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CAVAT (Capital Asset Value for Amenity Trees): valuing amenity trees as public assets

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ABSTRACT

Valuing amenity trees is important for calculating loss of amenity and replacement value following wilful or negligent damage, and for several aspects of urban forest management: planning, budget setting and decision-making. Capital Asset Value for Amenity Trees (CAVAT) is a tool for valuing amenity trees; it was first presented publicly in 2003. It includes two methods: the Full Method, which is used to provide a compensation replacement value for single trees; and the Quick Method, which is used to determine the value of a population of trees as an asset, for asset management purposes. CAVAT is widely adopted across the UK within local authority tree departments, and by major land-holding and transport organisations. It is also incorporated into the Joint Mitigation Protocol for use in the assessment of subsidence cases. This paper presents CAVAT for the first time in a formal publication. It describes the uses for which it has been designed, it comprehensively describes the methodology and shows where this deviates from similar valuation tools. Five case studies are presented as examples of its application and demonstration of its suitability-for-use. Finally, future potential developments that would facilitate wider use of CAVAT are also presented.

KEYWORDS
Urban trees; asset valuation; adequate compensation; replacement value

Highlights

- Tree officers need monetary values for amenity trees
- CAVAT is a trunk formula valuation method adjusted for tree health and function
- CAVAT valuations adjust for human population density to account for all potential beneficiaries
- Compensation for damaged public trees has been secured using the Full Method
- Quick Method has informed urban forest succession planning and resource allocation

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Introduction

Amenity trees are any that are not grown or managed for their value as a timber or other crop and that provide other benefits or values (Cullen, 2007). Examples include trees found in parks and other open spaces, or lining the sides of streets, railways, rivers and canals and in gardens. There are many reasons for wanting and needing to value amenity trees: for example, setting and justifying budgets (Cullen, 2007), calculating loss of amenity and replacement value following wilful or negligent damage of trees, and urban forest management planning and decision-making. Other reasons may include determining tree value and amenity status required for insurance claims (such as in subsidence cases), tax deductions, or real estate value contributions. In other words, valuation is a tool to provide the information required as a basis for rational decision-making (Cullen, 2007). However, with such a diverse range of decisions, the context and, therefore, the method for valuation varies. It is therefore important that valuers have at their disposal a range of valuation methods to choose from and an understanding of the purpose of a valuation in order to select the appropriate tool to use.

A range of valuation methods is available for use in the UK, including the Helliwell system, the CTLA (Council of Tree and Landscape Appraisers) methods (RICS, 2010), the i-Tree suite of tools (www.itreetools.org) and CAVAT (Capital Asset Value for Amenity Trees) – the focus of this publication. These methods and systems are described further below, following an introduction to the concept of "value".

The basis for valuation: "value"

Section 198 of The Town and Country Planning Act (TCPA) (1990) establishes trees as an amenity[1]. Amenity trees provide a wide range of tangible and intangible benefits to society. These include the "regulating ecosystem services" of cooling local air temperatures, intercepting rainfall and reducing air and water pollution and the socio-cultural ecosystem benefits of helping to make cities safer, more diverse and attractive, and wealthier (Davies, Doick, Handley, O'Brien, & Wilson, 2017; FAO, 2016; Ulmer et al., 2016). Each benefit has value; where value can be understood as: (a) the monetary relationship between properties (interests, benefits and rights) and those that buy, sell, or use them; or (b) the present worth of future benefits (Appraisal Foundation, 2006; In: Cullen, 2007). It is the latter of these two definitions that is usually referred to when considering the benefits and services provided by amenity trees (Cullen, 2007). Thus, value can be ascribed to amenity trees because "someone" anticipates or expects them to provide current and future benefits, to have utility (satisfy desires, needs, wants)[2], or to make a difference. Here, the notion of anticipation or expectation is important: utility is ascribed because of the benefits to be attained. To whom the benefits accrue is also important and must be specified within a valuation (Cullen, 2007). With natural resources like trees that may be publicly owned (e.g. a local authority tree) or regulated (e.g. privately owned trees under a Tree Preservation Order), single or multiple beneficiaries can be distinguished (i.e. benefits accrue to both individuals and society more broadly) (Cullen, 2007).

The challenge for amenity tree valuation is that neither the intangible amenity of trees, nor the tangible benefits or services they provide are market goods (i.e. they are not exchanged or traded and there are no market prices that would allow the application of an income or sales based approach to valuation). And while benefits-based approaches are available (e.g. the Helliwell system and i-Tree, see below), these reflect only a subset of amenity tree benefits (and values). Consequently, a tool that provides a compensation value for damage to or loss of an amenity tree is required. CAVAT has been designed to fill this void, using the conceptual framework created by tree protection under UK law and practice. CAVAT includes two methods: the Full Method, which is used to provide a compensation replacement value for single trees on a like-for-like basis; and the Quick Method, which is used principally to determine the value of a population of trees for asset management purposes, though is also used for individual valuations in tree asset management databases. While CAVAT has not been designed like i-Tree to value ecosystem services, it has been widely adopted. Since the first presentation of CAVAT in 2003, its trial in the London Borough of Barnet throughout 2006–2007, and its subsequent application by Local Authority Tree Officers across the UK (including across the London Boroughs, the Midlands and Bristol), CAVAT has been successfully used to defend trees from loss due to development as well as secure adequate and appropriate compensation for their removal through private development by application of the Full and Quick Methods. CAVAT has also been used to trigger alterations to infrastructure development plans allowing for the conservation of mature street trees by application of the Quick Method. As such, CAVAT appears to be used on a consistent basis by a large number of UK local authorities for urban amenity tree valuation and is providing an indication of a "market" price.

Valuation methods and their gaps

Valuation must consider what is being valued and a valuer must always consider whether the valuation method defines and limits the value of the amenity tree, or is simply a limitation of the method that must be specified alongside the determined value. For example, the Helliwell system (Helliwell, 1967) was retitled as "Visual amenity valuation of amenity trees and woodlands: the Helliwell system" to clarify that its scope is limited to "visual amenity" valuation (Cullen, 2007; Helliwell, 2003). Helliwell also argued that there was a need for a tree valuation method that is independent of both the cost of growing the tree and of the potential replacement cost (Helliwell, 2008). A call later echoed by Saraev (2011): an old and significant tree with local historical value may have grown with little or no financial outlay from a particular individual or group, while a tree that has been planted at significant capital cost may be inappropriately located, adding nothing to the local aesthetic.

The Helliwell system

The base approach of the Helliwell system is to allocate point scores under a number of different factors; the points are multiplied to give an overall comparative "score" for a tree (or woodland). Finally, a monetary conversion factor is applied to the score in order to attach a value where this is desirable. The six factors scored are: tree size, duration (useful life expectancy), importance (of position in the landscape), tree cover (presence of other trees), suitability to setting and form (RICS, 2010). The Helliwell system is an expert-based willingness-to-pay valuation method (Price, 2007). However the derivation of the base price remains somewhat unclear and thus it is difficult to comment on its robustness and relevance. In the UK, it has been used in court cases, insurance claims and public inquiries to place visual amenity values on individual trees and, to a lesser extent, has been used in court to place visual amenity values on woodland.

Council of Tree and Landscaper Appraisers (CTLA)

CTLA is a council of members from a consortium of North American green industry organisations who develop and describe valuation methods (Cullen, 2007). Recognising that a valuation method is simply a tool that cannot be used meaningfully without an understanding of the purpose for which the tool was designed, the CTLA have developed a range of tools for valuing amenity trees. The main CTLA methods of relevance to this publication are the replacement cost method (RCM), which is used for 1:1 size replacement, and the trunk formula method (TFM), which relies on unit costs to develop surrogate replacement costs for trees that are larger than commonly available replacements. Both methods are depreciated replacement cost (DRC)[3] approaches, used to overcome the issue of a lack of a comparative market based price upon which to base amenity tree valuation (Cullen, 2007 and references therein). In brief, DRC approaches take an initial cost estimate to buy, plant and establish a tree and depreciate for obsolescence and deterioration to produce a refined value (Hollis, 2007). DRC is well established in general guidance and standards worldwide and a full description is beyond the scope of this publication; for details the reader is referred to Cullen (2007). DRC is particularly applicable to local authority infrastructure, community, heritage and conservation assets (Cullen, 2007).

i-Tree

i-Tree is a suite of open source, peer-reviewed software tools developed for the specific purpose of supporting urban forest management (www.itreetools.org). i-Tree Eco is one of the tools in the i-Tree suite. It is designed to characterise the structure of the tree population, including species and age composition. Together with local environmental data, the urban forest is then analysed using the urban forest effects (UFORE) models to quantify some of the environmental functions it performs, including air quality improvement, stormwater control, carbon sequestration and carbon storage. These functions can then be valued for annual and total benefit using standard approaches. For example, UK Social Damage Costs for oxides of nitrogen and particulate matter ($PM_{2.5}$ and PM_{10}) can be multiplied by the tonnes of each of these pollutants removed annually from the atmosphere to provide values for these [ecosystem] services provided by the trees in the sample area (Defra, 2015). i-Tree Eco is adaptable to a variety of scales: from area-wide assessments to a single tree. i-Tree Eco reflects only a subset of amenity tree benefits and thus, very likely, undervalues many trees in the urban realm. Indeed, many i-Tree Eco studies conducted in the UK to date – including those in Wrexham (Rumble, Rogers, Doick, & Hutchings, 2014), “Area 1[4]” highways (Rogers & Evans, 2015), Glasgow (Rumble, Rogers, Doick, Albertini, & Hutchings, 2015) and London (Rogers, Sacre, Goodenough, & Doick, 2015) – have augmented their i-Tree Eco survey with the CAVAT methodology in order to address Eco’s short fall in cultural ecosystem service considerations. In each of the four reports, the replacement value of the trees (according to the CTLA v 9 method embedded in the i-Tree Eco software) and the “compensation for amenity trees” value of the trees (as returned by the CAVAT valuation) represent substantial values in comparison to the estimated accumulated benefit of per annum return of ecosystem services which accrue over time. When using such tools, it is, therefore, these replacement figures that provide the key reason to protect and maintain these trees, as enforced in the TCPA Act 1990[5].

Currently available methods, in the UK and Ireland, have been seen as lacking for at least some valuation problems. For example, the CTLA methods focus on the private value of a tree to its owner, so lending themselves to private disputes, but less so to the issue of the public value of trees. Where trees are on public land, or where what is sought is an expression of their public value, then the CTLA valuation may be of limited use.

On the other hand, the suitability of the Helliwell system can be questioned for three reasons: (a) the use of an arbitrary value per point (£33.01 1 January 2018; Arboricultural Association, 2018) caps the maximum value that can be ascribed to any single tree at £127,590, (b) its self-ascribed limitation to visual amenity valuation, and c. the mathematical approach tends to magnify even small differences between trees. This can be seen as valuing trees in terms of their contribution to visual amenity rather than valuing them per se. This could be useful for a relative assessment of one tree's worth in comparison to another, though not for providing a replacement cost of a tree.

CAVAT

The valuation system described herein – CAVAT – was originally created by Christopher Neilan between 1998 and 2003, recognising the limitations of the valuation approaches available at the time. Presented at the 2003 UK Arboricultural Association conference and later a meeting of the London Tree Officers Association (LTOA), the LTOA Executive Committee set up a working group to test the method and assist in its further development. The means of considering location was revised, life expectancy was incorporated and the name changed; "CAVAT" was adopted by the LTOA in 2006 and published on LTOA website as part of the 3rd edition of the Risk Limitation Strategy in 2008 and subsequently as a stand-alone document. CAVAT is an expert-based amenity tree valuation tool; it is free to use by any competent arborist, professional training is available.

CAVAT has been designed to assist local authorities in achieving an appropriate level of compensation where publicly owned trees are damaged or removed without consent and to provide a basis for managing public trees as assets rather than liabilities. The distinction of public trees being viewed as assets rather than liabilities is an important aspect of maintaining and enhancing the ecosystem services that trees provide in an urban setting.

Criticisms of CAVAT, however, have been made. The 2013 Natural England report "Green Infrastructure – Valuation Tools Assessment" concluded that CAVAT could be recommended for financial compensation for tree damage but not for economic valuation purposes (Natural England, 2013), i.e. it does not value the benefits of ecosystem services but estimates the cost of replacing a tree depending on various attributes. Others have stated that the expert judgements applied do not comply with the Green Book guidance for estimating value (Binner et al., 2017) and that CAVAT does not fully account for depreciation (RICS, 2010) as required to determine the replacement cost of an asset (Hollis, 2009). Despite these criticisms, it is currently widely used – several hundred transactions each year between local authorities and developers in respect of compensation issues on publicly owned trees, and as highlighted by these three quotes:

- Trees are an asset to citizens, just like other key urban infrastructure. If a lighting column falls down for example, people expect these to go back. How do we get this message central with respect to trees, their management and maintenance? Valuing trees as capital assets – as CAVAT does – is part of this process and that's why [we] undertake a [detailed] condition survey, including a CAVAT valuation, every 5 years (pers comm. John Parker, TfL, July 2016).

- [CAVAT]…attributes a value to an urban tree that two parties mutually agree on…[so is…] market driven rather than being the result of an academic exercise. It continues to be used widely across the UK when local authorities wish to agree compensation for tree damage when utilities, construction companies or developers damage public trees (pers comm. Jim C. Smith, Forestry Commission, January 2018).
- During a recent regeneration project, CAVAT was used within the S106 agreement. Over 400 trees, valued by the local community, were at risk. We modelled the CAVAT value that this tree population would reach by Project Completion and calculated how many trees would need to be planted on and off site to replace that value +5%. Subsequently, over 120 trees were retained. The application of CAVAT contributed to innovative design and construction; trees were retained close to major buildings and more trees proposed within the development than were removed. A further 900+ trees were planted in local streets, parks and housing land to enable CAVAT +5% to be delivered (pers comm. Luke Fay, Treework Environmental Practice, February 2018).

Thus CAVAT is providing a consistent and transparent protocol for agreeing a compensation value for amenity trees and providing an indication of a "market" price.

The aim of this paper to present CAVAT: (a) to state the uses for which it has been designed, (b) to comprehensively describe the methodology and (c) to show where this deviates from tools with similar aims. Five case studies are presented as examples of its application and demonstration of its suitability-for-use. Future potential developments that would facilitate wider use of CAVAT are also presented.

The CAVAT valuation method

This section describes the CAVAT method step-by-step. CAVAT is a TFM[6]-based DRC valuation method with adjustments made for the proximal human population set to benefit from the tree, the functional status of the tree and life expectancy. Thus, elements of CAVAT are not new, but taken from existing valuation methods or arboricultural good practice. For these elements, the literature precedent is referenced, and the step described in the sense of how the existing element is used within CAVAT. Where a new element was devised during the development of CAVAT the development process is presented in full.

CAVAT has been developed as two methods. The Full Method is used to provide a compensation replacement value for single trees or groups of trees, it is used when precision is required and sufficient time must be made available for a full assessment. The Quick Method is used to determine the value of a population of trees as an asset for asset management purposes; it is used as a strategic tool for the assessment and monitoring of a public tree stock as a financial asset in a rapid and cost-effective way.

The Full Method comprises seven steps and the Quick Method comprises four steps. The Full Method is described in Section 1. The Quick Method is described in Section 2. In overview, Step 1 of the Full Method relies on measurement and a unit conversion formula. Step 2 relies on government (census) data. Step 3 requires an assessment of accessibility. Steps 4, 5 and

6 rely on observation and arboricultural knowledge. Step 7 relies on a good understanding of tree health and the ability to estimate reliably the life expectancy of a tree. Steps 1 and 7 are not specific to CAVAT, but were adopted from existing valuation methods. Steps 2, 3, 4, 5, 6 are specific to the CAVAT valuation method. The seven steps for the Full Method are bulleted below and then presented consecutively, in detail including three worked examples.

Section 1. The Full Method

The Full Method has seven steps. The first establishes a base value, which the further six steps modify to achieve a final valuation. The steps of the Full Method are:

- Step 1. Determining the "base" value (size multiplied by a unit value factor).
- Step 2. Adjustment to determine the "community tree index (CTI)" value (a value adjustment based on location, in terms of population density).
- Step 3. Adjustment to determine the "location factor (LF)" value (a value adjustment made for the relative accessibility of the tree to the general public).
- Step 4. Adjustment to determine the "functional crown value [part 1]: structural framework" (an adjustment of the value according to crown size).
- Step 5. Adjustment to determine the "functional crown value [part 2]: Leaf cover completeness and condition" (an adjustment of the value according to the functional status (condition) of the present canopy).
- Step 6. Adjustment to determine the "amenity and appropriateness" value (a value adjustment for how well the particular tree species characteristics are suited to its location).
- Step 7. Adjustment to determine the "Full" value (a value adjustment for life expectancy (LE) and leading to the final value for the tree).

The seven steps of the Full Method are described in detail below.

Step 1: base value

The base value is calculated using trunk area, as a measurement of tree size, and the current unit value factor (UVF) using Equation (1).

Measurement of trunk area is not novel to CAVAT, but standard to TFM (see for example: Hollis, 2007). Trunk area is calculated in the standard way using the measured trunk diameter (TD), or circumference, at 1.5 m to determine the radius (BS5837, 2012).

The UVF is novel to CAVAT. The UVF represents the full cost of a newly planted tree on the basis of per unit of trunk cross-sectional area (i.e. £ per cm^2). Its derivation has two components: the nursery gate price and the planting cost (transport, planting, materials, immediate care and management costs, but not after-care). Specifically, the unit area cost is the average cost per square centimetre of stem area determined as the cost, at trade prices, of the top 10 mostly commonly purchased species/varieties as 12–14 cm diameter standard containerised trees. The 10 species/varieties were: *Pyrus calleryana Chanticleer, Betula pendula, Betula utilis Jacquemontii, Prunus Umineko, Quercus robur, Platanus x hispanica, Sorbus aucuparia Sheerwater Seedling, Prunus Sunset Boulevard, Tilia cordata Greenspire, Crataegus laevigata Pauls Scarlet*. These had been determined via a survey of tree officers and nurseries from across GB as being the most frequently used. The average for 10 species/varieties was selected rather than producing costs for each individual species (as is the case for the CTLA trunk formula method) in order to smooth differences in pricing caused by production factors or variation in demand. The assessed value of a particular tree then varies according to its objectively assessed characteristics. A planting cost factor was included, taken as 150% of the unit area cost, as a best estimate of the total costs of planting but excluding costs for the five-year establishment period. The planting cost factor was added to the unit cost area to provide the final UVF. The unit area cost was first determined in 2004/5; it has been increased each year in line with the retail price index (RTI) measure of inflation (originally using RPI/X, reverting to RPI when that particular measure was discontinued). The annually adjusted UVF is published on the CAVAT (www.cavattv.org) and LTOA (www.ltoa.org.uk/resources/cavat) websites for consistency across CAVAT users. The UVF was re-calculated in 2017 and determined to be £15.88.

The base value of a tree is then calculated using Equation (1).

$$\mathrm{BV} = \pi r^2 \times \mathrm{UVF} \tag{1}$$

where: BV = base value; r = radius of tree; UVF = unit value factor (a single value applicable across the UK)

Where a group of trees exists, each tree is considered separately. These can be then summed together at Step 7 where the valuer seeks a single value for the group. Where a single tree has multiple stems, each stem is measured and aggregated at Step 1 into a single unit using standard arboricultural techniques (for example, Swiecki & Bernhardt, 2001). A single value is therefore produced for multiple stem trees.

Worked examples. Three worked examples are presented: tree 1 is an English oak (*Q. robur*) that is part of a group in a public green space; it has a DBH of 31 cm and therefore a base value of £11,986. Tree 2 is a single common lime (*Tilia* x *europaea*) that is in a line of late Victorian plantings in a paved footway along the east side of a town centre high street. It has a DBH of 52 cm and thus a base value of £33,725. Tree 3 is a sycamore (*Acer pseudoplatanus*) that is in a private car park. It has a DBH of 86 cm. The height at which the measurement is taken is adjusted downwards, to avoid localised swellings below the crown break. It has a base value of £92,244.

The following steps introduce the different attributes that adjust the base value for location, relative contribution to amenity value, and assessment of functionality and life expectancy. CAVAT does not currently account for the difference between average values and marginal values (i.e. differentiate between the value of a tree if it is in a group of 20 or a 5); see Discussion for further details.

Step 2: CTI value adjustment

In step 2, a CTI factor is applied to the base value to account for population density; i.e. the potential number of people who could benefit from the tree. The CTI factor is derived from population density, as produced for each local authority in England and Wales by the Office of National Statistics (ONS; www.ons.gov.uk). Seven CTI factors are used within CAVAT and they vary from 100%, for population densities of less than 20 people per hectare, to 250% for highly populated areas such as Inner London. A CTI factor of 100% applies to the majority of the country[7]. The seven CTI factors are shown in Table 1. Care should be taken to use the

Table 1. The community tree index (CTI) factors that are applied to the base value of a tree to account for population density. A seven-point scale is used for adjustment, this scale is known as the CTI Band. CTI is applied in step 2 of both the Full Method and the Quick Method.

Population density (people/ha)	CTI factor (%)	CTI band
<20	100	1
20–39	125	2
40–59	150	3
60–79	175	4
80–99	200	5
100–119	225	6
>120	250	7

most up-to-date population density values. Population statistics have a shelf life; therefore, CAVAT values also are time bounded.

The CTI adjustment step was developed as part of the development of CAVAT. Its non-linear approach offers a conservative valuation in comparison to a linear progression, such as used in the UKNEA-FO (Church et al., 2014). For example, since the most densely populated areas have more than 6 times as many people than the least populated a 600% CTI factor would be applied if a linear progression is employed rather than the 250% adjustment defined by the non-linear approach. On one hand, this non-linear progression undervalues trees. On the other hand, however, adopting a conservative approach was considered by the LTOA Executive Committee during CAVAT development to be more acceptable to the range of stakeholders likely to use CAVAT and was, therefore, favoured.

Worked examples. All trees are from the same town. Published figures reveal that population density is <20 people/ha. Therefore for each of the three worked examples the base value is carried forward unchanged.

Step 3: LF value adjustment

In step 3, an adjustment is made for the location of the tree: how fully its public amenity benefits are available to the general public. The CTI adjusted value may be retained (100%) or reduced by up to 75%. Adjustments are made in 25% increments according to whether the tree is:

(1) fully visible in or from a public place e.g. within a public highway, public park or woodland. For these locations, the value remains 100%
(2) wholly visible though in a public area not widely accessible e.g. in a local authority owned location such as a school or housing estate, hotel or public golf course. For these locations, the CTI value is reduced by 25%
(3) less accessible while still being in a publicly owned area e.g. a courtyard of a local authority owned property, a sheltered housing unit or private golf course. For these locations, value is reduced by 50% (i.e. to 50% of its CTI adjusted value)
(4) not accessible or wholly invisible to the public e.g. in the back garden of a privately owned property. For these locations, the CTI adjusted score is reduced by 75%. The size of the reduction reveals how greatly the tree's location reduces its contribution to public amenity while recognising that a tree that is not publicly visible still makes a range of contributions to public amenity and well-being, including in respect of health, climate change and biodiversity.

By applying step 3, the CTI adjusted base value is modified to take account of location (i.e. at the sub-ward level) to produce a more refined assessment of the actual benefits received by the local population.

Worked examples. Trees 1 & 2 are on public land, either in or immediately adjacent to a public highway; they are fully visible. Tree 3 is in a private car park; however it is visible from several public buildings including a public health centre and the garden of a busy public house. It is also large enough to be glimpsed from the town centre high street. Trees 1 and 2: the step 2 CTI adjusted value is carried forward unchanged. Tree 3, the CTI adjusted value is reduced by 25% to £69,182.

Step 4: functional crown value adjustment [part 1]: structural framework

In steps 4 and 5 an assessment is made of how well the tree is performing biologically in comparison to what would be expected of a well-grown and healthy tree of the same species and girth in that location. In CAVAT, this is termed "functional crown value" and is considered firstly with respect to the structural framework (step 4) and subsequently as canopy completeness and condition (step 5). Given the comparison that is being made, this is an expert assessment, requiring a good knowledge of a species' characteristics and how these can vary with location, the surveyor must have proven appropriate arboricultural training.

The step 4 functional crown value part 1 adjustment considers the structural framework and results in either 100% of the LF value being retained or a negative adjustment made (i.e. the step 3 LF value is reduced). The basis of CAVAT is the cross-sectional area of a tree's trunk and an appropriately sized crown, corresponding to a fully formed tree whose growth has not been interrupted or compromised. For example, a newly planted tree would be expected to have the equivalent, well-developed and balanced trunk and head of branches that is able to support a full canopy as that of a healthy open-grown specimen. Similarly, a mature tree should display a well-developed trunk and branch structure, supporting (or being capable of supporting) a full leaf canopy that is in proportion to its cross-sectional trunk area.

The assessment considers the completeness of the woody structure and how damage and pruning have affected its potential to generate a fully developed canopy. The depreciation is directly proportionate to the degree of pruning, damage or any other reason for failure to develop. The positive impacts of skilful pruning (for example, in accordance with BS3998, 2010) would result in a lesser reduction in value than unskilful "topping" simply due to the differential in the tree's remaining ability to generate canopy. In assessing urban pollards, the assessor should allow for the ability of a well maintained, carefully pollarded tree to regenerate canopy more effectively. The step 4 assessment is nuanced by season as it can be impossible to see the branch structure of a tree that is fully in leaf. Therefore, the assessment considers: (leaf on season) "to what extent does the complete canopy present that expected of a model tree with this TD?" or (leaf off season) "to what extent does the complete woody framework present create the potential for the tree to generate a canopy expected of a model tree with this TD?"

Step 4 reduces the step 3 LF value to reflect the degree of variation in structural completeness. The adjustment is made irrespective of the causal factors, reflecting the assessed capacity of the tree to provide public amenity. Thus, the LF value is reduced if the woody framework has:

- been reduced in volume or density by pruning and the tree has not fully recovered,
- been reduced by natural causes, e.g. storm damage or disease, and the tree has not fully recovered, or
- failed to develop normally, e.g. because of root restriction, shading or grafting, and is smaller than would be expected from the stem size.

Where any of these crown size effects are present a single reduction in the LF value is made, rounded off to the nearest 10%. For example, if ca. 35% of the crown is missing due to a structure failure the LF value is reduced by 40%.

Worked examples. The woody structure of all three trees has been affected by pruning, and in the case of tree 1 growth habit has also been influenced by shade from adjacent trees and a building. All three have recovered a degree of crown potential, but to varying extents. All are growing strongly, without significant dieback. For tree 1 the pruning is minor and extended growth on the east side largely compensates for a diminished structural framework to the west. The framework is estimated to be 80% complete. Therefore, the step 3 LF adjusted value is reduced by 20% to £9589. For tree 2, the high pollard form has been established through a century of careful management and it has regrown strongly after recent pruning. The structural framework is estimated at 50% complete; the step 3 LF adjusted value is reduced by 50% to £16,863. For tree 3, occasional height and side reductions and extensive crown lifting have limited the extent of the woody structure, although it is recovering well after pruning. The structural framework is estimated at 40% complete; the step 3 LF adjusted value is reduced to £27,673.

Step 5: functional crown value adjustment [part 2]: canopy completeness and condition

In step 5, the step 4 functional crown value is adjusted according to the completeness and general (health) condition of the canopy that is present. At this step, the assessment considers whether the canopy present expresses fully the potential of the woody structure, as assessed in step 4. The value is reduced proportionately where functionality is impaired as a result of the expected canopy being either absent, reduced or in poor condition. For example, this may be as a result of the action of:

- biotic agents, such as leaf or shoot disease
- root disease that is affecting vitality
- canker, or severe trunk lesions (adversely affecting the tree's vitality and, therefore, the canopy)
- abiotic factors, such as fire or other forms of physical damage.

Where the potential canopy is fully present, an adjustment factor of 100% is applied to the step 4 value. Where any of these canopy condition effects are present, a reduction is made based on the percentage loss of the canopy potential, rounded off to the nearest 10%. Pests such as horse chestnut scale or oak processionary moth and diseases such as bacterial wetwood are not taken into account unless they are sufficiently severe to affect functionality adversely, or to affect appearance grossly. Similarly, physical conditions such as uneven form or wounding are not taken into account unless they are sufficiently severe to affect functionality adversely or to trigger crown reduction, in which case they should have been taken into consideration in step 4 (for example, deliberate pruning and accidental damage tends to affect the woody structure rather than the canopy and so is accounted for at step 4). A dead tree, a wholly dysfunctional tree or a tree requiring urgent removal is reduced to 0% of its value (i.e. has a value of £0).

Worked examples. For all three examples, the leafy canopy is full and uninfluenced by disease or other factors. Extension growth and bud formation for next year's canopy is good. Therefore for each of the three worked examples, the step 4 value is carried forward unchanged.

Step 6: amenity and appropriateness value adjustment

In step 6, the step 5 functional crown value is adjusted to take into account species related characteristics and how appropriate these are, given the location of the particular tree. The result is a single adjustment within the range –60% to +60%. It is an expert assessment of how the tree's positive or negative qualities affect its amenity contribution, given its specific location.

Expert arboricultural knowledge is key to making the appropriate adjustments within steps 5 and 6. However, to minimise subjectivity between assessors at step 6 defining qualities are summarised in Table 2. Positive adjustments are considered for amenity and negative adjustments for inappropriateness to location (see Table 2 for summary). Such factors are rare – most trees will not be adjusted, or will be adjusted only by a small amount. The positive (amenity) and negative (inappropriateness) adjustment factors are considered one-by-one to produce a rating (or score) for that column. To help ensure consistency in the application of CAVAT and for consistency throughout the CAVAT method, adjustments are conducted in 10% increments (except for "veteran tree" which scores +30%). Once all the column totals have been determined, a single amenity value adjustment score is then achieved by adding all of the column totals and this is applied to the step 5 functional crown value to produce the (step 6) "amenity and appropriateness" value. No adjustment is made where the positive adjustment factors are balanced by the negative adjustment factors.

Worked examples. All trees are in a conservation area, but not one where trees are a specific reason for its creation. None have particular intrinsic beneficial species characteristics, but the pollard lime (tree 2) will be widely recognised as part of a coherent, long-standing and valued nineteenth century civic improvement scheme, so has a 10% setting (landscape) factor enhancement. Trees 2 & 3 have potential adverse species characteristics that affect the valuation, but only in one case. For tree 2, the potential adverse impacts of suckering are dealt with by management and are minor; parking beneath its crown is short-term and used equally to other spaces. For tree 3, parking beneath its crown is of a longer term nature, so honey-dew is adjudged a negative physical characteristic in its setting and the value is correspondingly reduced by 10%. The vigorous character of trees 2 and 3 is an advantage in an urban setting (where less vigorous species often fail to thrive or have shortened life expectancies), providing any potential negative impacts are managed – which they have been. Therefore, for tree 1 no adjustment is made. For tree 2, a single 10% positive factor applies; the step 5 functional crown is increased by 10% to £18,549. For tree 3, a single negative 10% adjustment is made, reducing the step 5 value to £24,906.

Table 2. Amenity and appropriateness adjustment considered within Step 6. Is the tree appropriate in its context and does it make any notable positive or negative contributions to public amenity? See also table footnotes for further details amenity and scoring.

Considerations	Amenity (positive) factors		Appropriateness (negative) factors	
(1) Species attributes, as expressed in the setting	Innate characteristics significantly increasing public amenity value	E.g. notably attractive or distinctive flowers, leaf, winter stems, bark, fruit, or form, enhancing amenity and the local public context	Innate characteristics significantly lowering public amenity value	E.g. notably undesirable thorns, leaf, bark, blossom, fruit, or form, basal projections, harmful to amenity and the local public context
(2) Acquired attributes, as displayed in the setting	Characteristics acquired, generally through skilled pruning, significantly increasing public amenity value	E.g. careful pollarding or pleaching	Acquired characteristics significantly lowering public amenity value	E.g. obvious wounding, severe storm damage or other mechanical action causing badly distorted form, obvious "topping" points, basal suckering, harmful to amenity and the local public context
(3) Habitat	A veteran tree or hosting desirable wildlife	E.g. providing a nesting site, roost or food for desirable bird species, mammals or insects, especially designated NERC Section 41 species	Hosting undesirable wildlife	E.g. providing a nesting site, roost or food for undesirable bird species, mammals or insects, causing significant general problems in the area
(4) Setting	A veteran tree or enhancing its wider setting	E.g. integral to and enhancing a designed landscape, avenue or garden; part of a wider grouping of trees giving character to the area (e.g. long-maintained street pollards); or contributing to the setting of an important place or building	Detracting from its wider setting	E.g. detracting from a designed landscape, avenue or garden; detracting from a wider grouping of trees giving character to the area (e.g. long-maintained street pollards); or detracting from the setting of an important place or building
(5) Heritage	A veteran tree or making a notable positive contribution to local or national heritage	E.g. in a Conservation Area where the trees have contributed to the designation; commemorative or memorial tree or tree known to be planted by a notable person; or a locally designated tree, (e.g. Landmark or favourite tree)	Detracting significantly from local or national heritage	E.g. inappropriate species detracting from a conservation area; or damaging locally or nationally important building or monument; or harming a locally designated tree, (e.g. by overshadowing)
Note on amenity	Public amenity is as understood in planning legislation, i.e. impacts which potentially affect, for better or worse, the public as a whole. Because such contribution is considered and finite, the maximum adjustment is capped (see, notes on scoring, below). For decision-making, negative impacts on private amenity should be set against the contribution of the tree(s), but would not lower the CAVAT value directly.			
Notes on scoring	Each individual factor identified under all headings is scored at +10%. Scores are added to give the total score for that factor, capped at + 30%. Scores can be increased where justified by the amenity impact at the discretion of the assessor. Veteran status counts as 30%, allowing for its multiple benefits. Scores for each factor are then summed to provide the total adjustment for amenity factors, capped at + 60%.		Each individual factor identified under all headings is scored at −10%. Scores are added to give the total score for that factor; capped at −30%. The depreciation may be increased where justified by the amenity impact, at the discretion of the assessor. Scores for each factor are then summed to provide the total adjustment, for inappropriateness factors, capped at −60%.	
Overall score	The overall adjustment for amenity and appropriateness is the sum of the positive and negative factors. A single Step 6 adjustment is then made. The potential range of the adjustment is +60% to −60%. Assessors must be mindful to avoid double counting, positively or negatively.			

Step 7: full value, LE adjustment

In the seventh and final step, the amenity value is adjusted for LE, following the approach of BS5837 (2012), where LE is defined as the time scale for which it can reasonably be assumed that the tree can be retained in its location and, at least substantially, in its present form. How long a tree can be expected to remain with an acceptable degree of safety is key information required for long term planning and assessment (Barrell, 1993) and LE is an effective way to provide this information (BS5837, 2012). In BS5837, adjustment for LE follows a banding approach and so adopting this approach in the CAVAT method works well as it is consistent with the approach of the preceding steps. A banding approach helps provide robustness to an assessment, it reflects some of the practical difficulties of estimating age where a surveyor can be expected to estimate more accurately the LE of a tree where that LE is relatively short and the likely impact of visible condition is more predictable.

The value of adjustment made for LE is shown in Table 3. Trees with a LE greater than 80 years retain 100% of their Step 6 value; those with a LE of less than 5 years lose 90% of their Step 6 value; and a tree that is dead or cannot be safely retained has a LE score of 0, and thus a value of £0. Where the tree's life expectancy is <80 years, the weighting given to the lower expectancy derived from a step-function relationship, such that LE value is lost, slowly at first, and increasingly swiftly towards the end of a tree's life. No reduction is made for a condition, such as a structural weakness, where LE is not shortened and the tree is judged to be safe. In these circumstances, the functional status of the tree is sub-optimal (for example, a management intervention such as a crown reduction may have occurred or is now required) and the tree's value should have been accordingly adjusted at step 4: Functional crown value-structural framework.

Worked examples. For tree 1, there are no apparent limiting factors; its LE is assessed at 80 years or more and so no adjustment is made. The Full value of tree 1 is £9589. Trees 2 and 3 may well be capable of being managed for 80 years or more, but there are risk factors from the need for relatively frequent pruning in close proximity to buildings and services, for street or building works and some larger wounds are present in both trees, albeit with no current signs of decay. Each is assessed to have a LE of 40–80 years and their step 6 value is reduced by 5%. The Full value of tree 2 is £17,621. The Full value of tree 3 £23,660.

Section 2. The Quick Method

The CAVAT Quick Method is described below. The Quick Method is a tool that can support the strategic management of a public tree stock, such as that owned by a Local Authority. The objective is not simply to place a financial value on a single tree but rather to recognise

Table 3. Life expectancy (LE) adjustment factors used in Step 7 of the CAVAT Full Method and Step 4 of the CAVAT Quick Method (after: BS5837, 2012).

Life expectancy(Years)	Value retained(%)
>80	100
40–<80	95
20–<40	80
10–<20	55
5–<10	30
<5	10

that the tree stock is an asset whose collective value rises or falls with changes in the quality and character of the stock over time. As such, CAVAT would assist with active management of the tree stock as an asset and in developing a strategy to maintain or increase total value, and therefore amenity that they collectively provide. The Quick Method has the same basis as the Full Method but adapts the approach so that the data collection will not greatly increase survey times when integrated into a regular survey program of the tree stock, and data may be able to be extracted from existing methods. This methodological approach has been adopted to ensure that the CAVAT Quick Method is practical and applicable to its target users, for example Local Authorities. Data requirement is restricted in comparison to the Full Method, although it still allows the tree stock to be valued and key information is obtained to assist with management decisions.

The four steps of the Quick Method are:

- Step 1. Determining the "Base" value (size multiplied by the UVF)
- Step 2. Adjustment to determine the "CTI" value (adjustment based on location, in terms of population)
- Step 3. Adjustment to determine the "functional crown" value: a step with two considerations leading to a single adjustment of the value according to crown size and crown condition.
- Step 4. Life Expectancy adjustment to determine the final Quick Method value for the stock as a whole.

The main differences in the Quick Method compared to the Full Method are that:

- in Step 1, size in terms of TD is required as in the Full Method but this is then converted into one of 16 size-bands;
- community accessibility (the LF value adjustment carried out in the Full Method's Step 3) is not considered, as this detail is not collected during routine health and safety inspections of trees.
- in Step 3 (equivalent to the Full Method's Steps 4 and 5), functional crown value is considered in 25% gradations, rather than 10%, to aid the speed of assessment and
- the Full Method's Step 6: amenity value adjustment is not considered.

The four steps of the Quick Method are described in detail below.

Step 1: base value

In Step 1, the base value is determined according to trunk area and application of the UVF (see Full Method above), except that each tree's TD is graded according to one of 16 size bands to give its base value. The value bands are calculated as the midpoint of the diameter range multiplied by the UVF; except for the first and last bands where the value is calculated based upon a tree with DBH of 4.75 and 135 cm, respectively. As UVF varies year upon year, the value of the size bands also varies annually. The value for the sixteen size bands are shown in Table 4, based upon the 2017 UVF. The annually updated UVF and corresponding size bands are published at www.cavattv.org and www.ltoa.org.uk/resources/cavat.

For the purposes of the Quick Method a precise trunk measurement is not needed; however, if the DBH is being measured, for example as part of wider survey, it is possible to automate the allocation to value band by entering the survey information into the database or spread-sheet program.

Table 4. The value for the 16 size bands used in Step 1 of the Quick Method; based upon the 2017 UVF.

Size band No.	Trunk diameter (DBH, cm)	Value (£)
1	<6	280
2	6–<9	700
3	9–<12	1380
4	12–<15	2270
5	15–<20	3820
6	20–<25	6310
7	25–<30	9430
8	30–<40	15,300
9	40–<50	25,300
10	50–<60	37,700
11	60–<70	52,700
12	70–<85	70,200
13	85–<100	101,000
14	100–<115	138,000
15	115–<130	180,000
16	>130	227,000

Step 2: CTI value adjustment

In step 2, a CTI factor is applied to the base value to account for population density. The adjustment is identical to that of the Full Method (see Full Method step 2 above).

Step 3: functional crown value adjustment

In Step 3, an assessment is made of how well the tree is performing biologically in comparison to what would be expected of a well-grown and healthy tree of the same species and girth in that location. The approach combines steps 4 and 5 of the Full Method into a single incremental adjustment, and the step 2 value is either retained at 100% or reduced by 25, 50, 75% or, if the tree is dead or requires urgent removal, by 100%. See Full Method explanation above for details.

Step 4: final value (or life expectancy) adjustment

Finally, in step 4, the functional crown value is adjusted for the effect of life expectancy on the value of the entire tree stock. This step is equivalent to step 7 of the Full Method. See Full Method step 7 and Table 3 for full details.

In the following section, short case studies are presented on the real-life application of either the Full or Quick Method CAVAT assessment, including details of specific value adjustments and why these are made.

Case study examples on the use of CAVAT Full Method and Quick Method

Case study one: the use of the CAVAT Full Method in securing adequate appropriate compensation for removal of public trees for a private development

A planning application was received to develop a public house to the south of the Borough[8]. The pub was adjacent to a small park with mature trees. The developer was represented by a well-known arboricultural consultant who put forward a tree survey.

A mature horse chestnut in the park was identified for removal as the development would be compromised if this tree was not felled. The tree was part of a group in the corner of the park and so was not considered to be of high amenity by the developer. Site visits took place.

The Local Authority tree officer valued the tree at £50,000 and agreed with their senior management that, should this CAVAT value be realised, the compensation receipt would be split with 50% spent on tree planting and 50% on park's improvement. The compensation was agreed by the developer and the full value paid. As a result, one hundred new street trees were planted that winter, with the cost for watering during establishment also factored in.

Prior to the availability of CAVAT, the Borough would tend to have been offered comparatively cursory mitigation of around five new plantings and received minimal post-planting maintenance even though experience of development sites shows that these trees struggle to achieve independence in the landscape. The Borough continue to utilise CAVAT valuation and are in charge of mitigation planting; they plant adequate numbers of trees to meet their biosecurity risk, and ensure adequate watering and aftercare funding is factored in.

It is important to note from this case study that the compensation value was agreed by both parties, that it was agreed to remove the tree, and that the CAVAT value was considered suitable for reinvesting in the park and local area. However, just because something has a value it is not necessarily for sale (a home owner may wish to know the value of his or her house, but not intend to sell it), and in a recent case the Borough refused the removal of a semi-mature oak tree (incidentally also valued at £50,000) as it was considered to be a fundamental asset of the park and had long term benefits.

Case study two: the use of CAVAT Quick Method in revealing street trees to be a financial asset and bolstering their maintenance budget

A CAVAT valuation of one London Borough's[9] highways trees was undertaken using the Quick Method. At the time, this equated to £110,000,000. This exercise was considered to be a good way to raise the public and political profile of trees. An unexpected outcome was that the highways manager was then able to consider the trees as highways assets and apply Chartered Institute of Public Finance and Accountancy (CIPFA) methods and principles for valuing highway assets to the tree stock. Lifetime value models were created. These revealed the increase in CAVAT value of the tree as it grows and these values were compared to records for tree management and maintenance costs to provide whole life costings. The exercise demonstrated the case for the positive values that tree provide and enabled the Borough to ascertain the total replacement cost of the tree stock (i.e. the CAVAT valuation). Collectively, this led to an increase in the highways tree maintenance budget of approximately 20%.

Using the lifetime value models, enabled demonstration of how investment in tree planting could result in an increase in the total highway asset. Most highway assets depreciate with time; however healthy trees appreciate in value over decades. The lifetime value models showed that a small investment in tree planting can result in a large increase in asset value, as assessed by CAVAT, over a relatively short time.

As demonstrated in case study 1, CAVAT has also proved to be a very powerful tool in this Borough in getting compensation for removal of council-owned trees as result of development. Prior to CAVAT, two or three new trees would be offered as compensation for a single tree. Now the stated CAVAT value for the single tree is received, and invested into tree planting and maintenance.

Case study three: the use of CAVAT by a major highways authority

For the last few years a highway authority in London has incorporated the CAVAT Quick Method into its tree condition surveys to ensure that all of its street trees have a CAVAT valuation recorded on the database. CAVAT Quick Method enables the value of the stock to be quantified and changes in its quality and character to be measured and readily expressed. It can also be used to demonstrate to designers, engineers and other interested parties that replacing a large mature tree with one or even – as was often the case – with three young trees does not equate to a comparative replacement. It has proved to be a tool of huge importance and practical use. In a recent example, a scheme was planned to install a long section of cycle track immediately adjacent to an avenue of London planes in a part of the city which needs more green infrastructure, not less. The trees varied in condition and age, several were substantial specimens. The most straightforward design solution was to widen the carriageway by removing the trees, some 40 specimens in total.

The authority's tree officer protested against this proposal but was assured that it was the only viable solution. They questioned whether a more innovative raised cycle track had been considered that would allow excavation to be kept to a minimum, or avoided altogether, and thus avoid root damage or tree removal. The project manager was of the opinion that such a solution would cost in excess of £100,000; money not available in the budget.

Using the CAVAT valuations of the trees at risk, the tree officer argued that the value of the assets ear-marked for removal was in excess of £250,000 and that, in accordance with internal CAVAT-based procedures, tree removal would not be permitted until this sum had been transferred from the scheme budget into the tree budget. By comparing the value of the trees with the cost of the design solution the project team were able to make the case for the additional funding and, through a combination of redirection and raised sections, the desired outcome was delivered without the loss of the 40 trees.

Case study four: the use of CAVAT Full Method in the conservation of large trees threatened by development

Within the space of a year, permission was sought for two multi-storey developments to be built in central Bristol adjacent to Counterslip and Victoria Street. In both cases, planning permission was granted which showed the removal of local authority owned mature plane trees within the pavement and their replacement with new trees. Both developers on gaining permission approached the city's tree section to agree removal of the street trees.

Historically, it has proven difficult to plant new trees within the centre of Bristol due to the large number of services within the highway. The tree section wished to retain the trees due to their size and made a challenge to the planning department. The developer's view was that planning permission overrode ownership, however the planning department found in favour of the tree section. CAVAT was used to consider the trees and the CAVAT valuation was presented to each developer as the cost to remove the trees. In both instances, the value was in excess of £100,000. Neither developer wished to pay this amount and, in both cases, subsequently employed arboricultural consultants to work with the city's tree section to look at how the developments could be built whilst retaining the trees. At the Victoria Street development, the existing building had a basement that had acted as a root-barrier and so through careful supervised demolition the building could be removed. The new development was built with only minor pruning to the trees on the building side. Similar occurred at the second development. Observations were made of the foundations for the buildings being demolished on site. Further supervised excavation was carried out beneath these foundations to look for significant roots and none were found. Again, the foundations had acted as a root barrier. In both cases, the street trees were retained.

The benefits of using CAVAT combined with the legality of ownership meant that both developers were willing to invest time and money into looking at alternative solutions to retain the street trees. Retention was also a benefit for the city, who retained mature tree assets, and it removed the need to find replacement tree pits. It also meant that tenants moving into both new developments did so with mature trees *in situ* and meant that any potential complaints about blocking of views and light were easy to deal with, as the trees predated the developments.

Case study five: CAVAT and the Joint Mitigation Protocol on tree related subsidence

During the development of CAVAT, there was uncertainty about what exactly it would be useful for. During a LTOA seminar in the London Borough of Ealing, however, a presentation by ALARM (Association of Local Authority Risk Managers) linked the value of trees to the level of site investigation required in subsidence cases. There was a consensus in the room that this was common sense – the more valuable a tree the better evidence should be required to demonstrate the involvement of the tree, or not, in subsidence to a domestic dwelling. For many years, the evidence that had been submitted to LAs requesting tree removal in subsidence cases had been poor. The emergence of CAVAT broadened the discussion and allowed negotiation between the stakeholders. Subsidence had become a fractious process where an adversarial approach had become ingrained amongst tree officers and insurers. This did not help the policy holder whose property was suffering damage. All agreed to the principle of the ALARM proposal, which was that trees have value in their own right and also that they are highly valued by the public. Thus, such values need to be better considered in subsidence cases. The LTOA had played a key role in the development of CAVAT, they knew that it was quick and easy to apply, and so agreement to adopt CAVAT within a Joint Mitigation Protocol (JMP) valuation system made sense and development of the JMP began.

The JMP is an agreed method of subsidence claims management where trees are potentially implicated as being the cause of building movement. It seeks to establish good practice in the processing and investigation of tree root induced building damage, benchmarking time scales for responses and standards of evidence. It was launched in May 2008 following three years of negotiation, led by the JMP group. This group consisted of insurers, loss adjusters, tree officers, engineers and arboricultural consultants working on behalf of insurers. During the development of the JMP, understanding evolved of the pressure from policy holders on insurers and likewise an appreciation of tree officer responsibilities with regard to politicians, residents, the media as well as obligations under the Freedom of Information Act (2000) for transparency in decision-making.

The principal aims of the JMP are to provide the local authority with all the investigative evidence they require and to speed up the process of claims handling and decision-making while still recognising the value of trees in the built environment. JMP, with CAVAT at its core, has been adopted by nine London Boroughs and several LAs around the country. Trees that should be retained now are retained, and claims are processed quickly so that properties can be repaired without unnecessary delay.

Full details of values and site investigation requirements and agreed time-scales can be found at www.ltoa.org.uk/resources/joint-mitigation-protocol.

Discussion

CAVAT has been adopted and widely used by the LTOA since 2006 (see "Introduction"). It experienced a number of minor changes in its early days following feedback from users, including a change in step 7 from the incorporation of safe useful life expectancy (Barrell, 1993) to "life expectancy" (as defined in BS5837) to prevent adjusting for the same issue in consecutive steps. However, the CAVAT method has been consistent now since 2008; revisions to the online manual have clarified the application of the method rather than changing the tool per se. The most recent changes to CAVAT are in fact communicated through this article. The first relates to the guidance: the previously described five steps of CAVAT have been disaggregated to seven steps in order to clearly articulate each of the considerations that a valuer must undertake. The disaggregation provides additional clarity on the application of CAVAT without changing the value of the adjustments made. Secondly, the rate of depreciation at step 3 has been increased from 20% increments to 25% to make CAVAT consistent with other tree valuation approaches by evenly spacing these adjustment factors; and, thirdly, Table 2: the amenity and appropriateness adjustment factors considered within Step 6, have an expanded description to differentiate more clearly the positive and negative adjustment factors to be considered (i.e. those factors that affect a tree's contribution to public amenity and its appropriateness to that location).

Short-comings with the CAVAT Methodology

In this section, the criticisms previously levelled at CAVAT (and stated in the Introduction) are discussed. Firstly, depreciation: it has been reported that CAVAT does not make all the necessary adjustments for depreciation, thus leaving it not fit-for-purpose for the valuation of trees as assets (for example: RICS, 2010). However, following the approach of Hollis (2007), who compared the RICS International Valuation Standard against the depreciation factors in the CTLA 9th Guide (hereafter: CTLA), notable similarities between CAVAT and CTLA in their approaches to valuing urban trees are revealed: CTLA's condition factor is treated in the same way in CAVAT, via the application of LE (in step 7 in CAVAT); site rating (a LF within CTLA) is considered within steps 2 and 5 of CAVAT; placement (a CTLA location factor) is considered within CAVAT step 6 (Table 2); and environmental adaptability or site suitability (termed "species factor" in CTLA) is considered in step 6 (Table 2). Other "species factors" are also depreciated for in CTLA, namely: growth characteristics (crown size, longevity and maintenance) and pest and disease susceptibility. Depreciating for the "maintenance" demand of a tree species is not performed in CAVAT as it has been designed to feed into cost–benefit analyses of amenity trees and thus depreciating for maintenance would lead to double-accounting. Crown size, longevity and pest and disease susceptibility are not discretely depreciated for within CAVAT as the purpose of CAVAT is to provide a compensation replacement value for single trees, on a like-for-like basis. In CTLA the objective is not to define plant qualities that are replicated by replacing the tree, but to make deductions for all relevant forms of obsolescence and optimisation (species factors including crown size and pest and disease susceptibility and qualities including longevity) that could be produced by another cheaper species (Hollis, 2007). For example, the large canopy of a tree could be replaced at the structural (size and shape) level by another large-canopied tree that is cheaper to purchase. CAVAT is interested in final-tree quality and attributes – replacing on a like-for-like basis – and how to cost these. CTLA draws upon the nursery price of each tree species. CAVAT recognises that such prices are market costs (reflecting supply/demand) and not production cost (once seed is obtained the costs are approximately the same to grow each tree to the given size) and the impact of variances smoothed by averaging across the range of 10 common species and a range of nurseries; the emphasis is on the mature tree, not the purchase price of a tree. This only leaves tree frequency and tree dominance (which are locational factors in CTLA) unaccounted for by CAVAT. In part, these are considered within the functional crown adjustments made in steps 4 and 5. However, further considerations could be taken into account within the CAVAT methodology and these are explored below in the section Next steps. One final difference between CAVAT and CTLA is that CAVAT is concerned with trees as public amenity assets, whereas CTLA looks at valuing trees as personal assets, which is more applicable to tree ownership in the US.

Secondly, Natural England (2013) concluded that CAVAT could be recommended for financial compensation for tree damage but not for economic valuation purposes as it estimates the cost of replacing a tree depending on various attributes but does not value the benefits of ecosystem services. They also state that the expert judgements applied do not comply with the Green Book guidance for estimating value. Indeed, the expressed purposes of CAVAT – as described throughout this paper – are to enable trees to be better managed as assets and to allow a realistic value to be asserted in a variety of contexts, including in land use planning and for financial compensation for tree damage and loss. CAVAT has not been designed to quantify or value ecosystem services. However, with respect to Green Book compliance, steps 4 and 5 (functional crown) and step 6 (amenity and appropriateness value) adjustments consider crown size, condition, notable amenity attributes and appropriateness to location, respectively. These factors would be fundamental variables in a stated preference study. The stated preference score is here provided by an "expert". In stated preference surveys the general public is asked to give a comment that is otherwise considered an expert assessment and as such the lay public are being asked to present themselves as experts. CAVAT's strength therefore is that it uses experts to give a valuation where only experts can. In these respects, CAVAT is underpinned by primary economic principles and its suitability for use beyond financial compensation should be re-examined.

Lessons from the case studies

The case studies above provide useful illustrations of how CAVAT is highlighting in financial terms the value of amenity trees in the UK. Specifically, the significant monetary valuation of many trees emphasises the important contribution that these trees provide to the amenity of a place and raise awareness of the wider impacts of tree removal. It is evident within the valuations that amenity cannot be readily off-set, not least because replacement trees are planted elsewhere but also because of the time lapse for the new tree to reach equal stature and because of the challenges posed by underground services to siting new tree pits.

For the most part, public realm assets are valued on an asset register; for example, land, highways, lamp columns. Trees remained as one of the few public assets that had no value or entry on the asset register. This routinely meant that when a tree removal was proposed a cursory mitigation was offered and development could proceed or, where a subsidiary planting scheme was proposed and subsequently failed, the public asset was lost. Since the adoption of CAVAT, many local authorities have either influenced developers to change their designs to avoid tree damage or received adequate compensation for tree loss (see Case studies above). CAVAT has also been successful in securing compensation following wilful or negligent damage to local authority trees (see www.ltoa.org.uk/resources/cavat). Typically, the local authorities have reinvested the compensation back into their trees using it to bolster budgets for local tree planting and maintenance. Furthermore, the case studies have illustrated the little-known or rarely applied planning principle that a developer does not have an automatic right to remove a public tree just because planning has been consented on private land. They must seek permission from the local authority's department responsible for trees in order to remove the tree or work with them to secure its future.

CAVAT has also been useful in helping to change a view of trees that has become entrenched in many local authorities over recent decades. Rather than treating them as liabilities that must be strictly risk managed, they have started to treat them as assets that provide amenity that is valuable and not easily or quickly off-set. The mindset change has led to the recognition that healthy trees are assets that appreciate in value with time given appropriate management and a possible concomitant increase in the maintenance budget.

Next steps

CAVAT's UVF was being updated in the process of writing this publication, including the survey of tree officers and nurseries to determine the top-ten species being planted in the urban realm, and their average price. The approach adopted was identical to that when UVF was first determined and sought to secure a robust average price by cross-referencing multiple buyers (tree officers) and nurseries to come up with a definitive top-ten species list and price. However, a number of improvements may be considered in future iterations: prices collected were for the current financial year rather than averaged over several. This could leave the UVF vulnerable to sensitivities in changes in the top-ten popular species, such as the decline of common ash or a fashion-led increased use of magnolia or flowering cherry for a growing season. Economies of scale could also be factored in. Although trade price has been adopted in the calculation of the UVF, the impact of bulk purchasing on price was not considered. These factors could be considered in future work. However, it is noteworthy that averaging across multiple nurseries and the top-ten species already provides a normalising effect and implies that the impact on UVF would be small. Steps 2 through 7 of the Full Method adjust the base value according to location, relative contribution to amenity value, canopy functionality and life expectancy. These steps do not currently account for the difference between average values and marginal values. For example, it does not wholly differentiate between the value of a tree if it is in a group of 20 or a group of 5 – consideration is limited to the assessment of the canopy in step 4 as the canopies will be smaller than that of a full canopy of a healthy open-grown specimen. Such a consideration is important in the delivery of certain ecosystem services such as rainfall interception where the loss of one tree from a group leads to a loss in the amount of ecosystem services provided. But it is also important in the provision of amenity. Therefore, future work could consider how this could be taken fully into account, during steps 4 and 5 for example. Marginal value is particularly important with respect to landscape and amenity as urban (amenity) trees provide a relatively greater contribution to the local amenity value than to rainwater interception; however the contribution to amenity of a single tree in a small group relative to one in a large group remains unquantified.

CAVAT has been in use for over a decade now and the authors' knowledge of its use suggests that it is being used on a consistent basis by a large number of UK local authorities for urban amenity tree valuation. As such, CAVAT is showing that not only is there an urban amenity tree "market", but it is providing an indication of a "market" price, as revealed by the levels of "compensation" the local authorities are willing to accept and developers are willing to pay (see Case study examples). A useful next step will be to specifically determine if there is a market value for urban trees (for example, as exemplified by planning applications rejected because a developer has refused to pay) as well as market sensitivity across the country.

Notes

1. S198 of TCPA 1990 creates the power for local planning authorities to protect trees by legal order; subsequent sections create a legal framework for enforcement at Crown Court, including a potentially unlimited fine for serious offences. Local planning authorities are under no obligation to show that trees are an amenity or that the monetary value of that amenity is potentially substantial but they are obliged to consider how relevant aspects of the location and characteristics of particular trees influence the level of that potential value. Neither does TCPA reference a methodology for such considerations.
2. Economists use "utility" to describe the characteristics of products, goods or services that provide instrumental value (usefulness, desirability or the ability to satisfy human desires, needs or wants).
3. The underlying theory to depreciated replacement cost (DRC) approaches is that a "buyer" would not pay any more to acquire the asset being valued than the cost of an equivalent new one, with depreciation adjustments made to reflect differences between it and the replacement, such as comparative age, remaining economic life, running cost, comparative efficiency and functionality. In CTLA, the costs of providing an equivalent new tree include nursery cost, cost of delivery, planting, irrigation and warranty; and depreciation includes both internal factors (species characteristics and specimen condition) and external factors (location and functionality). Depreciation makes the connection to the value of the appraised tree.
4. Area 1 consists of the A30 and A38 trunk roads to the west of Junction 31 on the M5 near Exeter.
5. It is worth noting that, despite its importance as a policy question, there are many gaps in the state of knowledge regarding the total economic value of UK woodlands (Binner et al., 2017). i-Tree Eco is itself a partial representation of the available evidence. Total economic value includes all the direct and indirect use values associated with woodlands as well as non-use values. Use values refer to willingness to pay to make use of forest goods and services. Such uses may be direct, e.g. extractive uses, or indirect, e.g. watershed protection or carbon storage. Use values may also contain option values, willingness to pay to conserve the option of future use even though no use is made of the forest now. Such options may be retained for one's own use or for another generation (sometimes called a "bequest" value). Non-use values relate to willingness to pay which is independent of any use made of the forest now or any use in the future. Non-use values reveal the multi-faceted nature of the motivations for conservation, e.g. being driven by concerns about future generations, the "rights" of other sentient beings (Secretariat of the Convention on Biological Diversity, 2001).

6. See section "Council of Tree and Landscaper Appraisers (CTLA)" for a reminder on the meaning of these acronyms.
7. A guide is published on the CAVAT webpage to support ease of application of CTI.
8. To protect identity, the location is named simply as the Borough.
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