Forest Research

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Valuing Newport's Urban Trees: A supplementary report

The Research Agency of the
Forestry Commission

Forest Research is Great Britain's principal organisation for forestry and tree related research. Forest Research aims to support and enhance forestry and its role in sustainable development by providing innovative, high quality scientific research, technical support and consultancy services.

Treeconomics is a social enterprise, whose mission is to highlight the benefits of trees. Treeconomics works with businesses, communities, research organisations and public bodies to achieve this.

i-Tree is a state-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban and community forestry analysis and benefits assessment tools, including i-Tree Eco. The Forest Service, Davey Tree Expert Company, National Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, and Casey Trees have entered into a cooperative partnership to further develop, disseminate and provide technical support for the suite.

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Copies of this report, the main report and its two-page summary can be downloaded from:

https://www.forestresearch.gov.uk/research/i-tree-eco/

Contents

Introduction

This report provides the appendices to supplement the document ‘Valuing Newport’s Urban Trees’ (available from the above link).

Appendix I - Detailed Methodology

i-Tree Eco Models and Field Measurements

i-Tree Eco is designed to use standardised field data from randomly located plots along with local hourly air pollution and meteorological data to quantify:

- Urban forest structure (e.g. species composition, tree health, leaf area).
- Amount of water intercepted by vegetation
- Amount of pollution removed hourly by the urban forest and its associated per cent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<2.5 microns; $PM_{2.5}$).
- Total carbon stored and net carbon annually sequestered.
- Replacement cost of the forest, in addition to the value of air pollutant removal, rainfall interception and carbon storage and sequestration.
- Potential impact of possible pests and diseases outbreaks.

(Nowak et al., 2008)

All field data were collected during the leaf-on season to properly assess tree canopies. Within each plot, data collected included land use, ground and tree cover and individual tree attributes, including species, stem diameter, height, crown width, canopy missing and dieback.

Table 1. Land use definitions (adapted from the i-Tree Eco v6 manual)

Land-use	Definition
Residential	Freestanding structures serving one to four families each. (Family/person domestic dwelling. Detached, semi-detached houses, bungalows, terraced housing)
Multi-family residential	Structures containing more than four residential units. (Flats, apartment blocks)
Commercial/Industrial	Standard commercial and industrial land uses, including outdoor storage/staging areas, car parks not connected with an institutional or residential use. (Retail, manufacturing, business premises)
Park	Parks, includes unmaintained as well as maintained areas. (Recreational open space, formal and informal)
Cemetery	Includes any area used predominantly for interring and/or cremating, including unmaintained areas within cemetery grounds
Golf Course	Used predominately for golf as a sport
Agriculture	Cropland, pasture, orchards, vineyards, nurseries, farmsteads and related buildings, feed lots, rangeland, woodland. (Plantations that show evidence of management activity for a specific crop or tree production are included)
Vacant	Derelict, brownfield or current development site. (Includes land with no clear intended use. Abandoned buildings and vacant structures should be classified based on their original intended use)
Institutional	Schools, hospitals/medical complexes, colleges, religious buildings, government buildings,
Utility	Power-generating facilities, sewage treatment facilities, covered and uncovered reservoirs, and empty stormwater runoff retention areas, flood control channels, conduits
Water/wetland	Streams, rivers, lakes, and other water bodies (natural or man-made). Small pools and fountains should be classified based on the adjacent land use.
Transportation	Includes limited access roadways and related greenspaces (such as interstate highways with on and off ramps, sometimes fenced); railroad stations, tracks and yards; shipyards; airports. If plot falls on other type of road, classify according to nearest adjacent land use.
Other	Land uses that do not fall into one of the categories listed above. This designation should be used very sparingly as it provides very little useful information for the model.

[NOTE: For mixed-use buildings land use is based on the dominant use, i.e. the use that receives the majority of the foot traffic whether or not it occupies the majority of space.]

Calculating the volume of stormwater intercepted by vegetation: during precipitation events, a portion of the precipitation is intercepted by vegetation (trees and shrubs) while the other portion reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil becomes surface runoff. In urban areas, large extents of impervious surfaces can lead to highs amounts of surface runoff and to [localised] flooding during periods of high rainfall.

i-Tree Eco calculates the volume of precipitation intercepted by trees in order to enable valuation based upon, for example, flood alleviation or cost of treating surface water runoff avoided. To calculate the volume of surface runoff avoided calculations consider both precipitation interception by vegetation and runoff from previous and impervious surfaces. This requires field observation data, collected during the field campaign.

To calculate the volume of precipitation intercepted by vegetation an even distribution of rain is assumed within i-Tree Eco. The calculation considers the volume of water intercepted by vegetation, the volume of water dripping from the saturated canopy minus water evaporation from the canopy during the rainfall event, and the volume of water evaporated from the canopy after the rainfall event. This same process is applied to water reaching impervious ground, with saturation of the holding capacity of the ground causing surface runoff. Pervious cover is treated similarly, but with a higher storage capacity over time. The volume of avoided runoff is then summated. Processes such as the effect tree roots have on drainage through soil are not calculated as part of this model. See Hirabayashi (2013) for full methods.

The Standard volumetric rate – Surface water rebated per cubic metre value of £1.3398 set by the Welsh water was used as a representative value of the avoided cost of treating surface water runoff across the whole survey area.

Calculating current carbon storage: biomass for each tree was calculated using equations from literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations (Nowak, 1995). To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year *x*) to estimate tree diameter and carbon storage in year *x+1*.

Calculating air pollution removal: estimates are derived from calculated hourly tree-canopy resistances for ozone and sulphur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models (Baldocchi, 1988; Baldocchi et al., 1987). As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature (Bidwell & Fraser, 1972; Lovett,

1994) that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50% re-suspension rate of particles (Zinke, 1967).

Replacement costs: are based on valuation procedures of the US CTLA approach (CTLA, 1992), which uses tree species, diameter, condition and location information. In this case, values are calculated using standard i-Tree inputs such as per cent canopy missing.

This dieback does not include normal, natural branch dieback, i.e., self-pruning due to crown competition or shading in the lower portion of the crown. However, branch dieback on side(s) and top of crown area due to shading from a building or another tree would be included.

US Externality and UK Social Damage Costs

The i-Tree Eco model provides figures using US externality and abatement costs. These figures reflect the cost of what it would take a technology (or machine) to carry out the same function that the trees are performing, such as removing air pollution or sequestering carbon.

Official pollution values for the UK, however, are based on the estimated social cost of the pollutant in terms of impact upon human health, damage to buildings and crops. This approach is termed 'the costs approach'. Values were taken from Defra (2010) which are based on the Interdepartmental Group on Costs and Benefits (IGCB). There are three levels of 'sensitivity' applied to the air pollution damage cost approach: 'High', 'Central' and 'Low'. This report uses the 'Central' scenario based on 2010 prices.

Furthermore, the damage costs presented exclude several key effects, as quantification and valuation is not possible or is highly uncertain. These are listed below (and should be highlighted when presenting valuation results where appropriate).

The key effects that have not been included are:

- Effects on ecosystems (through acidification, eutrophication, etc.)
- Impacts of trans-boundary pollution
- Effects on cultural or historic buildings from air pollution
- Potential additional morbidity from acute exposure to particulate matter
- Potential mortality effects in children from acute exposure to particulate matter
- Potential morbidity effects from chronic (long-term) exposure to particulate matter or other pollutants.

CAVAT Analysis

An amended version of the CAVAT "quick" method was chosen to assess the trees in this study. To reach a CAVAT valuation the following was obtained:

- the current unit value factor rating
- DBH
- the Community Tree Index rating (CTI), reflecting local population density
- an assessment of accessibility
- an assessment of overall functionality, (that is the health and completeness of the crown of the tree)
- an assessment of safe life expectancy (SLE).

The unit value factor, which was also used in CTLA analysis, is the cost of replacing trees, presented in £/cm^2 of trunk diameter.

The CTI rating was constant across Newport at 100%. In actuality therefore, the survey concentrated on accessibility, functionality, appropriateness and SLE.

Accessibility was generally judged to be 100% for trees in parks, street trees and trees in other open areas. It was generally reduced to 80% for trees on institutional land, 40-60% on vacant plots, and 40% for trees in residential areas and on agricultural land.

Because CAVAT is a method for trained, professional arboriculturalists the functionality aspect was calculated directly from the amount of canopy missing, recorded in the field. For highway trees, local factors and choices could not be taken into account, nor could the particular nature of the local street tree make-up. However, the reality that street trees often have to be managed for safety and are frequently crown lifted or reduced (to a greater or lesser extent) and that they will have lost limbs through wind damage was acknowledged. Thus, as highway trees would not be as healthy as their more open-grown counterparts so tend to have a reduced functionality, their functionality factor was reduced to 50%. This is on the conservative side of the likely range.

For trees found in open spaces, trees were divided into those with 100% exposure to light and those that did not. On the basis that trees in open spaces are less intensively managed, an 80% functionality factor was applied to all individual open grown trees. For trees without 100% exposure to light the following factor was applied: 60% to those growing in small groups and 40% to those growing in large groups. This was assumed more realistic, rather than applying a blanket value to all non-highway trees, regardless of their situation to light and/or other trees.

SLE assessment was intended to be as realistic as possible and was based on existing circumstances. For full details of the method refer to www.ltoa.org.uk/resources/cavat.

Appendix II - Species Dominance List

Dominance values for all species encountered during the study (see Section 'Leaf Area' in the main report).

Rank	Species	Population (%)	Leaf area (%)	Dominance value
1	Leyland cypress	13.6	4	17.6
2	Sycamore	4.4	9.1	13.5
3	Common ash	6.9	6.3	13.2
4	Hawthorn	7.8	3.1	10.9
5	Sessile oak	3.9	6.4	10.3
6	Birch (Hybrid)	7.8	1.1	8.9
7	English oak	4.4	4.4	8.8
8	Hazel	4.1	4.6	8.7
9	Ash (Other Species)	4.1	4.3	8.4
10	Lawson's cypress	5.5	1.6	7.1
11	Horse chestnut	1.6	4.7	6.3
12	Willow spp	1.8	3.3	5.1
13	Common lime	0.9	3.4	4.3
14	Cherry spp	2.5	1.6	4.1
15	Apple	2.1	1.7	3.8
16	Cedar of lebanon	0.2	3.4	3.6
17	Crack willow	1.8	1.5	3.3
18	Oak spp	1.6	1.7	3.3
19	Silver birch	1.6	1.7	3.3
20	Field maple	1.2	1.9	3.1
21	Common holly	2.1	0.9	3.0
22	English yew	0.7	2.3	3.0
23	Maple spp	0.9	1.8	2.7
24	European hornbeam	1.6	1.1	2.7
25	Scots pine	0.7	1.8	2.5
26	White willow	0.5	1.9	2.4
27	Common beech	1.2	1.2	2.4
28	Goat willow	0.9	1.4	2.3
29	Norway maple	1.4	0.8	2.2
30	Cherry laurel	1.2	0.6	1.8
31	Laurel spp	0.7	1	1.7

32	Western red cedar	0.5	1.1	1.6
33	Rowan	0.9	0.6	1.5
34	Black poplar	0.5	1	1.5
35	European alder	0.5	1	1.5
36	Copper beech	0.2	1.2	1.4
37	Magnolia spp	0.9	0.5	1.4
38	Wych elm	0.7	0.7	1.4
39	Small-leaved Lime	0.2	1.1	1.3
40	European bird cherry	0.7	0.6	1.3
41	European aspen	0.5	0.6	1.1
42	Alder spp	0.2	0.8	1.0
43	Robinia spp	0.2	0.6	0.8
44	Bay laurel	0.5	0.3	0.8
45	Common juniper	0.2	0.4	0.6
46	European crabapple	0.2	0.4	0.6
47	Cordyline spp	0.5	0.1	0.6
48	Corsican pine	0.2	0.3	0.5
49	Blackthorn	0.2	0.1	0.3
50	Common pear	0.2	0.1	0.3
51	Common plum	0.2	0.1	0.3
52	Elderberry spp	0.2	0.1	0.3
53	Siberian crab	0.2	0.1	0.3
54	Spindle	0.2	0.1	0.3
55	Sweet chestnut	0.2	0.1	0.3
56	Wine grape	0.2	0.1	0.3
57	Amatungulu	0.2	0	0.2
58	Common lilac	0.2	0	0.2
59	Giant dracaena	0.2	0	0.2

Appendix III – Pests and Diseases

Acute Oak Decline

Acute oak decline (AOD) mainly affects mature trees (>50 years old) of both native oak species (*Quercus robur* and *Q. petraea*), but symptoms have also been identified on younger oaks and additional species, including *Q. cerris* and *Q. fabrei*. Some affected trees can die in as little as 4-6 years after symptoms have developed. Over the past few years, the reported incidents of stem bleeding and exit holes of the associated beetle *Agrilus bigatatus*, indicating potential AOD infection, have been increasing. The condition appears to be most prevalent in the Midlands and the South East of England, although is spreading west. There are confirmed cases of acute oak decline on the Welsh/English border and a case of AOD was confirmed in the Newport area in 2015. Acute Oak Decline poses a threat to 8.3% of Newport's urban forest.

Asian Longhorn Beetle

The Asian longhorn beetle (*Anoplophlora glabripennis*) is a major pest in China, Japan and Korea, where it kills many broadleaved species. There are established populations of Asian longhorn beetle (ALB) in parts of North America and have been outbreaks in Europe too. Where the damage to street trees is high, felling, sanitation and quarantine are the only viable management options.

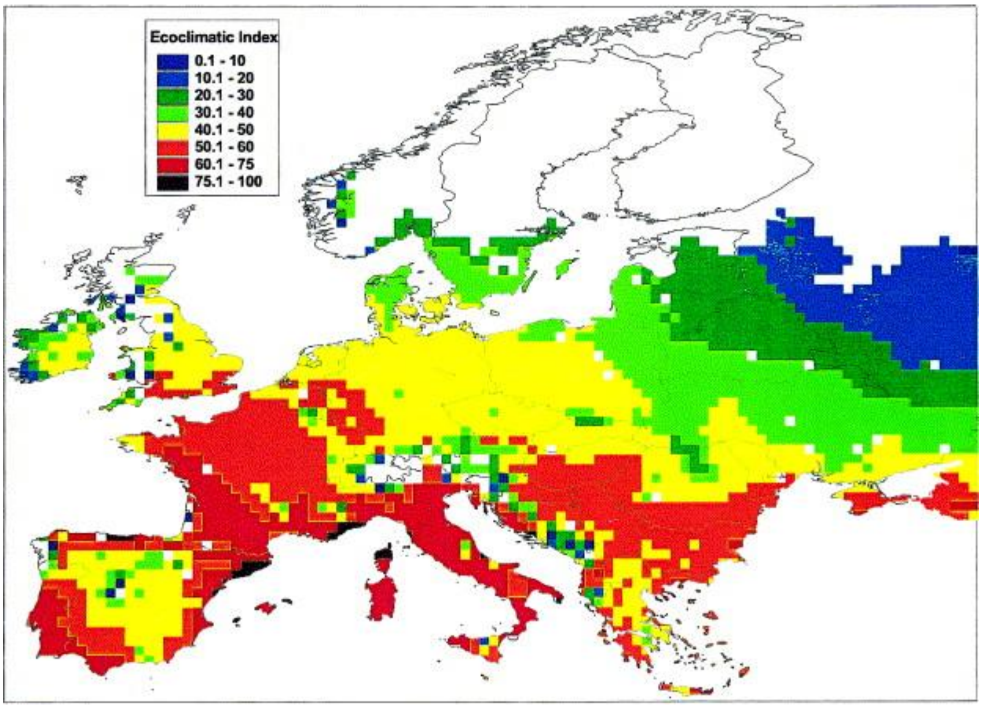

Figure 1. Ecoclimatic Indices for countries across Europe. An index of >32 is suggested to be suitable for ALB (Ref: MacLeod *et al.,* 2002).

In March 2012 an ALB outbreak was found in Maidstone, Kent. The Forestry Commission and Fera removed more than 2,000 trees from the area to contain the outbreak. No further outbreaks have been reported in the UK. MacLeod, Evans & Baker (2002) modelled climatic suitability for outbreaks based on outbreak data from China and the USA and suggested that CLIMEX (the model used) Ecoclimatic Indices of >32 could be suitable habitats for ALB. Figure 1 suggests that Newport may be vulnerable to ALB under this model.

If an ALB outbreak did occur in Newport it would pose a significant threat to 50.5% of the trees, not including attacks on shrub species.

The known host tree and shrub species include:

- *Acer spp.* (maples and sycamores)
- *Aesculus spp.* (horse chestnut)
- *Albizia julibrissin* (Mimosa silk tree)
- *Alnus spp.* (alder)
- *Betula spp.* (birch)
- *Carpinus spp.* (hornbeam)
- *Cercidiphyllum japonicum* (Katsura tree)
- *Corylus spp.* (hazel)
- *Fagus spp.* (beech)
- *Fraxinus spp.* (ash)
- *Koelreuteria paniculata* (Golden rain tree)
- *Malus spp.* (apple)
- *Platanus spp.* (plane)
- *Populus spp.* (poplar)
- *Prunus spp.* (cherry, plum)
- *Pyrus spp.* (pear)
- *Robinia pseudoacacia* (false acacia/black locust)
- *Salix spp.* (willow, sallow)
- *Sorbus spp.* (rowan, whitebeam etc)
- *Styphnolobium japonicum* (Japanese pagoda tree)
- *Quercus palustris* (American pin oak)
- *Quercus rubra* (North American red oak)
- *Ulmus spp.* (elm).

Bronze Birch Borer

The Bronze birch borer (*Agrilus anxius*) is a wood-boring beetle that feeds on the inner bark and cambium of birch trees. The disruption to water and nutrient flow that occurs as a result means that trees can die within a few years after symptoms appear. At current, the Bronze birch borer is present across North America, including the United States, where it is native, and Canada. Here, the borer has caused extensive mortality of *Betula spp*. planted as street and ornamental trees in towns and cities, due to its ability to colonize most birch species and cultivars. If the Bronze birch borer were to be introduced to the UK, and subsequently to Newport, then 9.5% of Newport's urban forest could be at risk.

Chalara Dieback of Ash

Ash dieback, caused by the fungus *Hymenoscyphus fraxineus*, is a highly destructive disease of ash trees, including *Fraxinus excelsior*, *F. excelsior* 'Pendula' and *F. angustifolia*. Young trees are particularly susceptible and can be killed within one growing season of symptoms becoming visible. Older trees can take longer to succumb, but can die from the infection or secondary pathogens (e.g. *Armillaria*) after several seasons. *H. fraxineus* was first recorded in the UK in 2012 in Buckinghamshire and has now been widely reported across the UK, including in urban areas. Chalara ash dieback is currently established in Newport and poses a threat to 11.1% of Newport's urban forest.

Emerald Ash Borer

Emerald ash borer (EAB) is likely to have a major impact on our already vulnerable ash population in the UK if established. There is no evidence to date that EAB is present in the UK, but the increase in global movement of imported wood and wood packaging heightens the risk of its accidental introduction. EAB is present in Russia and Ukraine and is moving West and South at a rate of 30-40 km per year, perhaps aided by vehicles (Straw et al., 2013). EAB has had a devastating effect in the USA due to its accidental introduction and could add to pressures already imposed on ash trees from diseases such as Chalara dieback of ash. Emerald Ash borer poses a potential future threat to 11.1% of Newport's urban forest.

Oak Processionary Moth

Oak processionary moth (OPM) was first accidentally introduced to Britain in 2005 and now there are established OPM populations in most of Greater London and in some surrounding counties. It is thought that OPM has been spread through imported nursery trees and it has been estimated that OPM could survive and breed in much of England and Wales. The caterpillars cause serious defoliation of oak trees, their principal host, which can leave them more vulnerable to other stresses. The caterpillars have urticating (irritating) hairs that can cause serious irritation to the skin, eyes and bronchial tubes of humans and animals. They are considered a significant human health problem when populations reach outbreak proportions, such as those in the Netherlands and Belgium in recent years. Whilst the outbreak in London is beyond eradicating, the rest of the UK maintains its European Union Protected Zone status (PZ) and restrictions on moving oak trees are in place to minimise the risk of further spread. This is particularly relevant to Newport, as there have been three confirmed cases found in Wales to date, including one case in South Wales. OPM poses a threat to 9.9% of Newport's urban forest.

Xylella fastidiosa

Xylella fastidiosa is a bacterium that has the potential to cause significant damage to a range of broadleaf trees and commercially grown plants. The bacterium has been found in Italy, France, Spain, the Americas and Taiwan, and can be spread through the movement of infected plant material and through insects from the Cicadellidae and Ceropidae families. There are four known sub-species: *Xylella fastidiosa* subsp. *multiplex, Xylella fastidiosa* subsp. *fastidiosa*, *Xylella fastidiosa* subsp. *pauca* and *Xylella fastidiosa* subsp. *Sandyi.* The subspecies *multiplex* is thought to be able to infect the widest variety of trees and plants, including *Quercus robur* and *Platanus occidentalis*. It is estimated that almost 10% of Newport's trees could be at risk of infection from *X. fastidiosa* subsp*. multiplex*, and if additional subspecies were to become prevalent in the area, this is likely to have a much wider impact, affecting ornamental and commercial shrubs and plants too.

For further information on the pests and diseases listed above, as well as other pathogens that pose a threat to the UK's trees, please visit https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources.

Appendix IV – Habitat Provision

A breakdown of the different foliage invertebrate groups supported by selected tree species in Newport.

Count	Common name	Beetles	Flies	True bugs	Wasps and sawflies	Moths and butterflies	Other	Total
41	Birch (2 spp.)	57	5	42	42	179	9	334
30	Common ash	1	9	17	7	25	9	68
22	Willow (5 spp.)	64	34	77	104	162	9	450
19	English oak & Sessile oak	67	7	81	70	189	9	423
18	Sycamore	2	3	11	2	20	5	43
14	Hazel	18	7	19	8	48	6	106
14	Common Hawthorn	20	5	40	12	124	8	209
9	Common holly	4	1	2	0	3	0	10
7	Horse chestnut	0	0	5	0	2	2	9
7	European hornbeam	5	3	11	2	28	2	51
5	Common beech	34	6	11	2	41	4	98
5	Field maple	2	5	12	2	24	6	51
5	Lime (2 spp.)	3	5	14	2	25	8	57
4	Poplar (4 spp.)	32	14	42	29	69	3	189
3	Rowan	8	3	6	6	33	2	58
3	Scots pine	87	2	25	11	41	6	172
3	English yew	0	1	1	0	3	1	6
3	Elm (2 spp.)	15	4	33	6	55	11	124
2	European alder	16	3	32	21	60	9	141
1	Sweet chestnut	1	0	1	0	9	0	11
1	Common juniper	2	5	7	1	15	2	32
1	European crab apple	9	4	30	2	71	2	118
1	Blackthorn	13	2	29	7	91	11	153