month, respectively, for these attributes in public forested areas, but is indifferent about the number of tree species. The fourth class, composed of 30% of the sub-sample, is indifferent about native or exotic trees, but prefers to have few species of trees and a mix of tree sizes, and is willing to pay $1.77 and $2.64 a month, respectively, for forested parks and medians with these attributes. Lastly, the fifth class, composed of 29% of the sample, prefers exotic trees and many species of trees and is willing to pay $15.05 and $13.21 a month, respectively, for these types of forests in public areas of their neighborhood, but is indifferent about tree sizes.

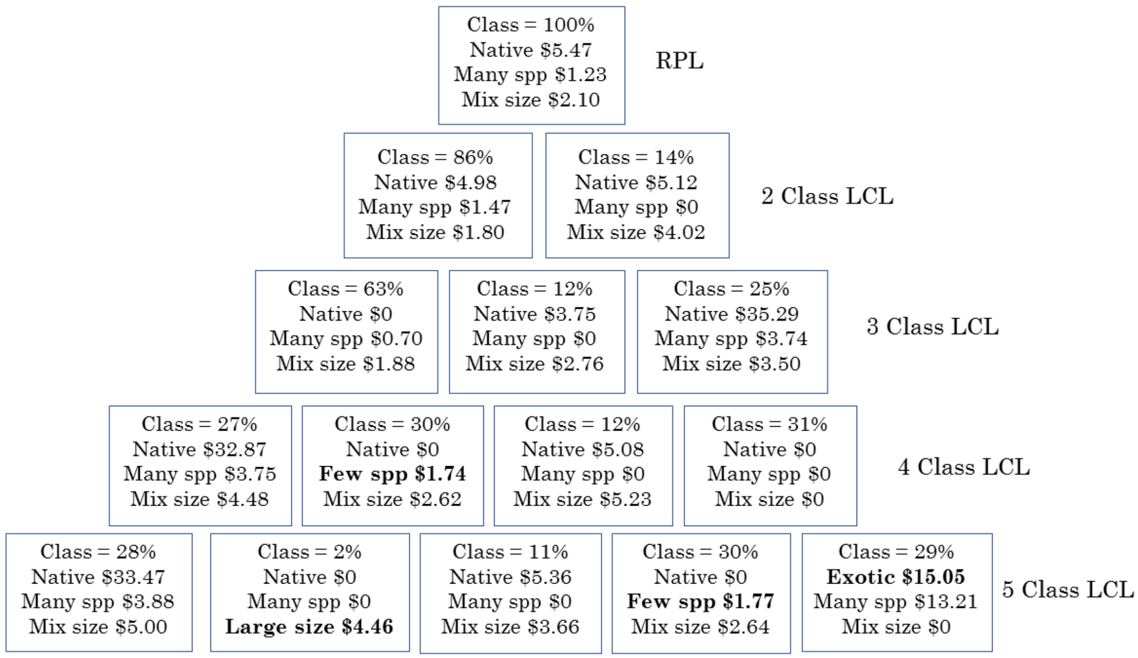

Figure 2. Willingness to pay for public area forest attributes. Parameter estimates for the Random Parameters Logit (RPL) and Latent Class Logits (LCL) are presented increasing the number of classes from top to bottom.

While all these models are interesting and informative, and confirm the existence of heterogeneous preferences for urban forest attributes, not all models are equally valid. Comparison of model fit using the Akaike Information Criteria (AIC) can aid selection of a superior model, which can then be used to inform policy decision making (Figure 3). In our case, the poorest fit is obtained with the conditional logit model (results not reported here). The random parameters logit, which allows for a very flexible specification of heterogeneous preferences, provides a much better fit than the conditional logit, and confirms the existence of preference heterogeneity. The random parameters logit also performs than most latent class logit models, with the exception of the five-class logit models, in both the public areas and private yard cases. The overall best fit is obtained with the five-class models.

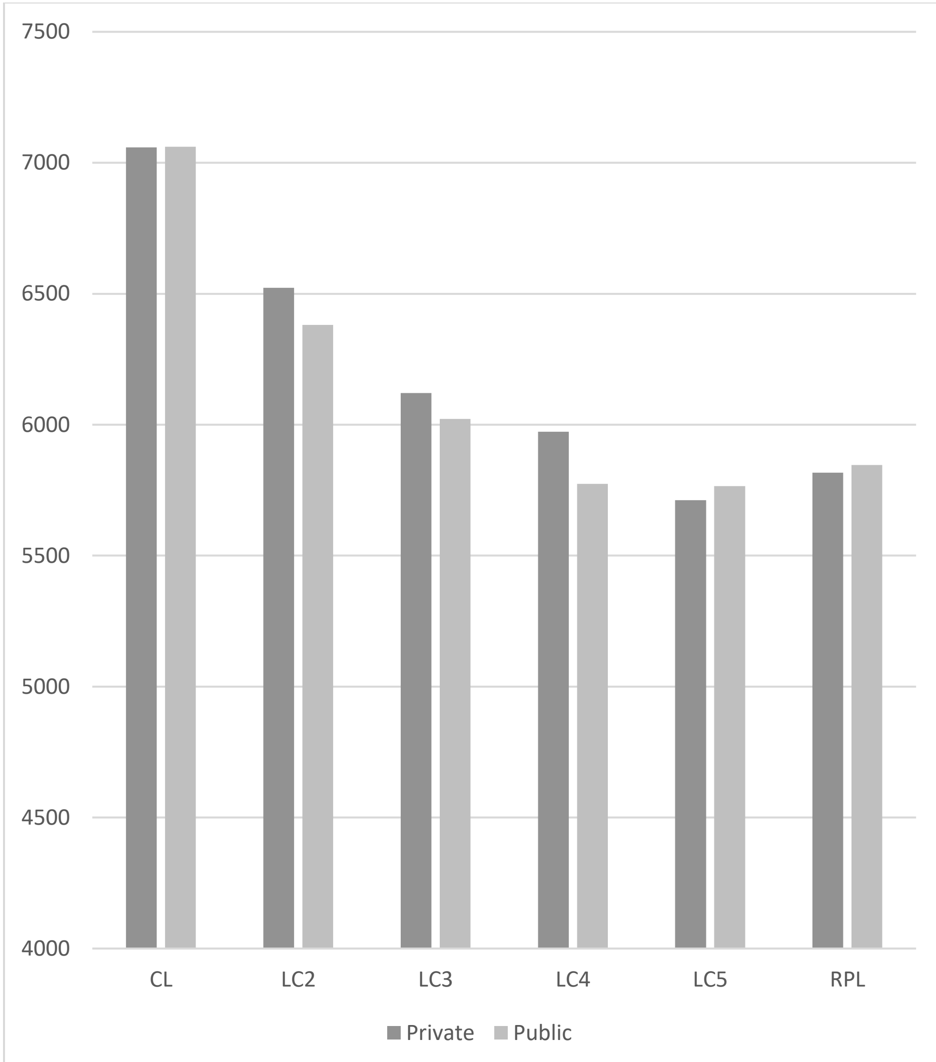

Figure 3. Akaike Information Criteria (AIC) comparison across estimated models. For both the private yard and public areas set of models, the five latent class logits perform better than all other estimated models.

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