The Trees of Middleton Park

A case study of natural capital valuation in Middleton Park Ward, Leeds

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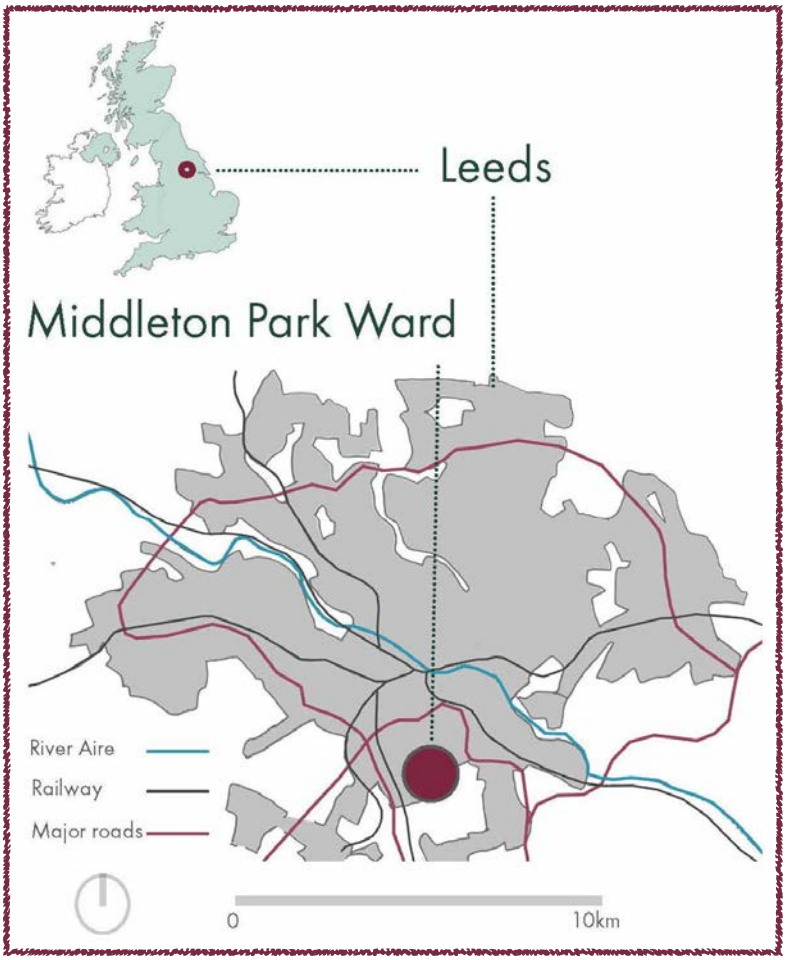
1. Background

Balancing the planting and management of urban trees with development is a continual challenge for local authorities. Using **natural capital** valuation tools to better understand the importance of trees as assets in the urban environment can help to inform decision making.

Trees are an important component of the urban green spaces that provide many benefits to populations in towns and cities. Green spaces contribute positively to human health and well-being, biodiversity, air quality, flood risk and climate change mitigation[1]. The value of these benefits to society may be quantified using natural capital valuation tools.



Middleton Park Ward is located within the Unitary Authority of Leeds and is home to over 30,000 people[2] with an area of 928 hectares[3]. This study aims to demonstrate how a range of natural capital valuation tools can be used to calculate the environmental benefits provided by trees in Middleton and to estimate the economic value of those benefits to society. The study explores the contribution of the trees to both the physical environment and to human health and wellbeing by using a collection of tools. **i-Tree Eco v6.0**[4] was used to estimate the number of trees, gain an understanding of the health and structure of the trees in Middleton Park, and to estimate the environmental benefits they deliver.

Bluesky National Tree Map (NTM) data[5] for Middleton was used as a secondary estimate of the number of trees in Middleton, based on a combination of light detection and ranging (LiDAR) images, aerial photography and digital surface models. The **Capital Asset Valuation for Amenity Trees (CAVAT)** was used to make an assessment of the amenity value of the trees[6]. The study also used **i-Tree Canopy**[7] to estimate the total canopy cover of the city of Leeds, and the ward of Middleton Park. The study is an example of citizen science in action, encouraging volunteers to help measure trees, as well as giving their views in our local public perception survey.

The trees in Middleton Park Ward were measured during the summer of 2018 by a core team from the University of Leeds and the United Bank of Carbon, with the help of volunteers from the community of Middleton Park. An assessment of canopy cover was carried out in 2019. These results represent a snapshot in time as the delivery of ecosystem services will change over the lifetime of a tree and with management that may take place.

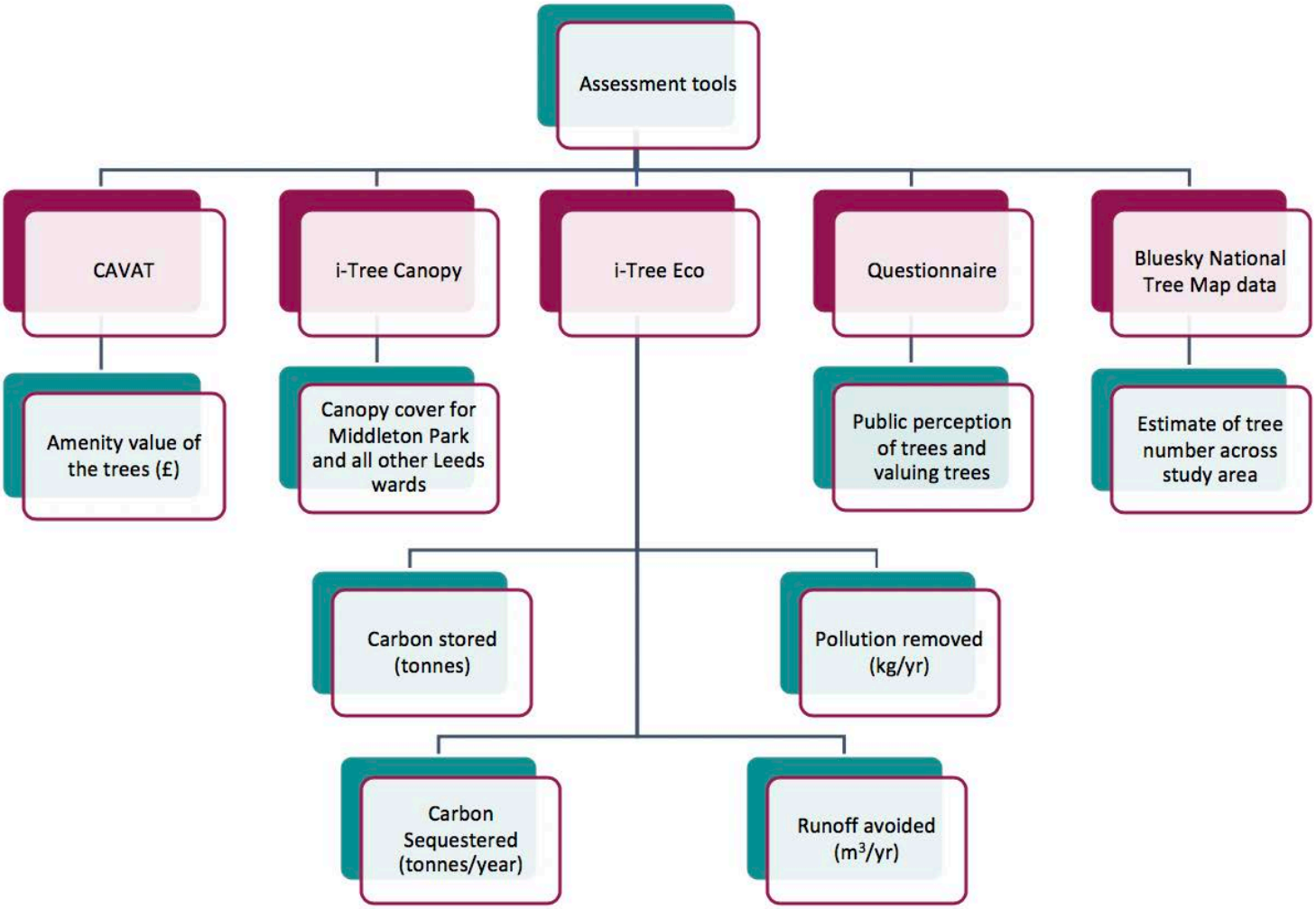
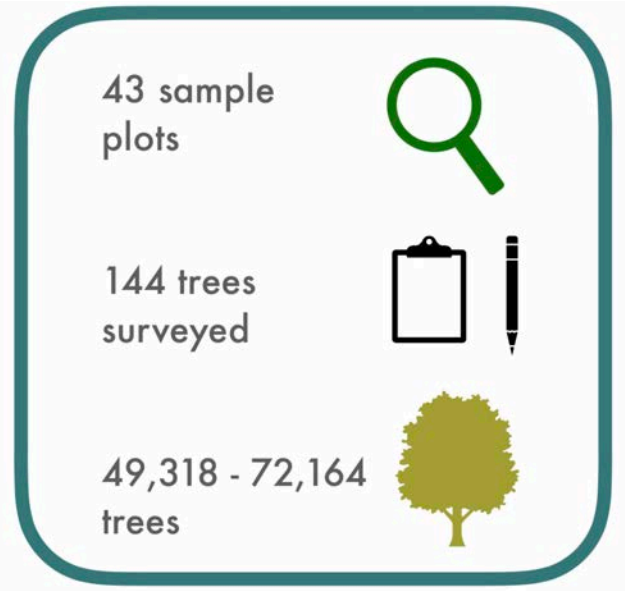


Figure 1. Natural capital valuation tools and other methods used in the study and the data obtained from each.

2. The Trees of Middleton Park: i-Tree

The survey

A plot-based sample survey of the trees in Middleton Park Ward was carried out using i-Tree Eco v6.0[4]. We defined 43 randomly located survey plots of 11.2 metres radius to sample the trees across the ward. This resulted in a sample of 144 trees to measure. i-Tree Eco software statistically extrapolates the surveyed trees to represent the trees across the whole ward, with consideration of the different land use types. From the 43 survey plots, using i-Tree Eco, it is estimated that there is a total of 72,164 trees in Middleton Park Ward. In contrast, the Bluesky NTM estimate for the same area is 49,318 trees (using Bluesky point data[5]). We use the two different estimates to generate a range of the ecosystem services delivered by the trees. The species of the trees are illustrated in Figure 2. The majority of trees in Middleton are small, with more than 80% of the trees estimated to be less than 30cm diameter.



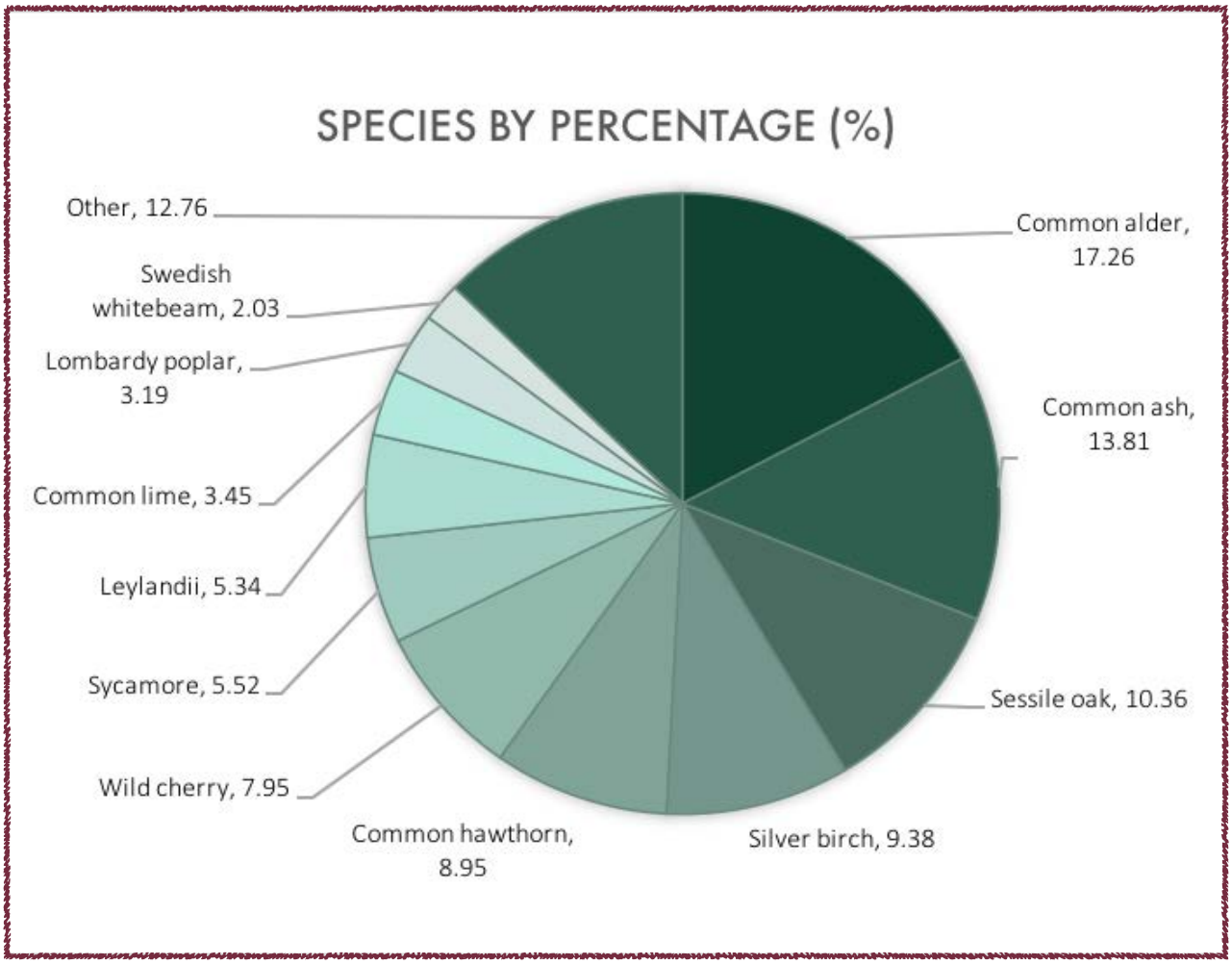


Figure 2. Species by percentage; percentages proportional to the trees surveyed in the i-Tree plot survey, scaled according to the occurrence of different land cover types in Middleton Ward.

Environmental benefits

The Millennium Ecosystem Assessment categorises **environmental benefits** into four categories: regulating, provisioning, supporting and cultural[8]. Regulating services provided by the trees were estimated in i-Tree Eco, using field measurements of the trees combined with local climate and air quality data, to assess the functional and structural services of trees. The regulating services covered in this study are storage of carbon, annual sequestration of carbon, annual removal of atmospheric pollutants and annual avoided runoff. The amount, and estimated financial value, of each of the services is summarised in Figure 3, where the lower value is proportional to the Bluesky NTM estimate of tree number, and upper values are proportional to the i-Tree estimate.

Environmental benefit	Amount	Estimated value	Equivalent to
Carbon storage (tonnes)	8,000-12,000	£2 million-£3 million[9]	The annual carbon footprint of 3,900 people (upper limit)[10]
Carbon sequestration (tonnes/year)	290-400	£72,000-110,000[9]	The annual carbon footprint of 140 people (upper limit)[10]
Pollution removal (kg/year)	3,800-5,500	£30,000-44,000[11]	NO_2 emissions equivalent to 1.3 million return car journeys from Middleton Park to Leeds City Centre (Euro6 Standard, upper limit)[12]
Runoff avoided (m^3/year)	5,500-8,100	/	The amount of water held in 14-20 swimming pools of 25m length[13]

Figure 3. Summary of the environmental benefits provided by the trees of Middleton.

Carbon storage and sequestration

The Intergovernmental Panel on Climate Change (IPCC) highlighted the importance of limiting global warming to 1.5°C above pre-industrial levels to mitigate the most severe impacts of climate change[14]. Trees can support our efforts to mitigate climate change by removing carbon dioxide (CO_2) from the atmosphere and storing it in their biomass. The total amount of carbon stored in the trees in Middleton Park Ward is estimated between 8,000 and 12,000 tonnes of carbon (equivalent to 29,000-43,000 tonnes of CO_2), valued at £2-3 million based on the UK Government's 2020 value of non-traded carbon[9]. The upper estimate of carbon storage is approximately equivalent to the annual carbon footprint of 3,900 people in the UK, around 10% of Middleton Park Ward's population[10, 2].

Trees take up carbon from the atmosphere during their lifetime as they grow, converting this to biomass. The trees in Middleton Park Ward are estimated to take up between 290 and 400 tonnes of carbon (1,100-1,500 tonnes of CO_2) per year, valued at £72,000-110,000 annually[9]. The upper estimate of carbon sequestration is approximately equivalent to the annual carbon footprint of 140 people in the UK[10].

Air pollution

Appropriately managing air pollution is important to human health due to the impact that pollutants can have on our respiratory system. The Air Quality Directive sets limits for air pollution in the UK. Leeds also has air quality management areas (AQMA) and the forthcoming UK government mandated Clean Air Zone to manage persistently high levels of nitrogen dioxide (NO_2)[15]. Trees can help to mitigate the effects of air pollution as they intercept pollution through collecting particles on the bark and absorbing pollutants through the stomata on their leaves. In this study, i-Tree Eco was used to estimate the pollution removed by the trees in Middleton, and the value of this to the public, using the UK Government's social damage costs[10]. The lower and upper limits presented represent pollution removal proportional to the Bluesky NTM and i-Tree estimate of tree number respectively. We estimated that the trees in Middleton remove approximately 3,800-5,500 kg of pollutants per year, worth an estimated £30,000- 44,000 annually[11]. The monthly removal of pollutants is illustrated in Figure 4, which demonstrates the seasonality of pollution removal by trees. When compared to car emissions, the upper estimate of NO_2 removed by the trees is equivalent to approximately 1.3 million return car journeys from Middleton Park to Leeds city centre[12].

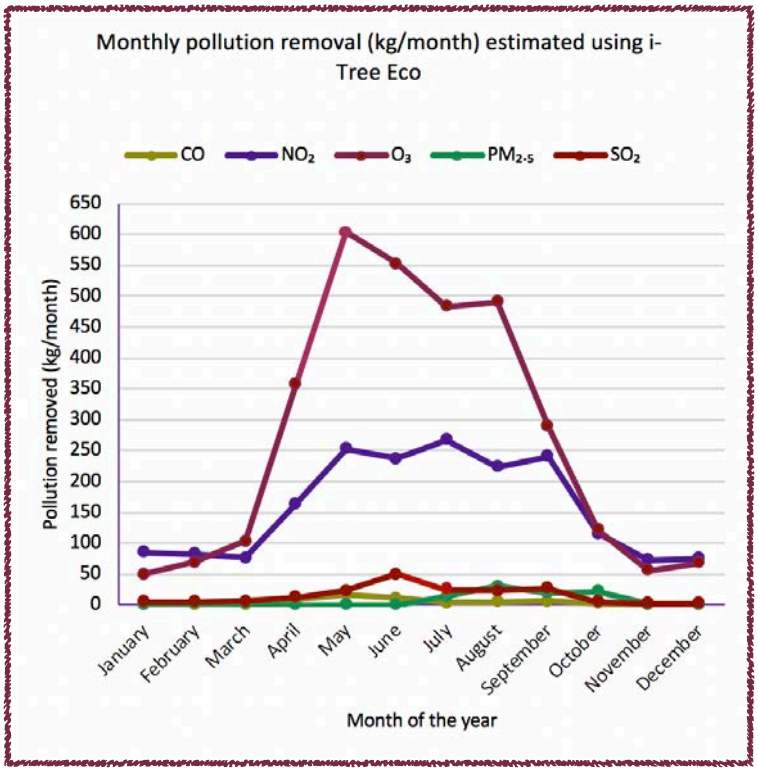


Figure 4. Monthly removal of pollutants (kg/month) by the trees of Middleton Park, proportional to the number of trees estimated with i-Tree Eco; carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter of less than 2.5 microns ($PM_{2.5}$), sulphur dioxide (SO_2).

Avoided runoff

Trees also contribute to flood management and the regulation of surface runoff by intercepting rainfall and absorbing water through their root systems. The trees in Middleton are estimated to prevent 5,500-8,100 m^3 of run off annually; equivalent to the amount of water held in 14-20 swimming pools of 25 m length[13]. The contribution of trees to amelioration of flood risk is particularly valuable in the UK due to the increasing frequency and severity of flood events impacting communities.

3. The Trees of Middleton Park: CAVAT

A wide body of research points to the benefits that greenspace provides to society through enhanced health and wellbeing[1]. Trees are identified to have an amenity value which is taken into account when planning decisions are made around the management of urban woodlands. The CAVAT assessment method serves to estimate the replacement value of a tree based on the attributes it holds and the value of the tree to the community. A CAVAT assessment of the 144 trees sampled was carried out, using the London Tree Officers Association (LTOA) Full Method[6]. Using the **Community Tree Index Factor** (CTI) for Leeds (100%) and the **Unit Value Factor** (UVF) of 15.88[6], alongside individual tree observations and measurements, the total amenity value of trees in Middleton Park Ward is estimated to be between £171 million and £251 million, with a mean value of approximately £3,500 for an individual tree.

Amenity value: CAVAT

Mean value £3,474

Total value £171 million - 251 million

4. The Trees of Middleton Park: Public Perception

We wanted to find out a little bit more about how the public feel about trees in their local area and also how they feel about putting an economic value on trees. A small public perception questionnaire was carried out as part of an undergraduate dissertation at the University of Leeds[16], involving 30 local people selected at random in Middleton Park. The questionnaire asked participants about various factors associated with the natural capital assessments, to identify factors that are perceived to be important to consider when valuing trees in this way. Figure 5 illustrates the factors that participants most disliked about trees (left) and the factors they valued most (right). Participants were asked if assigning a monetary value to the benefits provided by trees was useful, to support their preservation and ensure access to these benefits. The majority of answers were supportive of taking a natural capital approach to value trees. However, the factors that respondents placed importance on (Figure 5) reflect amenity and aesthetic attributes, including provision of greenspace, obstruction and appearance, which are more aligned with the CAVAT approach to natural capital valuation than i-Tree Eco[16].

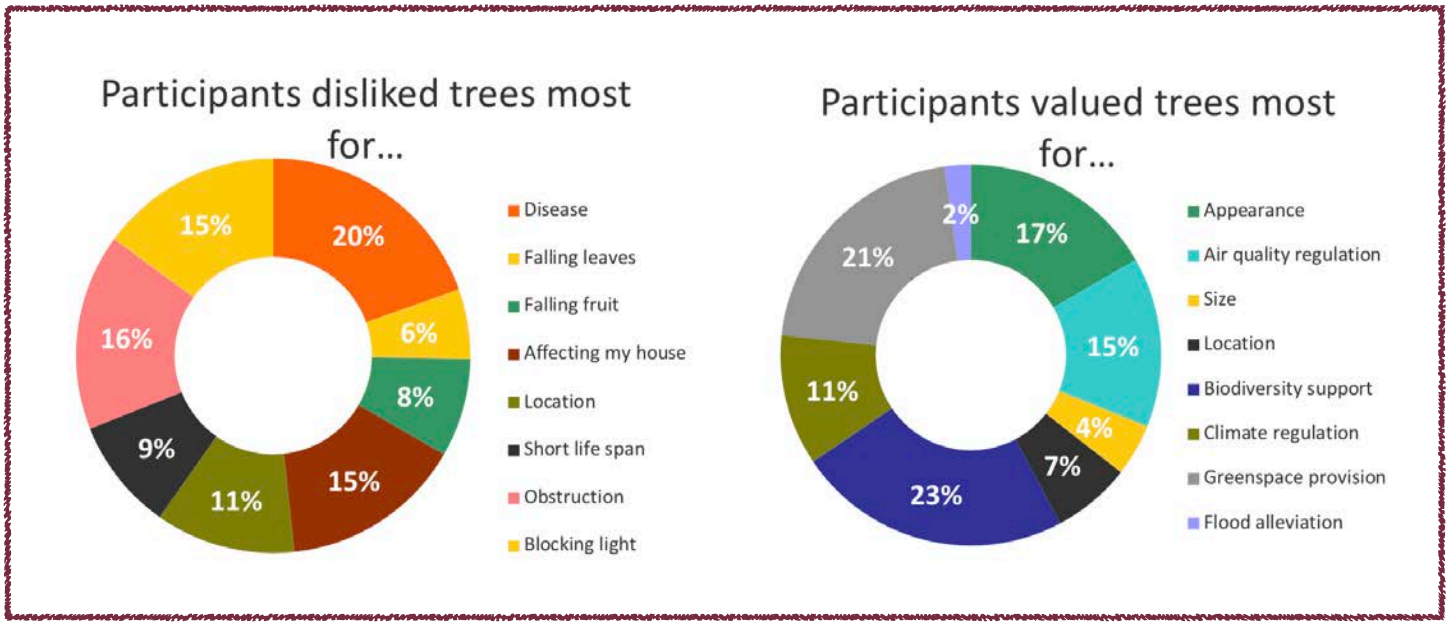


Figure 5. Participant responses to public perception of trees questionnaire: factors that are most valued and least valued with regards to trees (excerpt from the undergraduate dissertation of Hazel Mooney[16]).

5. Canopy Cover

Tree canopy cover analysis was carried out to estimate the distribution of trees across Leeds, and specifically in the Middleton Park Ward. i-Tree Canopy[7], a mapping tool using satellite imagery, was used to assess tree cover across the 33 wards of the city of Leeds. 800 sample points were collected for each ward to estimate percentage canopy cover. By mapping the values for each ward, the distribution of canopy cover across the city could be identified. The canopy cover map can be seen in Figure 6. Middleton Park has a particularly high total canopy cover, as can be seen in Figure 7, estimated at 23.9% compared to the city average of 17.1%.

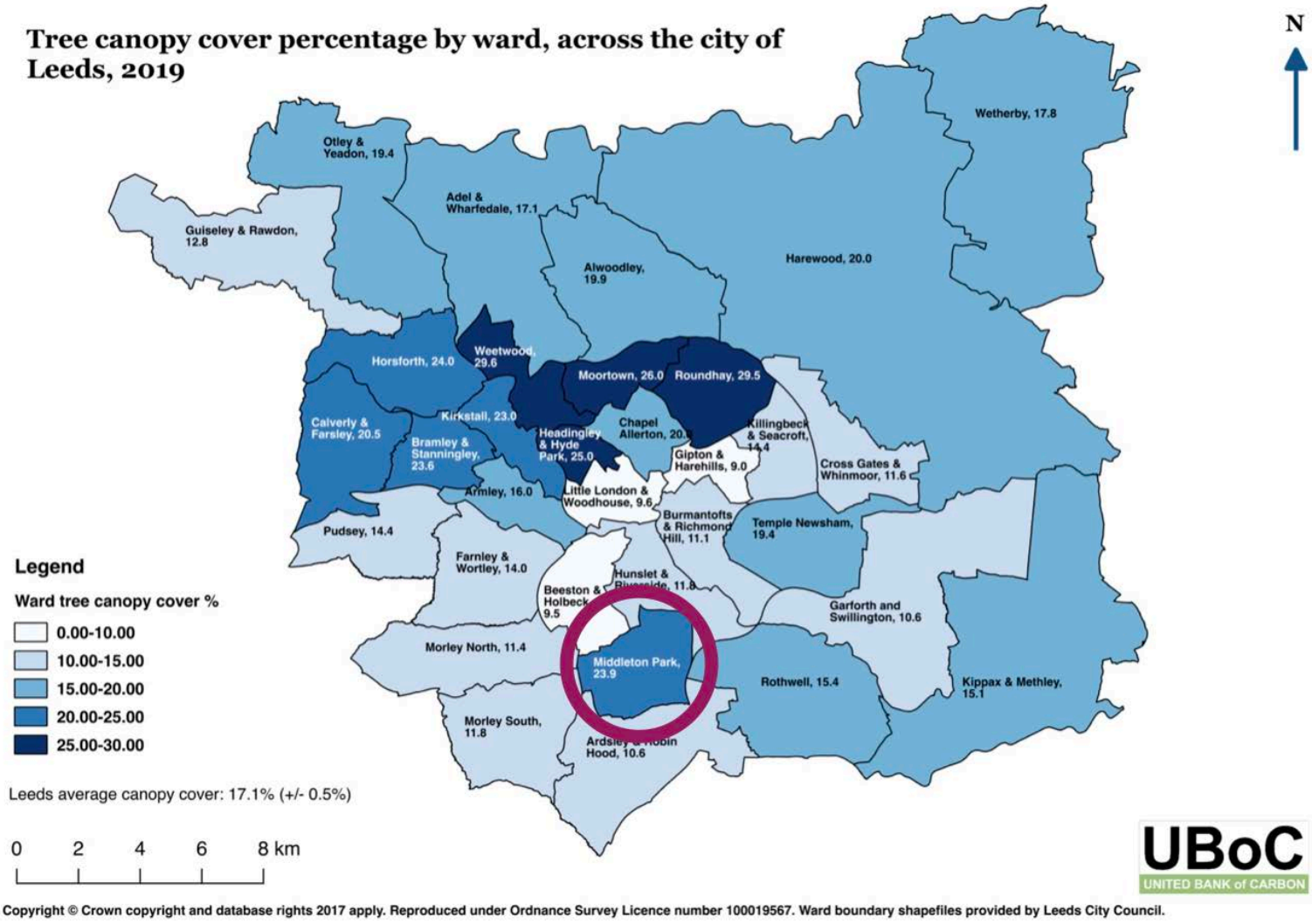


Figure 6. Map to show the estimated percentage tree canopy cover of Leeds wards (excerpt from previous work of the United Bank of Carbon as part of the Leeds4Trees project[17]).

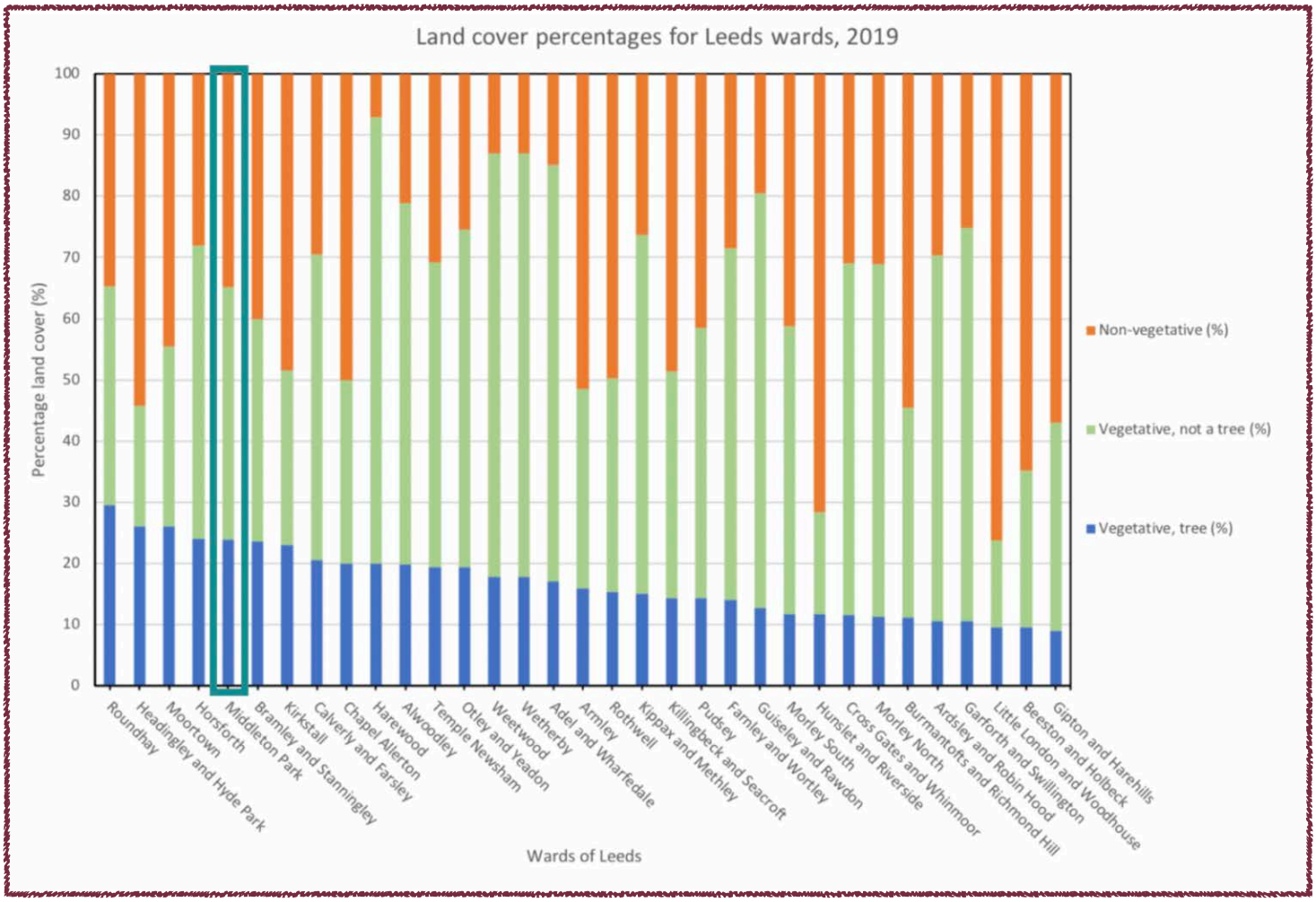


Figure 7. Percentage land cover estimates for Leeds wards, 2019; Non-vegetative; vegetative, not a tree; vegetative, tree (excerpt from previous works of the United Bank of Carbon as part of the Leeds4Trees project[17]).

In their 2019 net-zero report[18], the UK Committee on Climate Change advise that to support the transition to net-zero greenhouse gas emissions in the UK by the year 2050, tree planting of between 30,000 and 50,000 hectares per year will be required. The 30,000 hectare target forms part of the 'further ambition' scenario to achieve a 96% reduction by 2050, whilst the 50,000 hectare target represents the 'speculative option' to reach net-zero[18].

The national target can be translated to a local target for the city of Leeds in proportion to its land area (hectares)[19], population[20], greenhouse gas emissions (kt CO_2 equivalent)[21], or Gross Value Added (GVA)[22]. If Leeds adopted a planting strategy proportional to its share of national greenhouse gas emissions (approximately 1%), annual planting of between 356 and 594 hectares would be required. We estimate that if the lower target of 356 hectares was adopted, and those trees were planted within the unitary authority boundary of Leeds, the tree canopy cover of the city would approximately double by the year 2050. Whilst planting plans can be restricted by a number of environmental, social and economic constraints, assessing the variation in canopy cover across the city allows us to identify priority areas for new planting which, alongside preservation of existing canopy cover, would increase public access to the environmental benefits provided by trees.

6. Conclusions

This report demonstrates the application of a range of natural capital valuation tools that can help us to account for the benefits that the trees in Middleton provide to the local and wider community. The estimates of environmental benefits delivered by the trees vary dependent on the approach taken. We demonstrate that estimates of tree number produce a large range in the estimation of ecosystem services delivered, which is a limitation of our findings. The carbon stored in the trees is valued at approximately £2 million - £3 million, and the annual carbon sequestered valued at approximately £72,000-105,000. The pollution removed by the trees was found to be approximately equivalent to 1.3 million return car journeys from Middleton Park to Leeds city centre. Future research should seek to explore the variation between estimates of tree number, derived using different methods, in order to more accurately estimate the contribution of woodlands and urban trees to ecosystem services.

We also observe large variation in the economic value of different services provided by the trees, with the amenity value of the trees (CAVAT value) exceeding that of the services measured in i-Tree Eco. The overall CAVAT value of the trees in Middleton is estimated at approximately £171 million - £251 million.

The natural capital valuation of the trees in Middleton demonstrates the importance of maintaining healthy, mature trees and planting more to enhance the delivery of ecosystem services. Where possible, it would be valuable to plant trees, in line with the Committee on Climate Change planting targets, in areas with lower canopy cover than Middleton, as shown in Figure 6, to increase public access to the benefits of trees. By maintaining existing canopy cover whilst engaging in woodland creation plans for Leeds, the benefits outlined in this report will be enhanced across the city.

7. Glossary

1. Natural capital: the value of a natural system that can be monetised to demonstrate the value of nature to society.
2. i-Tree Eco: Peer reviewed software to assess the environmental benefits of trees based on field measurements and statistical analysis.
3. Bluesky LiDAR: Data for tree location and number estimated using light detection and ranging (LiDAR) technology in the air to identify the location of trees below.
4. CAVAT: Capital Asset Valuation for Amenity Trees; a natural capital valuation tool to assess the amenity value of a tree to people.
5. i-Tree Canopy: Peer reviewed software using satellite imagery to estimate the canopy cover of a given area.
6. Environmental benefits: The benefits ecosystems provide to people, categorised as regulating (e.g. removing pollution from the atmosphere), supporting (e.g. nutrient cycling), provisioning (e.g. food and materials), and cultural services (e.g. relaxing greenspace).
7. Community Tree Index Factor: the value of a tree asset relative to population density of the location surveyed.
8. Unit Value Factor: the cost of replanting a tree in a given location.
9. Tree canopy cover: the area of ground that trees cover with the stem, branches and leaves when viewed from above.

8. References

1. Leeds Ecosystem, Atmosphere and Forest (LEAF) Centre, the Sustainable Cities Group and the United Bank of Carbon (UBoC). *A brief guide to the benefits of urban green spaces*. [Online]. University of Leeds. [Accessed: 15/06/2020]. Available from: https://leaf.leeds.ac.uk/wp-content/uploads/sites/86/2015/10/LEAF_benefits_of_urban_green_space_2015_upd.pdf

2. Leeds City Council. 2019. *Health Profile Overview for Middleton Park Ward*. [Online]. Leeds: Leeds City Council. [Accessed: 10/06/2020]. Available from: https://observatory.leeds.gov.uk/wp-content/uploads/2018/11/Middleton-Park-Ward-2018.pdf

3. Office for National Statistics. 2018. Wards (May 2018), UK BFC. *Office for National Statistics*. [Online]. [Accessed 17/06/20]. Available from: http://geoportal.statistics.gov.uk/datasets/348e06537c8f45749e354dc5eea513d2

4. i-Tree. 2020. *i-Tree Eco* (v6) [Software]. [Accessed: 05/06/2020].

5. Bluesky International. National Tree Map. *Bluesky International*. [Online]. [Accessed: 01/06/2020].

6. Neilan, C. 2017. *CAVAT Full Method User Guide*. [Online]. London: London Tree Officers Association. [Accessed: 05/06/2020] Available from: https://www.ltoa.org.uk/documents-1/capital-asset-value-for-amenity-trees-cavat

7. i-Tree. 2011. *i-Tree Canopy* (v6.1). [Software]. [Accessed: 12/07/19].

8. World Health Organisation. 2005. *Ecosystems and human well-being: health synthesis: a report of the Millennium Ecosystem Assessment*. [Online]. Washington: Island Press [Accessed: 01/05/2020]. Available from: https://www.millenniumassessment.org/documents/document.356.aspx.p

9. Department for Business, Energy and Industrial Strategy. 2017. Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal: Data tables 1-19: supporting the toolkit and the guidance. *Department for Business, Energy and Industrial Strategy*. [Online]. [Accessed: 05/06/2020]. Available from: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

10. Department for Environment, Food and Rural Affairs. 2019. UK's Carbon Footprint 1997-2017. *Department for Environment, Food and Rural Affairs*. [Online]. [Accessed: 05/06/2020]. Available from: https://www.gov.uk/government/statistics/uks-carbon-footprint#history

11. Department for Environment, Food and Rural Affairs. 2020. Air quality appraisal: damage cost toolkit. *Department for Environment, Food and Rural Affairs*. [Online]. [Accessed: 05/06/2020]. Available from: https://www.gov.uk/government/publications/assess-the-impact-of-air-quality

12. *Regulation (EC) No. 715/2007 of the European Parliament and the Council of 20 June 2007. Official Journal of the European Union, L171*. [Online]. [Accessed: 15/06/2020]. Available from: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32007R0715

13. Sport England. 2013. *Appendix 1 Pool types and technical design issues*. [Online]. Sport England. [Accessed: 10/06/2020]. Available from: https://sportengland-production-files.s3.eu-west-2.amazonaws.com/s3fs-public/swimming-pools-2013-appendix-1.pdf

14. IPCC. 2018. *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. [Online]. In Press. [Accessed: 10/05/2020]. Available from: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf

15. Leeds City Council. 2019. *2019 Air Quality Annual Status Report*. [Online]. Leeds: Leeds City Council. [Accessed: 17/06/2020]. Available from: https://cleanairleeds.co.uk/sites/default/files/Leeds%20ASR%202018.pdf

16. Mooney , H. 2019. *Valuing the City's Trees: Can combining ecosystem service assessments and public perception inform how we manage trees?* Unpublished BSc dissertation, University of Leeds.

17. United Bank of Carbon. 2019. *Estimating tree canopy cover across the city of Leeds using i-Tree Canopy (v6.1)*. [Online]. Leeds: United Bank of Carbon. [Accessed 17/06/2020]. Available from: https://leaf.leeds.ac.uk/wp-content/uploads/sites/86/2020/01/Report_Canopy-of-Leeds_UBoC_Sept_2019_v2.10-1.pdf

18. Committee on Climate Change. 2019. *Net Zero: the UK's contribution to stopping global warming*. [Online]. UK: Committee on Climate Change. [Accessed: 10/06/20]. Available from: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

19. Office for National Statistics. 2019. Counties and Unitary Authorities 2019 Boundaries UK BFE. *Office for National Statistics*. [Online]. [Accessed: 17/06/20]. Available from: https://www.arcgis.com/home/item.html?id=0de4288db3774cb78e45b8b74e9eab31

20. Office for National Statistics. 2018. Population mid-year estimates 2018. *Office for National Statistics*. [Online]. [Accessed: 17/06/20]. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland

21. Department for Business, Energy and Industrial Strategy. 2019. UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2017. *Department for Business, Energy and Industrial Strategy*. [Online]. [Accessed: 17/06/20]. Available from: https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017

22. Office for National Statistics, 2017. Regional gross value added by local authority in the UK: 1997 to 2015. *Office for National Statistics*. [Online]. [Accessed:17/06/20]. Available from: https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/regionalgvaibylocalauthorityintheuk

Mooney, H., Walker, H., Gugan, A., and Scott, C. 2020. The Trees of Middleton: a case study of natural capital valuation in Middleton Park Ward, Leeds. Leeds: United Bank of Carbon and University of Leeds.