Ecosystem Services

provided by

Mountshannon Village Trees

Ecosystem Services provided by Mountshannon Village Trees

2016

Bernard Carey and Brian Tobin

for further information or to conduct an i-Tree study in your area,
contact Bernard by email at ilex@eircom.net

Acknowledgments

Clare County Council, in association with the Department of the Environment, Community and Local Government, provided a generous grant to support this project. Funds were provided under Local Area Agenda 21 (LA 21) framework.

Special thanks are due to Kenton Rogers of Treeconomics, without whom this project would not have happened. Likewise Al Zeyela of Davey assisted by providing access to the latest version of i-Tree Eco and who also helped run the analyses.

The contribution of Antonio Cacherino Vivar who helped with collecting, reconfiguring and uploading the data to i-Tree is much appreciated.

The authors are very grateful to Michael Doyle of Treemetrics Ltd. for his time and help with the 3D scanning and associated estimation of the Mountshannon champion oak timber volume.

The front cover, designed by Paul Berg, shows Holy Island (Inis Cealtra) round tower and church adjacent to Mountshannon Village and, also, the recently reintroduced sea eagle which is now breeding successfully on an island close to the village harbour. The oak branch represents the historical oak woodland that once covered the land around the village. The oak has been used to mark the 100 year anniversary of the 1916 Rising in Mountshannon this year through the planting of over 100 locally sourced oak saplings in and around the village.

Contents

Tables

Figures

Definitions

Biodiversity:

The variety of life on Earth, the wide variety of ecosystems and living organisms: animals, plants, their habitats and their genes.

Source: The International Union for the Conservation of Nature (IUCN)

Carbon sequestration:

The net removal of carbon dioxide from the atmosphere and storage in plant biomass or other pools.

Ecosystem services:

The direct and indirect contributions of ecosystems to human wellbeing. Examples include carbon sequestration, pollination, recreation and clean oxygenated air.

Source: The Economics of Ecosystems and Biodiversity (TEEB)

Externalities:

Effects of a person's or firm's activities on others which are not compensated. They can be negative or positive. An example is when a company pollutes a local environment in the production of goods, but does not compensate the local community for the negative impacts they experience.

Source: The World Bank.

Natural Capital:

The elements of nature that produce value - directly and indirectly - to people, such as the stocks of forests, rivers, soil, minerals and oceans.

Source: Irish Forum on Natural Capital, http://www.naturalcapitalireland.com/

Natural Capital Accounting:

A rapidly evolving new way of thinking about how we value the economic benefits we derive from the natural environment.

Source: The World Forum on Natural Capital 2013

Urban forest

The urban Forest is the ecosystem containing all of the trees, plants and associated animals in an urban environment, both in and around a city – Sands, 2005.

A contiguous area with over 10% tree canopy cover can be classified as forest – Food and Agriculture Organisation (FAO) of the United Nations

Summary

Understanding an urban forest's structure, function and value can support and promote management decisions that will improve human health and environmental quality. An assessment of the structure, function and value of a section of the Mountshannon urban forest was conducted during 2016. Data describing 418 trees from across an area of 6.85 hectares in the public areas of Mountshannon village were analysed using the i-Tree Eco model, developed by the U.S. Forest Service, Northern Research Station.

The main outputs derived from this analysis are listed below. There is an impressive diversity of species (24) represented on the public areas of Mountshannon, nine of which are native species. Of particular interest is the fact that the amount of carbon storage within the study area is equivalent to the amount of carbon emitted in Mountshannon in 66 days or the annual carbon emissions from 90 cars. Also, the largest tree in the village, the 'Bé Binn' champion oak (the largest recorded oak in Ireland) has accumulated over 17,000 kg of carbon within it and every growing season develops a leaf area of over 2,600 m^2. Using the CAVAT (Capital Asset Valuation for Amenity Trees) valuation model this tree was valued to be worth €422,209 to the local community.

It should be noted that the survey of urban trees only covered a proportion of the village area. It is hoped that subsequent surveys will increase this inventory area. However, since there are substantial areas not covered by the inventory, as well as all the trees growing on private property also within the village boundary, the estimates of services and their valuation are a considerable underestimate of what is actually produced.

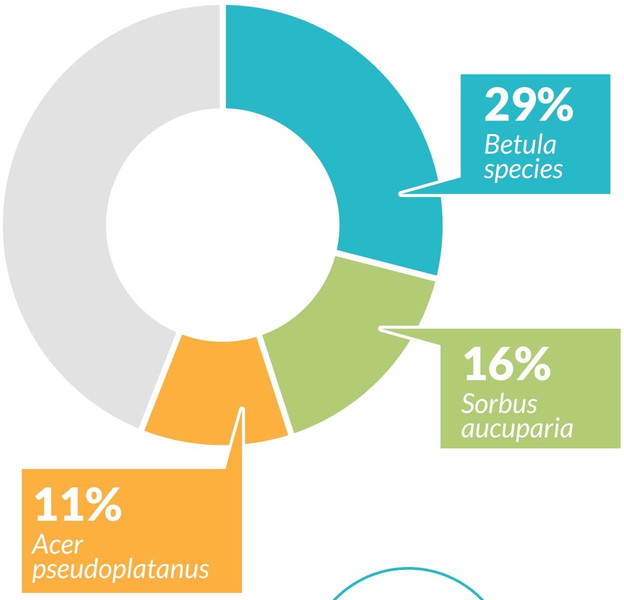
Highlights at a glance

418
Trees measured

6.85ha
Survey area

1.52ha
Tree cover

20.6%
Proportion of trees less than 6” (15.2 cm) diameter



235 m^3/year
(€134/year)
Avoided runoff

116 tonnes
(€2,223)
Carbon storage

9 tonnes/year
(€331/year)
Oxygen production

Structural value
€544,000**

< 1 tonne/year
(€480/year)
Pollution removal

4 tonnes/year
(€77/year)
Carbon sequestration

The ‘Bé Binn’ champion oak
(€422,209)
Most valuable individual tree

** This value becomes €932,276 if the structural and functional value of the Bé Binn champion oak is included

1. Introduction

Whilst most people recognise the intrinsic beauty of trees, we often don't know or take for granted the other benefits that urban trees and woodland – which we collectively describe as the urban forest – provide to society. As a result they may be overlooked and not given the consideration or management and protection they deserve.

The 21st Conference of Parties (COP21) agreement in Paris in December 2015 has once again raised awareness of the global implications of increased greenhouse gas concentrations in our atmosphere and has included the importance of trees in the final COP21 agreement text. Trees can be considered as one of the few environmentally friendly ways of off-setting our carbon emissions.

But the positive effects of trees do not stop at producing oxygen and absorbing carbon dioxide. Other benefits of trees include:

- Storm water attenuation - trees can help reduce local flooding by intercepting rainfall and maintaining/increasing soil permeability.
- Protection and enhancement of biodiversity - mature oak trees can host up to 423 invertebrates[1]
- Improvements in air quality – the interception of fine particles improves air quality.
- Property value amelioration - a study in Portland, Oregon showed that property prices were 3% - 15% higher when there were large/mature trees present.[2]
- Improved health benefits – a Canadian study in Toronto showed that residents reported feeling better and having fewer health problems when there were more trees on their street.[3]
- We socialise better when big trees are present - housing developments with large trees have been found to attract people to the outdoors, to talk with their neighbours, and encourage the development of stronger social bonds.[4]

However, assigning a value to some of these benefits can be difficult. i-Tree is a state-of-the-art, peer-reviewed software system designed to evaluate the natural capital of such ecosystem services as carbon sequestration, air pollutant removal and storm water attenuation that trees can provide. It was devised in the United States and has been used throughout the world. In Britain places such as Edinburgh, Luton, London, Torbay and other towns and cities have utilised i-Tree assessments of their local natural capital (see Appendix 3). An inventory was carried out of Dublin's urban trees[5] by Dr Tine Ningal (UCD School of Geography) and iTree was used for an analysis of tree canopy.

This project involved using the i-Tree software to analyse a survey of the trees in a defined area in Mountshannon village. The i-Tree assessment provides an opportunity for various key stakeholders

---

[1] Source: http://www.countrysideinfo.co.uk/woodland_manage/tree_value.htm

[2] Source: http://depts.washington.edu/hhwb/Thm_Economics.html

[3] Source: http://www.theguardian.com/society/2015/jul/10/more-trees-on-your-street-means-fewer-health-problems-says-study

[4] Source: The economics of biophilia (Heerwagen, 2006).

[5] Source: http://logmytree.blogspot.ie/2012/10/inventory-of-dublins-urban-trees.html

to understand the significance and value of the trees in Mountshannon and will provide verifiable evidence to legitimise the funding requirements for managing and improving this important resource in the future.

Mountshannon is a picturesque village on the shores of Lough Derg (Figure 1). It is a popular and peaceful haven for tourists and is on the route of the East Clare Way walking trail. It once relied on the peak summer months for its tourism revenue but now enjoys a steady year round trade. The tree-lined village won the Tidy Towns Competition in the past and it is extremely popular with anglers and boatmen who use the harbour and pier facilities of a calm and sheltered bay. The nearby Inis Cealtra, or Holy Island, is now uninhabited but was once a monastic settlement and has a well-preserved round tower, the ruins of several small churches, as well as part of 4 high crosses and a holy well.

The area contributed to the success of the Irish reintroduction programme of white-tailed eagles when a breeding pair nested on a nearby island in Lough Derg in 2012. In 2013 the first eaglets were born in Ireland since the re-introduction programme began; one in the Killarney National Park and two in Mountshannon. In 2014 and 2015 further chicks were hatched.

Figure 1: Map of Mountshannon village.

2. Methodology

This project builds on the tree survey work carried out by Nicholas de Jong Associates and Michael Garry, Arboriculturalist in the Clare County Council-funded project *Trees in Towns and Villages in County Clare*. As time was limited by funding constraints and seasonal issues for this project (trees should ideally be in full leaf when carrying out such a survey), it was decided that the trees selected for measurement would be based on those previously tagged by Nicholas De Jong and Michael Garry. The tagged trees were resurveyed (approximately 75) while additional trees associated with these tagged tree groups were also surveyed. Trees surveyed were within the publicly accessible areas of the village and within the Mountshannon Townland boundary (with the exception of the inclusion of the trees on the western end of the village adjacent to St Caimin's RC church). The total area surveyed comprised approximately 6.85 ha and this area is illustrated in Figure 2.

Figure 2: The tree inventory area, highlighted in pink, was 6.85 ha in extent but still only covered a portion of the village's public area.

Amongst the data collected were tree species, height, diameter at breast height (DBH), crown width, percentage crown missing, percentage crown dieback, proportion of impervious ground underneath canopy and type of land use / urban street designation.

i-Tree Eco analysis supports both total inventories (i.e. where all trees are measured) or random (stratified) sampling. This survey used the previously tagged trees as the basis of random samples, but with substantially increased frequency in order to describe groupings of trees. The survey was completed on three main occasions, with follow-up surveys to confirm results. Data were initially sorted and formatted in MS Excel before conversion to MS Access for uploading onto the beta Version 6 of i-Tree Eco for full analysis.

Transferability was a requirement for the receipt of funding for this project, i.e. it should be possible to apply the same methodology to other villages, towns and cities to generate similar and comparable analyses. Consequently, this project set out to produce a practical template for other communities to use, but with modifications to streamline the sampling and data collection protocols.

3. Tree Characteristics of the Urban Forest of Mountshannon

"A functioning urban forest needs trees of all shapes and sizes and in the right proportions to ensure that benefits can continue to be delivered for the future" (Rogers *et al*, 2015).

The urban forest survey of Mountshannon measured 418 individual trees. The entire survey area covered approximately 6.85 ha, whilst specific tree cover was 1.52 ha. The dominant tree species in Mountshannon was *Betula* (birch) at 29.2% followed by *Sorbus aucuparia* (mountain ash) at 16% and *Acer pseudoplatanus* (sycamore) at 10.8% (See Figure 3). Both mountain ash and birch are native species but are considered relatively short-lived (pioneer) species. Whilst the longer-lived (climax species) native *Quercus* (oak) and *Fraxinus* (ash) only represent 5.2% and 4.8% respectively. The large number of birch occurred mainly in two large groups planted in Aistear Park and the land adjoining the northern exit road. The area of birch at the northern end of the village has recently been under-planted with locally sourced oaks.

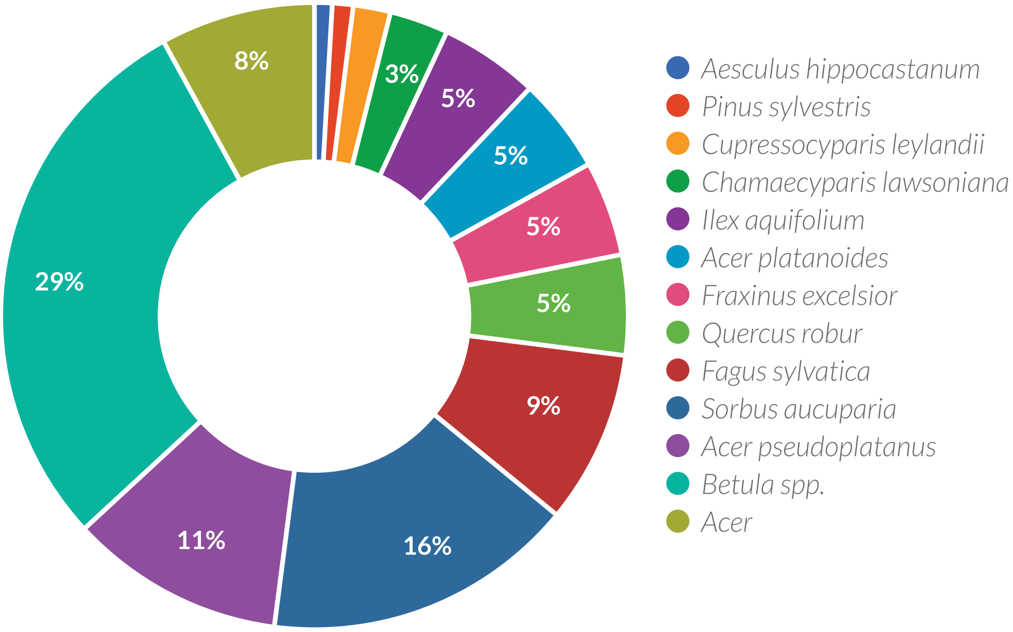


Figure 3: Species composition of the trees sited in public areas at Mountshannon.

Urban forests are composed of native and exotic tree species. Thus, urban forests often have a tree diversity that is higher than surrounding native landscapes. Increased tree diversity can minimize the overall impact or destruction by a species-specific insect or disease, but it can also pose a risk to native plants if some of the exotic species are invasive plants that can potentially out-compete and displace native species. In Mountshannon 64% of the trees are native to Ireland with 34% native to Europe (see Figure 4). Invasive plant species are often characterized by their vigour, ability to adapt, reproductive capacity and a general lack of natural enemies. These abilities enable them to displace native plants and make them a threat to natural areas (National Invasive Species Information Center 2011). None of the tree species in Mountshannon are considered invasive in Ireland.

The DBH (Diameter at Breast Height) class distribution gives an indication of the size of trees. It is an important factor in managing a sustainable tree population and insures that there is succession of trees to replace the older ones. It also offers an insight to the resilience of the tree population as larger trees are important for their ecological benefits not offered by smaller and younger trees. Figure 5 illustrates the DBH classification of the trees in Mountshannon. The DBH class distribution indicates that significant planting of trees has been ongoing in Mountshannon (this year alone, 100 oaks were added to this population).

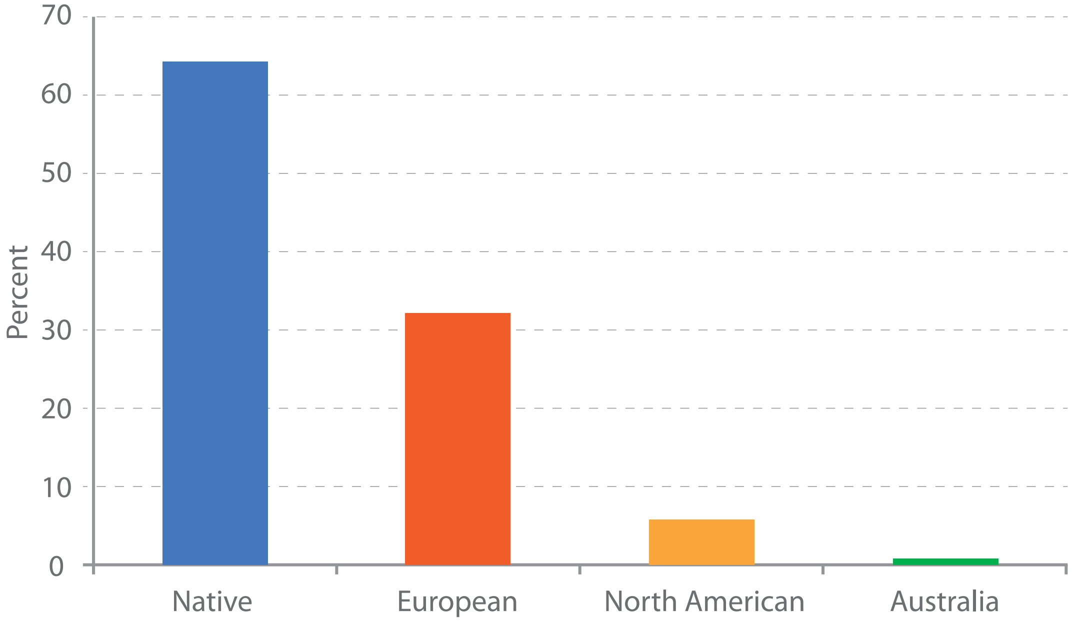


Figure 4: Percentage of Mountshannon public trees by region of native origin.

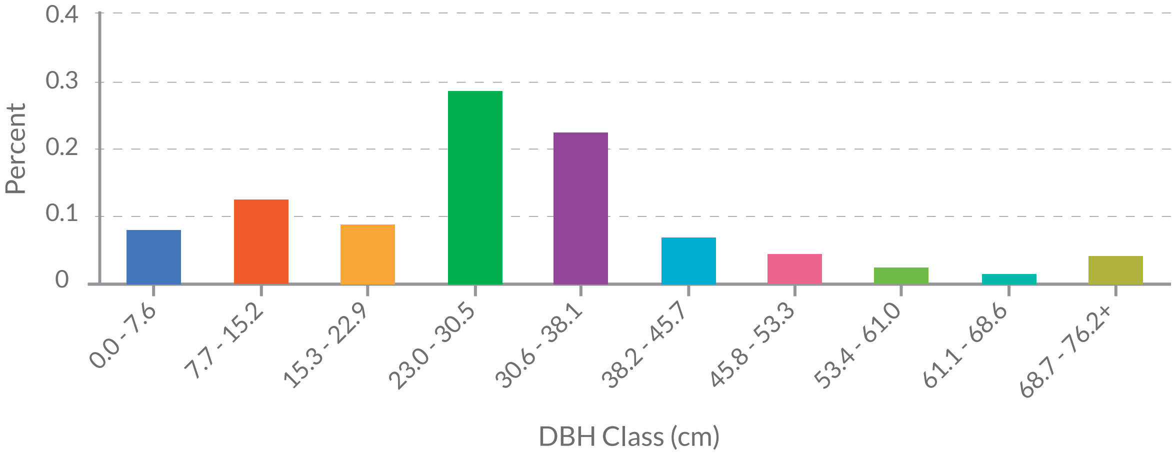


Figure 5: Percentage of tree population by diameter class (DBH = stem diameter at 1.3 m aboveground level).

4. Urban Forest Cover and Leaf Area

"Leaf area and tree canopy cover are the driving forces behind tree benefits"- (Rogers *et al*, 2015).

Many tree benefits relate directly to the amount of healthy leaf surface area of the plant. Tree canopy cover was approximately 1.5 ha of the 6.85 ha (21.9%) surveyed in Mountshannon and supported 0.062 km^2 of leaf area. Whilst birch, sycamore and mountain ash had the highest percentage of leaf area in the village (see Table 1), this does not necessarily mean that these trees should be planted in favour of other tree species. Rather it indicates their dominance in the current tree population. Larger and longer-lived trees such as oak can intercept more pollutants, store more carbon and contribute to leaf area longer than smaller ones. But equally important in terms of management is that the same effort goes into establishing a small, short-lived tree such as mountain ash as for a long-lived species such as oak.

In Mountshannon, the most dominant species in terms of leaf area are birch, sycamore, and mountain ash. The 10 species with the greatest importance values are listed in Table 1. Importance values (IV) are calculated as the sum of percent population and percent leaf area. High importance values do not mean that these trees should necessarily be encouraged in the future; rather these species currently dominate the urban forest structure.

Table 1: Comparison among the 10 most productive tree species in Mountshannon. Importance values (IV) are calculated as the sum of percent population and percent leaf area. High importance values denote species that dominate the urban forest structure.

Species name	Percent population	Percent leaf area	IV
Betula spp.	29.2	21.3	50.5
Acer pseudoplatanus	10.8	16.4	27.2
Sorbus aucuparia	16.0	7.3	23.3
Fagus sylvatica	8.4	9.0	17.4
Quercus robur	5.3	8.2	13.5
Fraxinus excelsior	4.8	6.1	10.9
Acer platanoides	5.3	4.5	9.8
Ilex aquifolium	5.0	0.3	5.3
Chamaecyparis lawsoniana	2.6	7.1	9.8
Cupressocyparis leylandii	1.7	6.6	8.2

The four seasons of an Oak tree
in Woodpark Pitch and Putt.

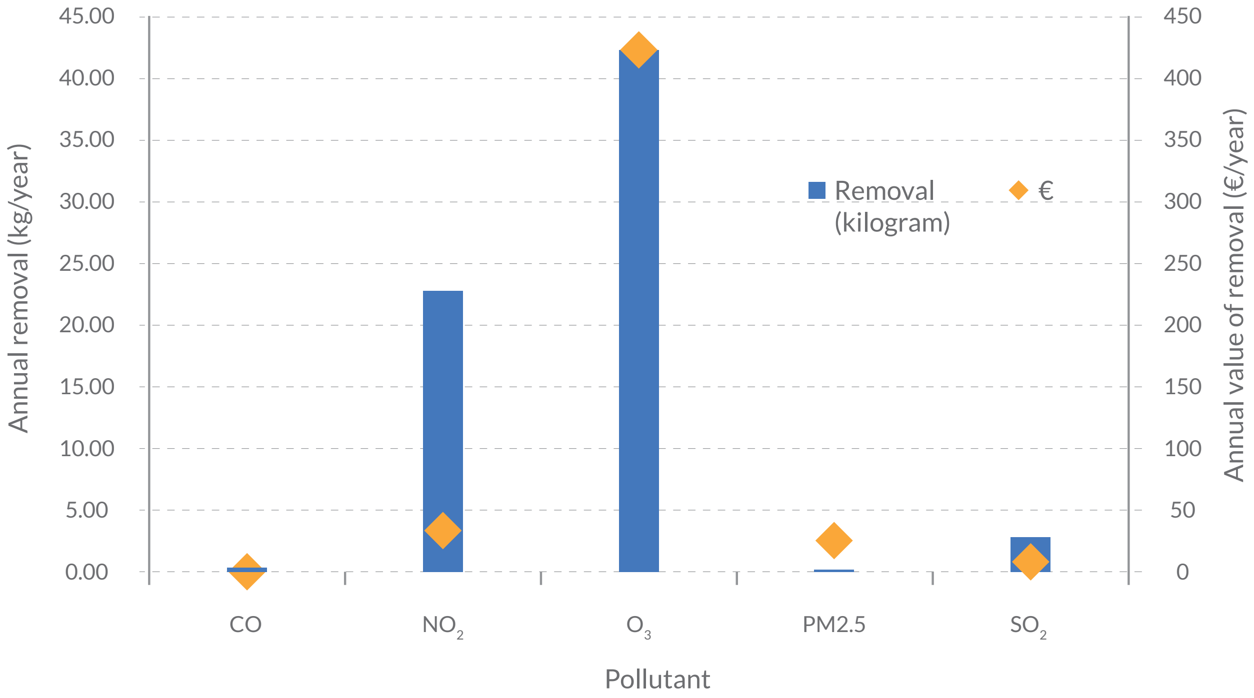
Winter scene of Lough Derg viewed
from the Slieve Aughties

5. Air Pollution Removal by Urban Trees

> “Ireland is required under EU Law to decrease exposure to PM2.5 by 10% between 2012 and 2020 due to its impact on health; this will result in 359 fewer respiratory deaths every year in Dublin alone.”
> (Asthma Society Ireland)

Poor air quality is a common problem in many urban areas. It can lead to decreased human health, damage to landscape materials and ecosystem processes, and reduced visibility. The urban forest can help improve air quality by reducing air temperature and directly removing pollutants from the air. Pollution removal by trees in Mountshannon was estimated using field data and recent available pollution data from the UK and weather data from Shannon airport. As indicated in Figure 6, the greatest pollution removal was for ozone. Mountshannon trees were estimated to remove 0.069 tonnes of air pollution (including ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter less than 2.5 microns (PM2.5), and sulphur dioxide (SO_2) per year with an associated value of €480 (see Appendix 1 for more details).

Figure 6: Annual atmospheric pollution (including carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter less than 2.5 microns (PM2.5), and sulphur dioxide (SO_2)) removal by Mountshannon trees and the associated market values.



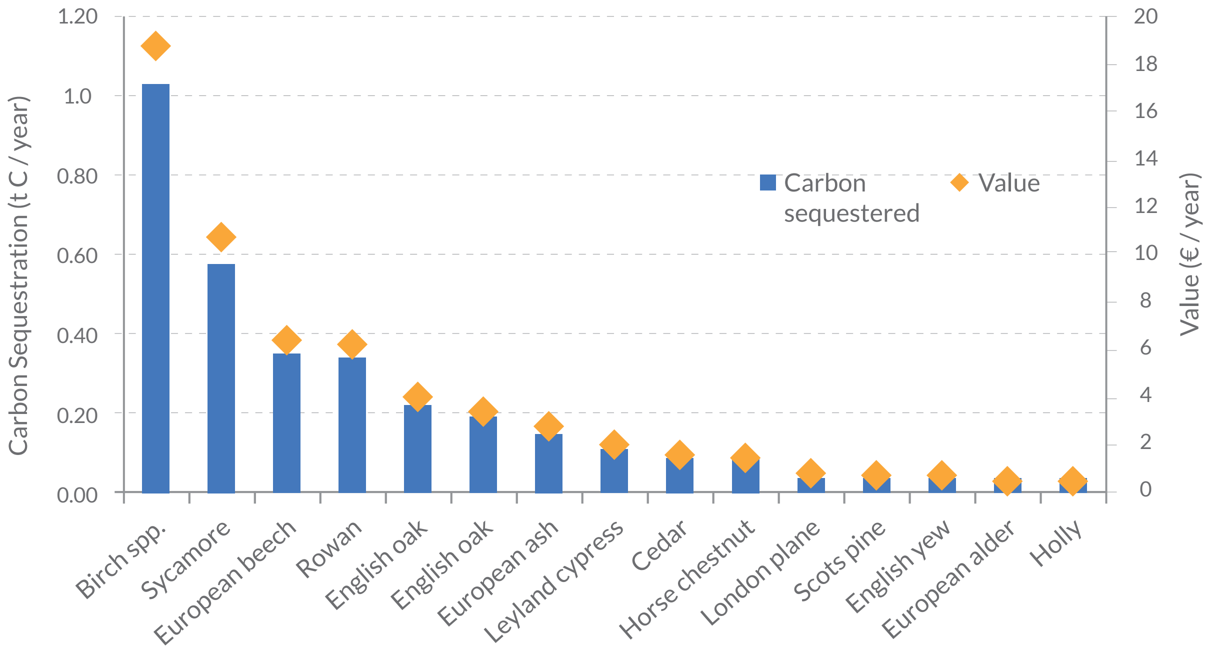
6. Carbon Sequestration and Storage

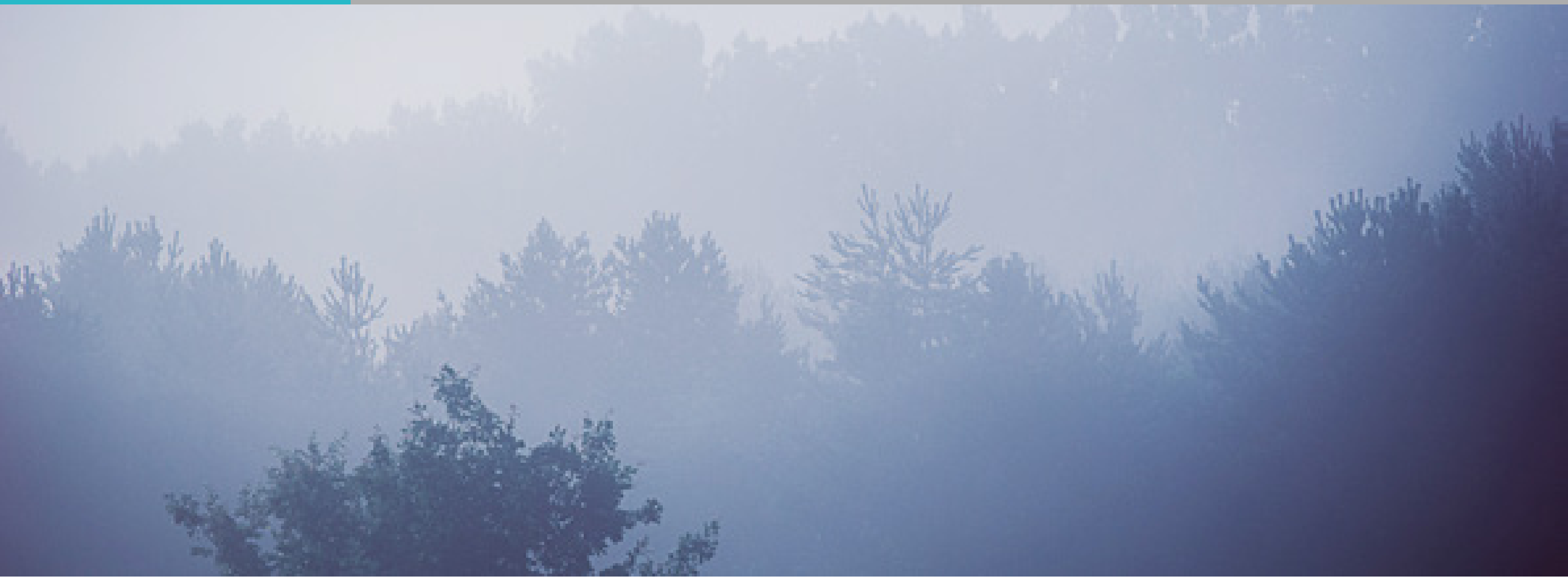
"The national forest estate represents an important carbon reservoir of 381 million tonnes. The gross annual sequestration rate was estimated to be 5.44 million tonnes carbon annually over the period 2006 to 2012." Ireland's Second National Forest Inventory, Main Findings, Government of Ireland, 2013.

Climate change is an issue of global concern. Urban trees can help mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in tissue and by altering energy use in buildings, and consequently altering carbon dioxide emissions from fossil-fuel based power sources (Abdollahi *et al*, 2000).

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered increases with the productivity rate and health of the trees. The gross sequestration of Mountshannon trees (see Figure 7) was approximately 4 tonnes of carbon per year with an associated value of €77 per year. Net carbon sequestration in the urban forest was about 4 tonnes. See Appendix I for more details on methods.

Figure 7: Estimated annual carbon sequestered (blue bars) and its value (diamond symbols) for the more productive species in Mountshannon.

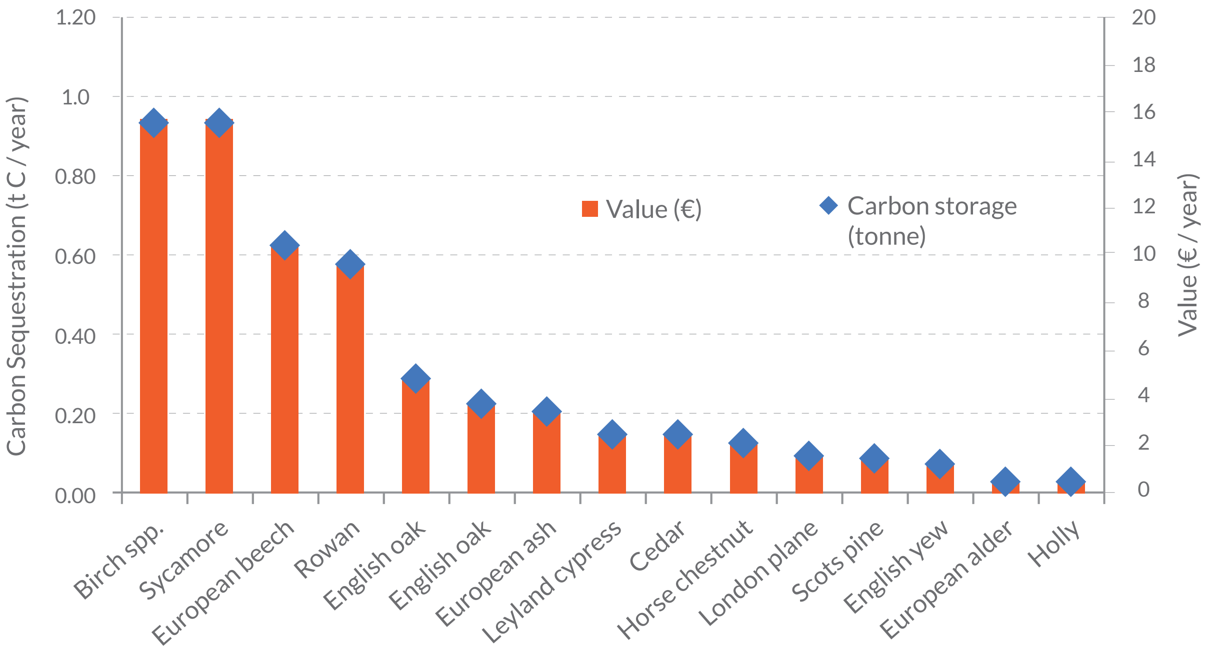




Carbon storage is another way trees can influence global climate change. As a tree grows, it stores more carbon by holding it in its accumulated tissue. As a tree dies and decays, it releases much of the stored carbon back into the atmosphere. Thus, carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose. Maintaining healthy trees will keep the carbon stored in trees, but tree maintenance can contribute to carbon emissions (Nowak *et al*, 2002b). When a tree dies, using the wood in long-term wood products, to heat buildings, or to produce energy will help reduce carbon emissions from wood decomposition or from fossil-fuel or wood-based power plants.

Trees within the study area of Mountshannon (see Figure 8) were estimated to store 116 tonnes of carbon with an associated value of €2,223. Of the species sampled, Betula species stored and sequesterd the most carbon (approximately 20.2% of the total carbon stored and 29.3% of all sequestered carbon).

Figure 8: Estimated carbon storage for urban tree species (blue diamond symbols) and their market value (red bars).



7. Oxygen Production

National Geographic (2004) claims that photosynthesis by phytoplankton (mostly single-celled phototrophs, such as cyanobacteria, green algae and diatoms) account for about half of the earth's oxygen production. The other half, they claim, is produced on land by trees, shrubs, grasses, and other plants.

Oxygen production is one of the most commonly cited benefits of urban trees. The net annual oxygen production of a tree is directly related to the amount of carbon sequestered by the tree, which is tied to the accumulation of tree biomass.

Trees in in the study area of Mountshannon are estimated to produce 9 metric tonnes of oxygen per year. However, this tree benefit is relatively insignificant because of the large and relatively stable amount of oxygen in the atmosphere and the extensive production by nearby extensive aquatic systems. Our atmosphere has an enormous reserve of oxygen. If all fossil fuel reserves, all trees, and all organic matter in soils were burned, atmospheric oxygen would only drop a few percent (Broecker 1970).

Nevertheless, assuming the cost of industrial oxygen supply (€2.32 per m^3), this means the trees of Mountshannon are supplying a value of €331 of O_2 annually.

Table 2: The top 20 oxygen producing species at Mountshannon.

Species name	Oxygen (tonnes)	Net carbon sequestration (tonnes/yr) Number of trees	No. of trees
Betula spp.	2.74	1.03	122
Acer pseudoplatanus	1.55	0.58	45
Fagus sylvatica	0.93	0.35	35
Sorbus aucuparia	0.91	0.34	67
Quercus robur	0.58	0.22	22
Fraxinus excelsior	0.50	0.19	20
Acer platanoides	0.41	0.15	22
Cupressocyparis leylandii	0.29	0.11	7
Chamaecyparis lawsoniana	0.23	0.09	11
Aesculus hippocastanum	0.21	0.08	6
Platanus x acerifolia	0.12	0.04	1
Pinus sylvestris	0.11	0.04	6
Taxus baccata	0.11	0.04	2
Populus nigra	0.08	0.03	3
Alnus glutinosa	0.07	0.03	3

Species name	Oxygen (tonnes)	Net carbon sequestration (tonnes/yr) Number of trees	No. of trees
Ilex aquifolium	0.07	0.03	21
Carpinus betulus	0.07	0.02	1
Populus tremuloides	0.06	0.02	2
Abies alba	0.06	0.02	3
Malus angustifolia	0.05	0.02	3

View of Mountshannon harbour and Holly island in the distance.

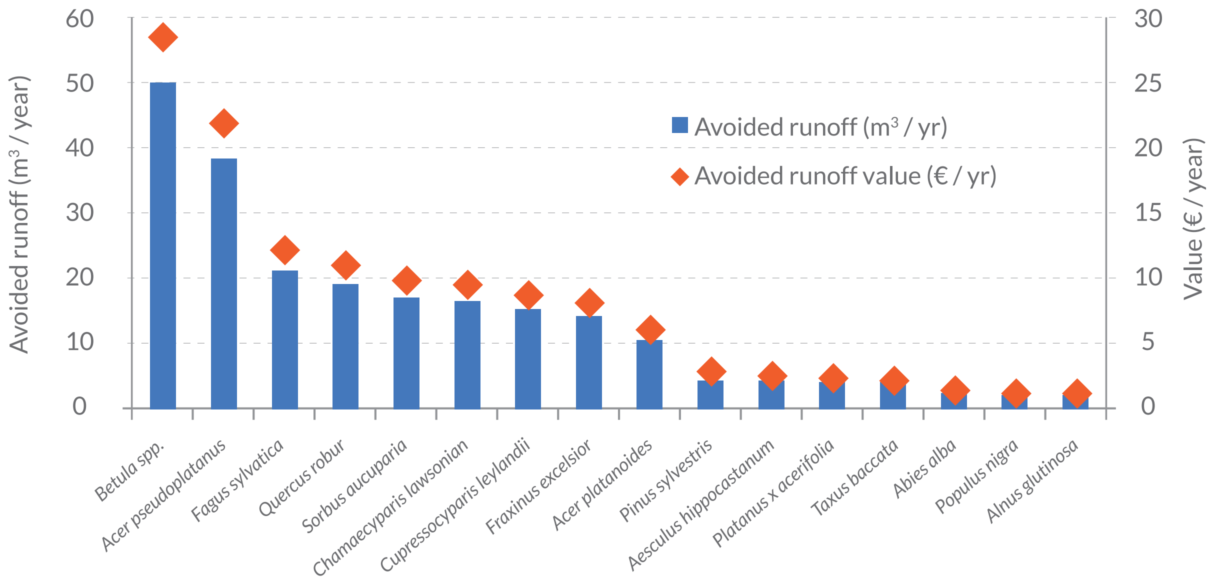
8. Rainwater Runoff Avoided

"... trees intercept rainfall, direct precipitation into the ground through trunk flow, and take up storm-water through their roots." (Day and Dickinson, 2008)

Surface runoff can be a cause for concern in many urban areas as it can contribute pollution to streams, wetlands, rivers, lakes, and oceans. During precipitation events, some portion of the falling water is intercepted by vegetation (trees and shrubs) while another portion reaches the ground. The portion of precipitation that reaches the ground and does not infiltrate into the soil becomes surface runoff (Hirabayashi, 2012). In urban areas, the large extent of impervious surfaces increases the amount of dangerous and fast moving surface runoff.

Urban trees and shrubs are beneficial in reducing surface runoff. Trees and shrubs intercept precipitation, while their root systems promote infiltration and storage in the soil. The trees of Mountshannon (see Figure 9) help to reduce runoff by an estimated 235 m^3 a year with an associated value of €134 (see Appendix 1 for more details).

Figure 9: Tree species with most impact on rain runoff quantities at Mountshannon.



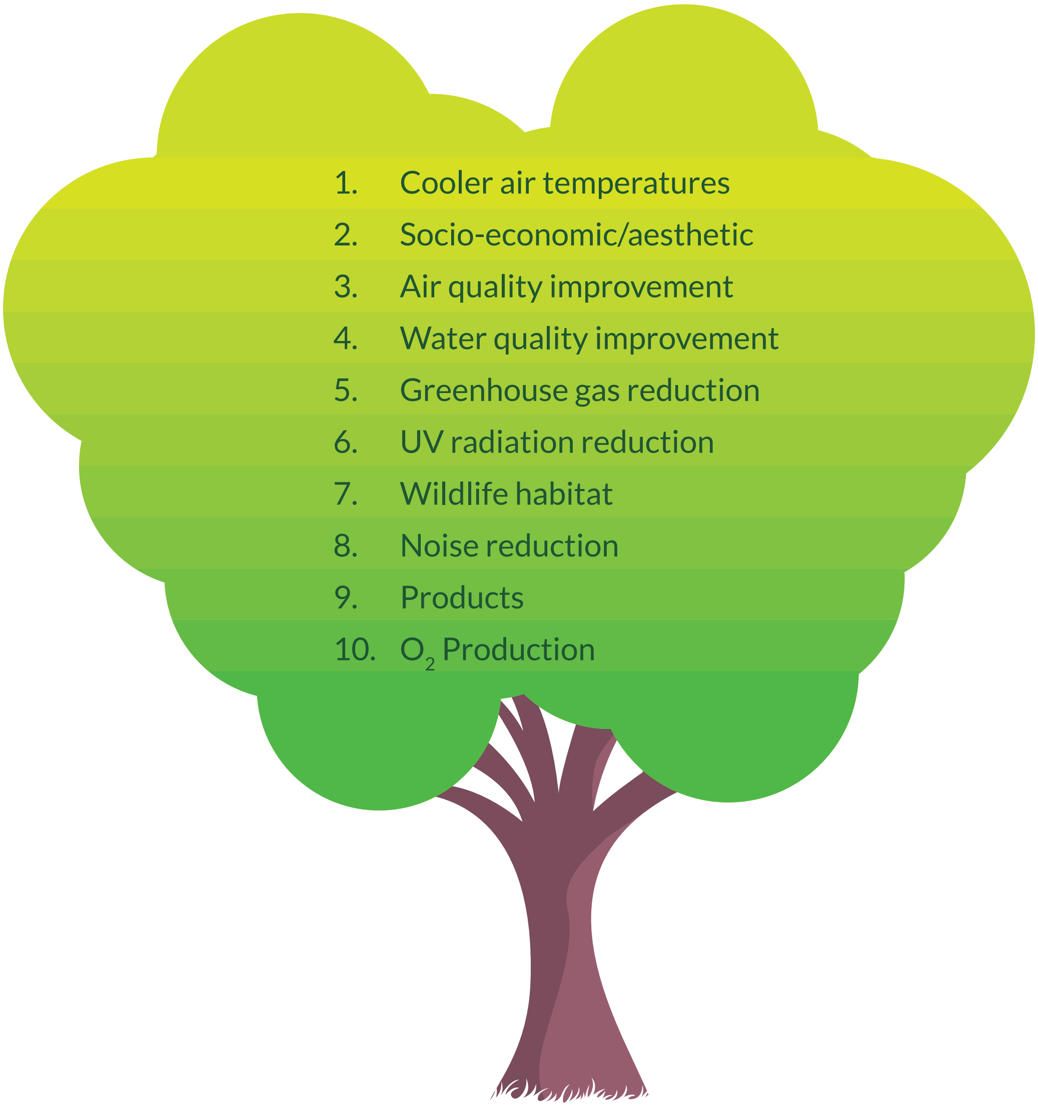
9. Trees and Energy Use of Buildings

“Climate-effect trees, particularly evergreen species, can also reduce heat loss from buildings in winter by reducing wind speed and, thus, air infiltration into the building.” (Liu and Harris, 2008)

Trees affect energy consumption by shading buildings, providing evaporative cooling and blocking winter winds. Trees tend to reduce building energy consumption in the summer months and can either increase or decrease building energy use in the winter months, depending on the location of trees around the building. Estimates of tree effects on energy use are based on field measurements of tree distance and direction to space conditioned residential buildings (McPherson and Simpson, 1999). In Ireland the planting of trees for their shelter effect, as shelter belts or hedges from south westerly winds is widely practiced.

Data for examining building energy effects from the trees in Mountshannon was not collected during this survey due to time constraints.

Figure 10: Benefits provided by urban trees, (David Nowak)



1. Cooler air temperatures
2. Socio-economic/aesthetic
3. Air quality improvement
4. Water quality improvement
5. Greenhouse gas reduction
6. UV radiation reduction
7. Wildlife habitat
8. Noise reduction
9. Products
10. O_2 Production

Even severely decayed trees can continue
to provide Ecosystem Services.

10. Structural and Functional values

Urban forests have a structural value based on the trees themselves (e.g. the cost of having to replace an existing tree with a similar tree); they also have functional values (either positive or negative) based on the functions these trees perform.

The structural value of an urban forest tends to increase with rising numbers and size of healthy trees (Nowak *et al*, 2002a). Annual functional values also tend to increase with increased number and size of healthy trees. Through proper management, urban forest values can be increased; however, the values and benefits also can decrease as the amount of healthy tree cover declines.

Structural value in the United Kingdom is calculated using the same procedure as the U.S. (Nowak *et al*, 2002a). Base costs and species values are derived from the Royal Institute of Chartered Surveyors and Barchams and Hillers catalogues and applied to all places in the UK. This approach was also used here (see Figure 11).

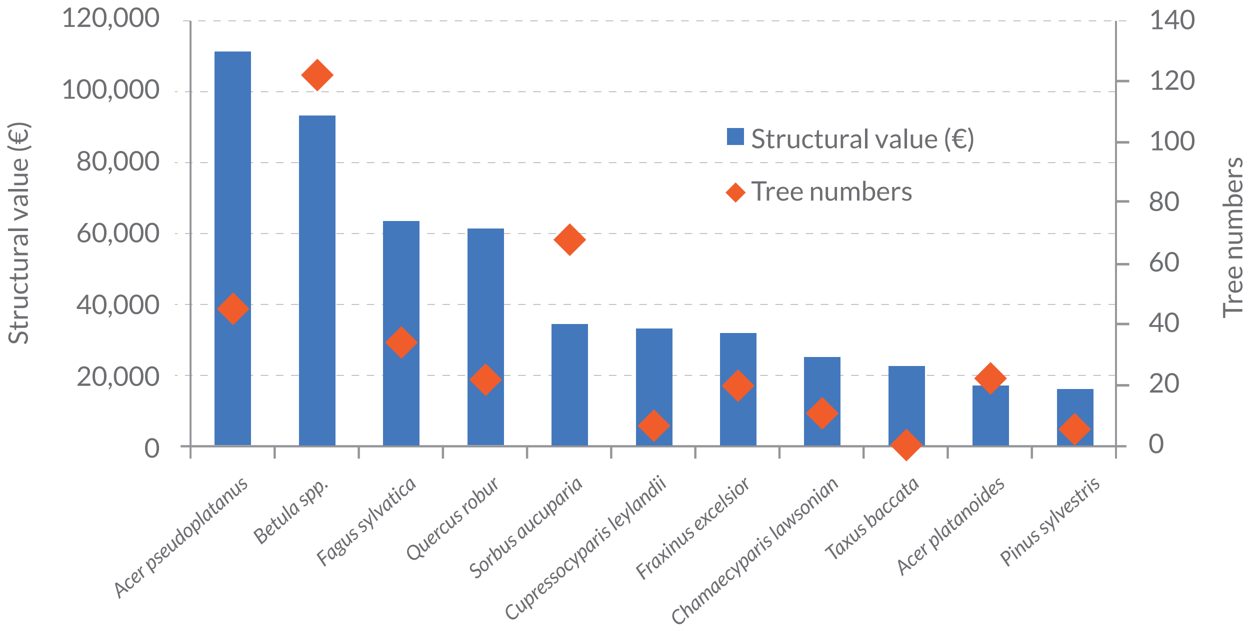
The urban trees surveyed in Mountshannon have the following structural values:

Structural value:	**€544,000**
Carbon storage:	**€2,223**

Urban trees in Mountshannon have the following annual functional values:

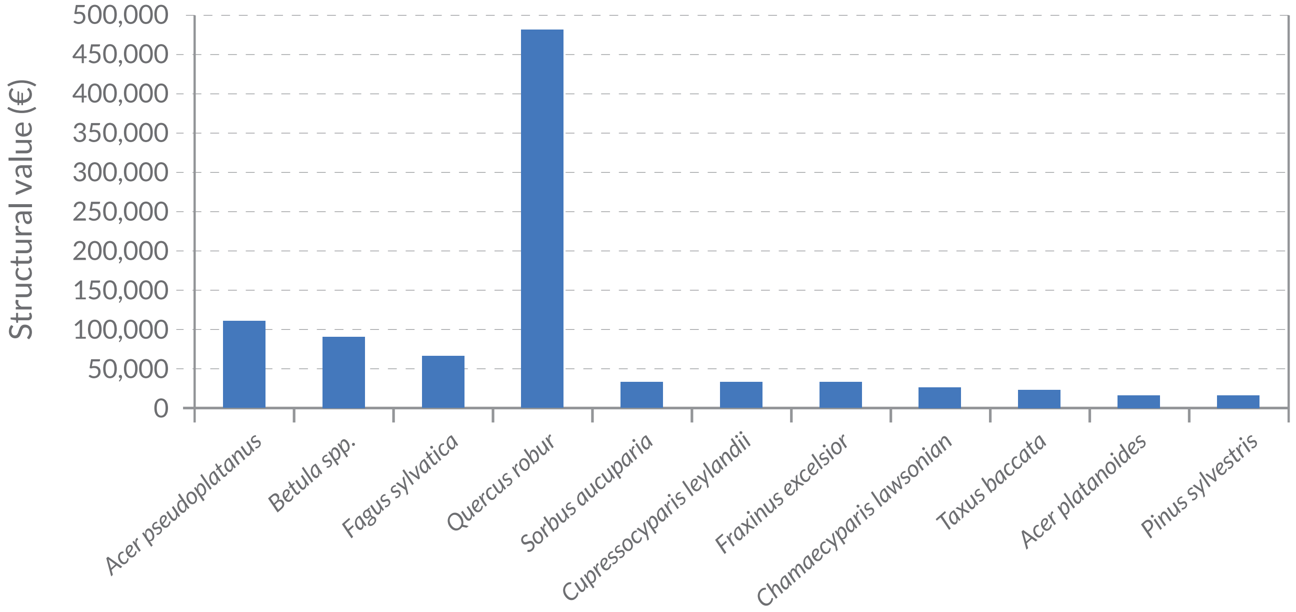
Carbon sequestration:	**€76**
Pollution removal:	**€480**
Avoided runoff:	**€134**
Oxygen production:	**€331**

Figure 11: Tree species of greatest structural value in Mountshannon.



The total structural value per species is largely a function of the numbers of trees per species and their size. Therefore, given the most frequent and largest trees in Mountshannon are the sycamore and birch trees (*Acer pseudoplatanus* and *Betula spp.*) consequently they have the largest replacement value. If the Bé Binn champion oak (see section 12) is included, the range of values is altered significantly (see Figure 12).

Figure 12: Structural values of the highest value tree species in Mountshannon (including the Bé Binn champion oak).



11. Potential Impacts of Pests and Diseases on Trees in Mountshannon

The annual cost of imported insect pests in the United States is $2 billion to local governments and $1.5 billion in lost property values to home owners.

http://www.caryinstitute.org/sites/default/files/public/images/project/lovett/cost_per_sector_VF.jpg

By the first quarter of 2016, some €2.6 million has been paid out to remove Chalara-infected ash in Ireland and over 733 hectares of infected and associated ash plantations have been cleared and replanted or are in the process of being replanted with alternative species.

https://www.agriculture.gov.ie/forestservice/ashdiebackchalara/#background

Various insects and diseases can infest urban forests, potentially killing trees and reducing the health, structural value and sustainability of the urban forest. As pests tend to have differing tree hosts, the potential damage or risk of each pest will differ among cities. Ireland, as an island located on the western seaboard of Europe has up until recently been relatively disease and pest free. But membership of the then EEC and the continued expansion of the EU, freedom of trade within the EU and wider afield in conjunction with climate change has led to some recent introductions (O'Hanlon, 2015; McCracken, 2013).

One of the most recent introductions is the disease of ash commonly known as *Chalara fraxinea* but now referred to as *Hymenoscyphus fraxineus*. It may be fortunate that ash (4.8%) is a relatively minor species in Mountshannon. There is also some concern that the Emerald Ash borer *Agrilus planipennis fairmaire*, which has decimated the ash populations with which it has come into contact in the USA, is slowly making its way across Europe having been found in Ash outside Moscow.

Another emerging bacterial disease that could affect a range of species such as oak and common plane (*Platanus occidentali*) is caused by *Xylella fastidiosa spp multiplex*. It has caused havoc with the olive trees of the Mediterranean, but there are fears now that as it mutates it may make its way to the UK and Ireland via the importation of infected plants. More importantly is the fungus which causes sudden oak death (*Phytophthora ramorum*) disease, which is present in Ireland. Likewise, the oak processsionary moth (*Thaumetopoea processionea*) is a pest that not only defoliates Oaks, but its fine hair can cause skin and lung irritation to those with whom it comes in contact. To date it has not been found in Ireland, but is present in the UK.

Red band needle blight (*Dothistroma septosporum*) of conifer is of particular concern to the native[6] Scots pine (*Pinus sylvestris*) which represent 1.4% of the Mountshannon population as it causes defoliation and weakens the tree which can lead to its eventual death. It is believed increased incidence for this disease may be due to increased rainfall in spring and summer in Ireland coupled with warmer weather in spring. With climate change such conditions maybe become more prevalent.

---

[6] Many Scots pine populations died out in Ireland and a subsequent reinstatement from Scottish stock has meant that the species has been regarded as being non-native. However, a number of refugial populations have been identified using genetic analysis in western areas of the country which returns the species to its native status again.

Bleeding canker (*Pseudomonas syringae pv. aesculi*) of Horse chestnut has increased dramatically since 2000 in the UK. Even the Lawson cypress hedging of many adjoining private households can become infected by Phytophthora lateralis and the more widely-planted beech tree (*Fagus sylvatica*) can become infected by P. kernoviae. In addition the possible arrival of Asian longhorn beetle (*Anoplophora glabripennis*) is of on-going concern as it would devastate a range of species.

Simply put, native home-grown tree species should be planted first, exotics home-grown second! Imported timber products with bark on them should not be bought e.g. firewood. As the climate changes, increased species diversity and age diversity will offer resilience in the tree population against such pest and disease threats.

You're never too young to start measuring Ecosystem Services

Bé Binn, Ireland’s largest recorded Oak tree

12. Ireland’s Largest Recorded Oak Tree

Ireland’s largest recorded oak tree (*Quercus robur*), known locally as “Bé Binn”[7], is growing on private property in the village of Mountshannon. This champion tree stands 32 m tall, with a girth of 9.3 m and a diameter of 3 m (at 1.3 m above ground). During this project, with the help of Treemetrics Ltd., a 3D scan of the tree was carried out (see Figure 13). Analysis of this scan involved fitting a Grosenbaugh formula to estimate the volume of the multiple stems. The resulting 46.97 m^3 of stem volume was converted (using a density factor from Knaggs and Xenopoulou, 2004) to a weight of 35.2 tonnes of dry biomass. Using a carbon fraction for stem timber of 48.4% (Balboa-Murias *et al*, , 2006) the carbon stored in the tree stem alone (based purely on the conservative estimate of stem timber from the 3D scan analysis) was estimated to be 17.06 tonnes.

In addition, using results from the i-Tree Eco analysis, the amount of carbon sequestered annually was low (10 kg/yr) compared to the most common tree species in the village, birch, where a typical specimen sequestered 15.6 kg/yr (Table 3). This is expected since young vigorous trees will sequester more carbon than a tree at maturity. Likewise, a similar situation arises when it comes to O_2 production with a typical birch producing 41.6 kg/yr, out-performing the oak’s 26.7 kg/yr.

Figure 13 : The Bé Binn oak within Mountshannon village is the largest recorded of the species in Ireland.

---

[7] There is an oak tree named Brian Boru in nearby Tuamgraney. Bé Binn was a daughter of Brian Boru.

In assessing the amenity value of such a remarkable tree, use was made of the CAVAT (Capital Asset Valuation for Amenity Trees) valuation model (Neilan, 2010) developed by the London Tree Officers Association. This model makes a basic valuation based on the tree dimensions and then takes into consideration such factors as population density (that benefits from the presence of the tree), accessibility to the tree by the public, the tree's functional value and life expectancy. Such adjustments are made to reflect the degree of benefit that the tree provides to the owners and local population.
The value of the Bé Binn oak was consequently estimated to be worth €422,209 to the local community. This valuation was designed to reflect realistically the contribution of the tree to public welfare through tangible and intangible benefits.

Table 3: Comparison between ecosystem services provided by a typical birch and the large champion oak in Mountshannon.

Attribute	*Betula*	*Quercus Robur*
DBH (cm)	31.3	296
Height (m)	12.2	31.6
Crown projection (m^2)	44.2	907.9
Leaf area (m^2)	278.4	2,615.7
Leaf biomass (kg)	17.4	174.1
Leaf area index	6.3	2.9
Basal area (m^2)	0.1	6.9
Avoided runoff (m^3)	1.1	9.9
Oxygen production (kg/yr)	41.6	26.7
Carbon storage (kg)	239.4	17,064.2
Gross carbon sequestration (kg/yr)	15.6	10

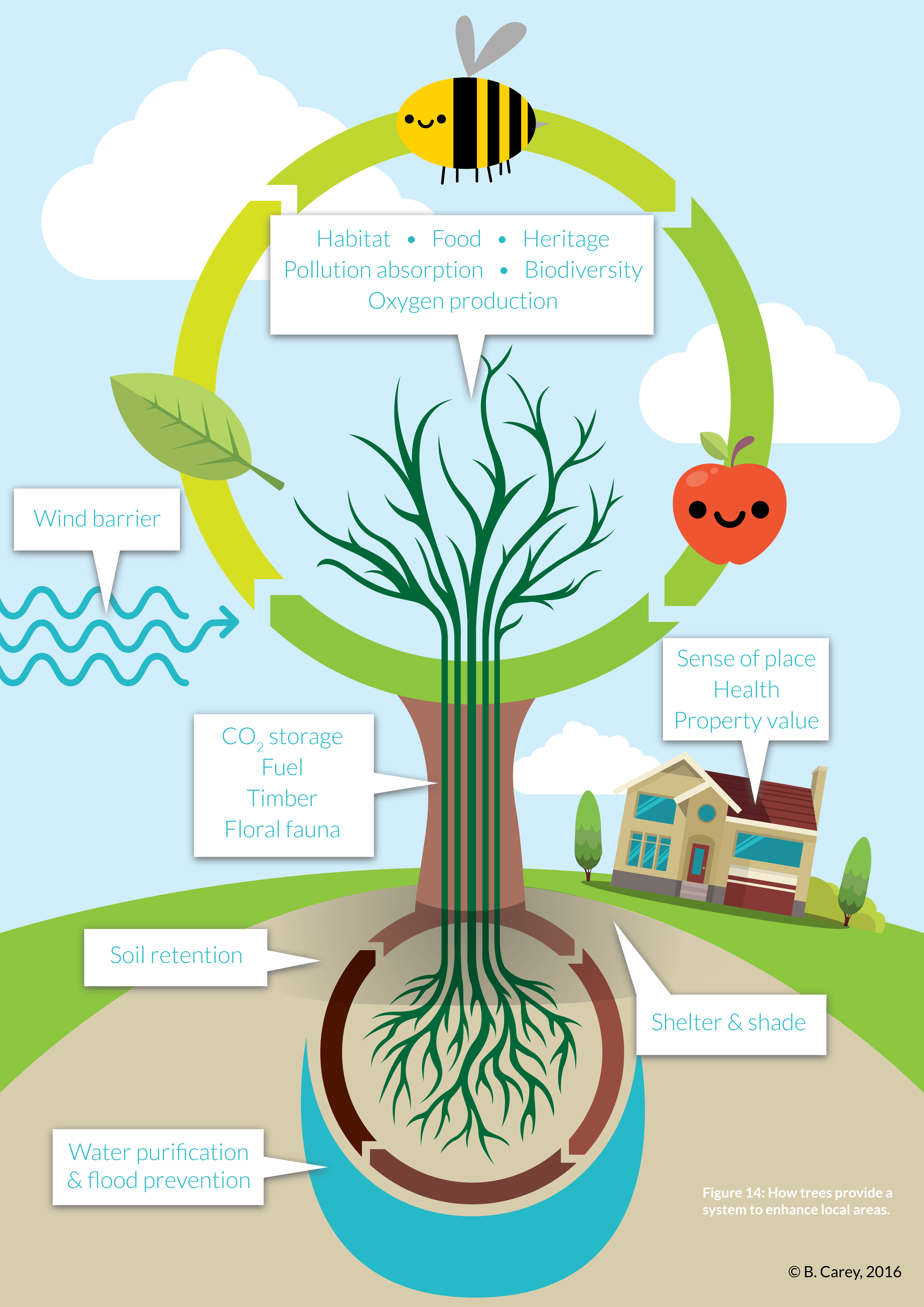


Figure 14: How trees provide a system to enhance local areas.

© B. Carey, 2016

13. Conclusions

The results presented in this report help to demonstrate both the range and scale of benefits provided by a section of Mountshannon's urban forest. How this information is used will be crucial in securing these benefits for decades to come but will support the planning of a specific strategic management and planting programme for Mountshannon. The diverse nature of the tree population, in terms of age structure as well as species richness, should infer a degree of resistance against the threat of storm or pest/disease damage. However, the survey does identify specific areas within the village where dense pockets of pioneer species (e.g. birch and rowan species) might benefit from a plan for a mixed planting of more successional (and longer lived) species to increase the diversity and improve resistance as well as to increase the natural capital investment in the village.

Too often the main interactions between people and trees occur when they become a problem due to age (size) or disease and associated decay. Thus, they can be neglected until they come to the attention of managers due to the danger they pose. However, by placing a value on the wide range of services the trees provide to the community, management of the trees can better be justified, enabling more trees to be planted and the community to become more sustainable. The detailed inventory of trees (and their associated attributes) provided by this project will provide a firm basis on which to base future planning decisions. Hopefully, future surveys will increase the area covered and involve more community groups to increase the degree of local ownership and appreciation of the urban forest.

This evaluation of the natural capital literally growing in the streets and parks around the Mountshannon Village should be used locally to support the sustainable management of the urban and suburban environments, complement existing initiatives such as Tidy Towns and to build a greater appreciation among the general public of the value of the trees that surround them.

14. References

Abdollahi, K.K.; Ning, Z.H.; Appeaning, A., eds. 2000. Global climate change and the urban forest. Baton Rouge, LA: GCRCC and Franklin Press. 77 p.

Animal and Plant Health Inspection Service. 2010. Plant Health – Asian longhorned beetle. Washington, DC: U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Balboa-Murias, M.A., Rojo, A., Alvarez, J.G. and Merino, A. 2006. Carbon and nutrient stocks in mature Quercus robur L. stands in NW Spain. Annals of Forest Science 63 (5): 557-565.

Baldocchi, D. 1988. A multi-layer model for estimating sulfur dioxide deposition to a deciduous oak forest canopy. Atmospheric Environment. 22: 869-884.

Baldocchi, D.D.; Hicks, B.B.; Camara, P. 1987. A canopy stomatal resistance model for gaseous deposition to vegetated surfaces. Atmospheric Environment. 21: 91-101.

Bidwell, R.G.S.; Fraser, D.E. 1972. Carbon monoxide uptake and metabolism by leaves. Canadian Journal of Botany. 50: 1435-1439.

British Columbia Ministry of Water, Land, and Air Protection. 2005. Residential wood burning emissions in British Columbia. British Columbia.

Broecker, W.S. 1970. Man's oxygen reserve. Science 168(3939): 1537-1538.

Bureau of Transportation Statistics. 2010. Estimated National Average Vehicle Emissions Rates per Vehicle by Vehicle Type using Gasoline and Diesel. Washington, DC: Burea of Transportation Statistics, U.S. Department of Transportation. Table 4-43.

Carbon Dioxide Information Analysis Center. 2010. CO_2 Emissions (metric tons per capita). Washington, DC: The World Bank.

Cardelino, C.A.; Chameides, W.L. 1990. Natural hydrocarbons, urbanization, and urban ozone. Journal of Geophysical Research. 95(D9): 13,971-13,979.

Ciesla, W. M.; Kruse, J. J. 2009. Large Aspen Tortrix. Forest Insect & Disease Leaflet 139. Washington, DC: U. S. Department of Agriculture, Forest Service. 8 p.

Clarke, S. R.; Nowak, J.T. 2009. Southern Pine Beetle. Forest Insect & Disease Leaflet 49. Washington, DC: U.S. Department of Agriculture, Forest Service. 8 p.

Cranshaw, W.; Tisserat, N. 2009. Walnut twig beetle and the thousand cankers disease of black walnut. Pest Alert. Ft. Collins, CO: Colorado State University.

Seybold, S.; Haugen, D.; Graves, A. 2010. Thousand Cankers Disease. Pest Alert. NA-PR-02-10. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry.

Susan Downing Day and Sarah B. Dickinson. 2008. Managing Stormwater for Urban Sustainability Using Trees and Structural Soils.

DeMars, C.J., Jr.; Roettgering, B.H. 1982. Western Pine Beetle. Forest Insect & Disease Leaflet 1. Washington, DC: U.S. Department of Agriculture, Forest Service. 8 p.

Diller, J.D. 1965. Chestnut Blight. Forest Pest Leaflet 94. Washington, DC: U.S. Department of Agriculture, Forest Service. 7 p.

Eastern Forest Environmental Threat Assessment Center. Dutch Elm Disease. http://threatsummary.forestthreats.org/threats/threatSummaryViewer.cfm?threatID=43

Energy Information Administration. 1994. Energy Use and Carbon Emissions: Non-OECD Countries. Washington, DC: Energy Information Administration, U.S. Department of Energy.

Energy Information Administration. 2013. CE2.1 Fuel consumption totals and averages, U.S. homes. Washington, DC: Energy Information Administration, U.S. Department of Energy.

Energy Information Administration. 2014. CE5.2 Household wood consumption. Washington, DC: Energy Information Administration, U.S. Department of Energy.

Federal Highway Administration. 2013. Highway Statistics 2011.Washington, DC: Federal Highway Administration, U.S. Department of Transportation. Table VM-1.

Fellin, D.G.; Dewey, J.E. 1986. Western Spruce Budworm. Forest Insect & Disease Leaflet 53. Washington, DC: U.S. Department of Agriculture, Forest Service. 10 p.

Ferrell, G.T. 1986. Fir Engraver. Forest Insect & Disease Leaflet 13. Washington, DC: U. S. Department of Agriculture, Forest Service. 8 p.

Georgia Forestry Commission. 2009. Biomass Energy Conversion for Electricity and Pellets Worksheet. Dry Branch, GA: Georgia Forestry Commission.

Heirigs, P.L.; Delaney, S.S.; Dulla, R.G. 2004. Evaluation of MOBILE Models: MOBILE6.1 (PM), MOBILE6.2 (Toxics), and MOBILE6/CNG. Sacramento, CA: National Cooperative Highway Research Program, Transportation Research Board.

Gibson, K.; Kegley, S.; Bentz, B. 2009. Mountain Pine Beetle. Forest Insect & Disease Leaflet 2. Washington, DC: U. S. Department of Agriculture, Forest Service. 12 p.

Haugen, D.A.; Hoebeke, R.E. 2005. Sirex woodwasp - Sirex noctilio F. (Hymenoptera: Siricidae). Pest Alert. NA-PR-07-05. Newtown Square, PA: Department of Agriculture, Forest Service, Northern Area State and Private Forestry.

Hessburg, P.F.; Goheen, D.J.; Bega, R.V. 1995. Black Stain Root Disease of Conifers. Forest Insect & Disease Leaflet 145. Washington, DC: U.S. Department of Agriculture, Forest Service.

Hessburg, P.F.; Goheen, D.J.; Bega, R.V. 1995. Black Stain Root Disease of Conifers. Forest Insect & Disease Leaflet 145. Washington, DC: U.S. Department of Agriculture, Forest Service.

Hirabayashi, S. 2012. i-Tree Eco Precipitation Interception Model Descriptions, Available at http://www.itreetools.org/eco/resources/iTree_Eco_Precipitation_Interception_Model_Descriptions_V1_2.pdf

Hirabayashi, S.; Kroll, C.; Nowak, D. 2011. Component-based development and sensitivity analyses of an air pollutant dry deposition model. Environmental Modeling and Software. 26(6): 804-816.

Hirabayashi, S.; Kroll, C.; Nowak, D. 2012. i-Tree Eco Dry Deposition Model Descriptions V 1.0

Holsten, E.H.; Thier, R.W.; Munson, A.S.; Gibson, K.E. 1999. The Spruce Beetle. Forest Insect & Disease Leaflet 127. Washington, DC: U.S. Department of Agriculture, Forest Service. 12 p.

Houston, D.R.; O'Brien, J.T. 1983. Beech Bark Disease. Forest Insect & Disease Leaflet 75. Washington, DC: U. S. Department of Agriculture, Forest Service. 8 p.

Interagency Working Group on Social Cost of Carbon, United States Government. 2013. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

Knaggs, G. and Xenopoulou, S. 2004. Guide to Irish Hardwoods. COFORD, Dublin.

Kruse, J.; Ambourn, A.; Zogas, K. 2007. Aspen Leaf Miner. Forest Health Protection leaflet. R10-PR-14. Juneau, AK: U. S. Department of Agriculture, Forest Service, Alaska Region.

Kucera, D.R.; Orr, P.W. 1981. Spruce Budworm in the Eastern United States. Forest Pest Leaflet 160. Washington, DC: U.S. Department of Agriculture, Forest Service. 8 p.

Layton, M. 2004. 2005 Electricity Environmental Performance Report: Electricity Generation and Air Emissions. CA: California Energy Commission.

Leonardo Academy. 2011. Leonardo Academy's Guide to Calculating Emissions Including Emission Factors and Energy Prices. Madison, WI: Leonardo Academy Inc.

Liebhold, A. 2010 draft. Personal communication on the geographic distribution of forest pest species.

Liu and Harris. 2008. Effects of shelterbelt trees on reducing heating-energy consumption of office buildings in Scotland. Applied Energy 85 (2-3), 115-127

McCracken, A. 2013. Current and emerging threats to Ireland's trees from diseases and pests. Irish Forestry 70: 36-60.

McPherson, E.G.; Simpson, J.R. 1999. Carbon dioxide reduction through urban forestry: guidelines for professional and volunteer tree planters. Gen. Tech. Rep. PSW-171. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 237 p.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Crowell, A.M.N.; Xiao, Q. 2010. Northern California coast community tree guide: benefits, costs, and strategic planting. PSW-GTR-228. Gen. Tech. Rep. PSW-GTR-228. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Vargas, K.E.; Maco, S.E.; Xiao, Q. 2006a. Coastal Plain Community Tree Guide: Benefits, Costs, and Strategic Planting PSW-GTR-201. USDA Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Vargas, K.E.; Xiao, Q. 2007. Northeast community tree guide: benefits, costs, and strategic planting.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Gardner, S.L.; Cozad, S.K.; Xiao, Q. 2006b. Midwest Community Tree Guide: Benefits, Costs and Strategic Planting PSW-GTR-199. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Gardner, S.L.; Vargas, K.E.; Xiao, Q. 2006c. Piedmont Community Tree Guide: Benefits, Costs, and Strategic Planting PSW-GTR 200. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Xiao Q.; Mulrean, E. 2004. Desert Southwest Community Tree Guide: Benefits, Costs and Strategic Planting. Phoenix, AZ: Arizona Community Tree Council, Inc. 81 :81.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Scott, K.I.; Xiao, Q. 2000. Tree Guidelines for Coastal Southern California Communities. Local Government Commission, Sacramento, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q. 1999. Tree Guidelines for San Joaquin Valley Communities. Local Government Commission, Sacramento, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q.; Maco, S.E.; Hoefer, P.J. 2003. Northern Mountain and Prairie Community Tree Guide: Benefits, Costs and Strategic Planting. Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q.; Pittenger, D.R.; Hodel, D.R. 2001. Tree Guidelines for Inland Empire Communities. Local Government Commission, Sacramento, CA.

Mielke, M.E.; Daughtrey, M.L. How to Identify and Control Dogwood Anthracnose. NA-GR-18. Broomall, PA: U. S. Department of Agriculture, Forest Service, Northeastern Area and Private Forestry.

Neilan, C. 2010. CAVAT (Capital Asset Value for Amenity Trees). Full method, User's guide. London Tree Officers Association.

Nowak, D.J. 1994. Atmospheric carbon dioxide reduction by Chicago's urban forest. In: McPherson, E.G.; Nowak, D.J.; Rowntree, R.A., eds. Chicago's urban forest ecosystem: results of the Chicago Urban Forest Climate Project. Gen. Tech. Rep. NE-186. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 83-94.

Nowak, D.J. 2000. The interactions between urban forests and global climate change. In: Abdollahi, K.K.; Ning, Z.H.; Appeaning, A., eds. Global Climate Change and the Urban Forest. Baton Rouge, LA: GCRCC and Franklin Press: 31-44.

Nowak, D.J., Hirabayashi, S., Bodine, A., Greenfield, E. 2014. Tree and forest effects on air quality and human health in the United States. Environmental Pollution. 193:119-129.

Nowak, D.J., Hirabayashi, S., Bodine, A., Hoehn, R. 2013. Modelled PM2.5 removal by trees in ten U.S. cities and associated health effects. Environmental Pollution. 178: 395-402.

Nowak, D.J.; Civerolo, K.L.; Rao, S.T.; Sistla, S.; Luley, C.J.; Crane, D.E. 2000. A modeling study of the impact of urban trees on ozone. Atmospheric Environment. 34: 1601-1613.

Nowak, D.J.; Crane, D.E.; Dwyer, J.F. 2002a. Compensatory value of urban trees in the United States. Journal of Arboriculture. 28(4): 194 - 199.

Nowak, D.J.; Crane, D.E.; Stevens, J.C.; Hoehn, R.E. 2005. The urban forest effects (UFORE) model: field data collection manual. V1b. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station, 34 p. http://www.fs.fed.us/ne/syracuse/Tools/downloads/UFORE_Manual.pdf

Nowak, D.J.; Crane, D.E.; Stevens, J.C.; Ibarra, M. 2002b. Brooklyn's urban forest. Gen. Tech. Rep. NE-290. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 107 p.

Nowak, D.J.; Hoehn, R.; Crane, D. 2007. Oxygen production by urban trees in the United States. Arboriculture & Urban Forestry. 33(3):220-226.

Nowak, D.J.; Hoehn, R.E.; Crane, D.E.; Stevens, J.C.; Walton, J.T; Bond, J. 2008. A ground-based method of assessing urban forest structure and ecosystem services. Arboriculture and Urban Forestry. 34(6): 347-358.

Nowak, D.J.; Stevens, J.C.; Sisinni, S.M.; Luley, C.J. 2002c. Effects of urban tree management and species selection on atmospheric carbon dioxide. Journal of Arboriculture. 28(3): 113-122.

O'Hanlon, R. 2015. Two further threats to Ireland's trees from non-native invasive Phytophthoras. Irish Forestry 72: 87-100.

Rogers, K., Sacre, K., Goodenough, J. and Doick, K. 2015. Valuing London's Urban Forest. Results of the London i-Tree Eco project. Treeconomics. Available at http://www.forestry.gov.uk/pdf/LONDONI-TREEECOREPORT151202.pdf/$FILE/LONDONI-TREEECOREPORT151202.pdf

Sands, R. 2005. Forestry in a Global Context. CABI.

Schmitz, R.F.; Gibson, K.E. 1996. Douglas-fir Beetle. Forest Insect & Disease Leaflet 5. R1-96-87. Washington, DC: U.S. Department of Agriculture, Forest Service. 8 p.

Smith, S.L.; Borys, R.R.; Shea, P.J. 2009. Jeffrey Pine Beetle. Forest Insect & Disease Leaflet 11. Washington, DC: U. S. Department of Agriculture, Forest Service. 8 p.

Society of American Foresters. 2011. Gold Spotted Oak Borer Hitches Ride in Firewood, Kills California Oaks.

Forestry Source 16(10): 20.

U.S. Environmental Protection Agency. 2010. Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards. Washington, DC: U.S. Environmental Protection Agency. EPA-420-R-10-012a

U.S. Forest Service. 2005. Hemlock Woolly Adelgid. Pest Alert. NA-PR-09-05. Newtown Square, PA: U. S. Department of Agriculture, Forest Service, Northern Area State and Private Forestry.

U.S. Forest Service. 2011. Laurel Wilt. Atlanta, GA: U. S. Department of Agriculture, Forest Service, Forest Health Protection, Southern Region.

University of California. 2014. Polphagous Shot Hole Borer. Sacramento, CA: University of California, Division of Agriculture and Natural Resources.

van Essen, H.; Schroten, A.; Otten, M.; Sutter, D.; Schreyer, C.; Zandonella, R.; Maibach, M.; Doll, C. 2011. External Costs of Transport in Europe. Netherlands: CE Delft. 161 p.

Vargas, K.E.; McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Xiao, Q. 2007a. Interior West Tree Guide.

Vargas, K.E.; McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Xiao, Q. 2007b. Temperate Interior West Community Tree Guide: Benefits, Costs, and Strategic Planting.

Vargas, K.E.; McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Xiao, Q. 2008. Tropical community tree guide: benefits, costs, and strategic planting. PSW-GTR-216. Gen. Tech. Rep. PSW-GTR-216. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Worrall, J.J. 2007. Chestnut Blight. Forest and Shade Tree Pathology. http://www.forestpathology.org/dis_chestnut.html

Zinke, P.J. 1967. Forest interception studies in the United States. In: Sopper, W.E.; Lull, H.W., eds. Forest Hydrology. Oxford, UK: Pergamon Press: 137-161.

Appendix 1: i-Tree Eco Model and Field Measurements

i-Tree Eco is designed to use standardised field data from randomly located plots and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects (Nowak and Crane 2000), including:

- Urban forest structure (e.g. species composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percentage air quality improvement throughout a year.
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power sources.
- Value of the structural aspect of the forest, as well as the value for air pollution removal and carbon storage and sequestration.
- Potential impact of infestations by pests, such as Asian long-horned beetle, emerald ash borer, gypsy moth, and Dutch elm disease.

In the field 0.04 hectare plots were randomly distributed. Typically, all field data are collected during the growth season (with leaves present) to properly assess tree canopies. Within each plot, typical data collection (actual data collection may vary depending upon the user) includes land use, ground and tree cover, individual tree attributes of species, stem diameter, height, crown width, crown canopy missing and dieback, and distance and direction to residential buildings (Nowak *et al*, 2005; Nowak *et al*, 2008).

During data collection, trees are identified to the most specific taxonomic classification possible. Trees that are not classified to the species level may be classified by genus (e.g. ash) or species groups (e.g. hardwood). In this report, tree species, genera, or species groups are collectively referred to as tree species.

Tree Characteristics:

Leaf area of trees was assessed using measurements of crown dimensions and percentage of crown canopy missing. In the event that these data variables were not collected, they are estimated by the model.

An analysis of invasive species is not available for studies outside of the United States. For the U.S., Invasive species are identified using an invasive species list for the state in which the urban forest is located. These lists are not exhaustive and they cover invasive species of varying degrees of invasiveness and distribution. In instances where a state did not have an invasive species list, a list was created based on the lists of the adjacent states. Tree species that are identified as invasive by the state invasive species list are cross-referenced with native range data. This helps eliminate species that are on the state invasive species list, but are native to the study area.

Air Pollution Removal:

Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter less than 2.5 microns. Particulate matter less than 10 microns (PM10) is another significant air pollutant. Given that i-Tree Eco analyses particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health. Air pollution removal estimates are derived from calculated hourly tree-canopy resistances for ozone, and sulfur 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 and Fraser, 1972; Lovett, 1994) that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere (Zinke, 1967). Recent updates (2011) to air quality modeling are based on improved leaf area index simulations, weather and pollution processing and interpolation, and updated pollutant monetary values (Hirabayashi *et al*, 2011; Hirabayashi *et al*, 2012; Hirabayashi, 2011). Trees remove PM2.5 when particulate matter is deposited on leaf surfaces (Nowak *et al*, 2013). This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors. Generally, PM2.5 removal is positive with positive benefits. However, there are some cases when net removal is negative or resuspended particles lead to increased pollution concentrations and negative values. During some months (e.g. with no rain), trees resuspend more particles than they remove. Resuspension can also lead to increased overall PM2.5 concentrations if the boundary layer conditions are lower during net resuspension periods than during net removal periods. Since the pollution removal value is based on the change in pollution concentration, it is possible to have situations when trees remove PM2.5 but increase concentrations and thus have negative values during periods of positive overall removal. These events are not common, but can happen. For reports in the United States, default air pollution removal value is calculated based on local incidence of adverse health effects and national median externality costs. The number of adverse health effects and associated economic value is calculated for ozone, sulfur dioxide, nitrogen dioxide, and particulate matter less than 2.5 microns using data from the U.S. Environmental Protection Agency's Environmental Benefits Mapping and Analysis Program (BenMAP) (Nowak *et al*, 2014). The model uses a damage-function approach that is based on the local change in pollution concentration and population. National median externality costs were used to calculate the value of carbon monoxide removal (Murray *et al*, 1994). For international reports, user-defined local pollution values are used. For international reports that do not have local values, estimates are based on either European median externality values (van Essen *et al*, 2011) or BenMAP regression equations (Nowak *et al*, 2014) that incorporate user-defined population estimates. Values are then converted to local currency with user-defined exchange rates.

For this analysis, pollution removal value is calculated based on the prices of €1,417 per metric ton carbon monoxide, €9,982 per metric ton of ozone, €1,460 per metric ton of nitrogen dioxide, €2,542 per metric ton of sulfur dioxide, €87,102 per metric ton of particulate matter less than 2.5 microns.

Carbon Storage and Sequestration:

Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation. To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations (Nowak, 1994). 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.Carbon sequestration is the net removal of carbon dioxide from the atmosphere by plants. 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.Carbon storage and carbon sequestration values are based on estimated or customised local carbon values. For international reports that do not have local values, estimates are based on the carbon value for the United States (Interagency Working Group on Social Cost of Carbon 2013) and converted to local currency with user-defined exchange rates.

For this analysis, carbon storage and carbon sequestration values are calculated based on a conservative value of €5 per tonne CO_2.

Oxygen Production:

The amount of oxygen produced is estimated from carbon sequestration based on atomic weights: net O_2 release (kg/yr) = net C sequestration (kg/yr) × 32/12. To estimate the net carbon sequestration rate, the amount of carbon sequestered as a result of tree growth is reduced by the amount lost resulting from tree mortality. Thus, net carbon sequestration and net annual oxygen production of the urban forest account for decomposition (Nowak *et al*, 2007). For valuation purposes, the cost of industrial O_2 supply was used (€2.32/m^3).

Avoided Runoff:

Annual avoided surface runoff is calculated based on rainfall interception by vegetation, specifically the difference between annual runoff with and without vegetation. Although tree leaves, branches, and bark may intercept precipitation and thus mitigate surface runoff, only the precipitation intercepted by leaves is accounted for in this analysis. The value of avoided runoff is based on estimated or user-defined local values. For international reports that do not have local values, the national average value for the United States is utilised and converted to local currency with user-defined exchange rates. The U.S. value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series (McPherson *et al*, 1999; 2000; 2001; 2002; 2003; 2004; 2006a; 2006b; 2006c; 2007; 2010; Peper *et al*, 1999; 2000; Vargas *et al*, 2007a; 2007b; 2008).

Building Energy Use:

If appropriate field data were collected, seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature (McPherson and Simpson, 1999) using distance and direction of trees from residential structures, tree height and tree condition data. To calculate the monetary value of energy savings, local or custom prices per MWH or MBTU would be utilised. However, there wasn't sufficient scope within the present project to carry out this analysis.

Structural Values:

Structural value is the value of a tree based on the physical resource itself (e.g. the cost of having to replace a tree with a similar tree). Structural values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition, and location information (Nowak *et al*, 2002a; 2002b). Structural value may not be included for international projects if there is insufficient local data to complete the valuation procedures. Potential pest risk is based on pest range maps and the known pest host species that are likely to experience

Potential Pest Impacts:

The complete potential pest risk analysis is not available for studies outside of the United States. The number of trees at risk to the pests analysed is reported, though the list of pests is based on known insects and disease in the United States. This was updated for Ireland from a recent publication (McCracken, 2013; O'Hanlon, 2014)

For the U.S., potential pest risk is based on pest range maps and the known pest host species that are likely to experience mortality. Pest range maps for 2012 from the Forest Health Technology Enterprise Team (FHTET) (Forest Health Technology Enterprise Team 2014) were used to determine the proximity of each pest to the county in which the urban forest is located. For the county, it was established whether the insect/disease occurs within the county, is within 250 miles of the county edge, is between 250 and 750 miles away, or is greater than 750 miles away. FHTET did not have pest range maps for Dutch elm disease and chestnut blight. The range of these pests was based on known occurrence and the host range, respectively (Eastern Forest Environmental Threat Assessment Center; Worrall 2007).

Relative Tree Effects:

The relative value of tree benefits reported in Appendix II is calculated to show what carbon storage and sequestration, and air pollutant removal equate to in amounts of municipal carbon emissions, passenger automobile emissions, and house emissions. Municipal carbon emissions are based on 2010 U.S. per capita carbon emissions (Carbon Dioxide Information Analysis Center 2010). Per capita emissions were multiplied by city population to estimate total city carbon emissions. Light duty vehicle emission rates (g/mi) for CO, NOx, VOCs, PM10, SO_2 for 2010 (Bureau of Transportation Statistics 2010; Heirigs *et al*, 2004), PM2.5 for 2011-2015 (California Air Resources Board 2013), and CO2 for 2011 (U.S. Environmental Protection Agency 2010) were multiplied by average miles driven per vehicle in 2011 (Federal Highway Administration 2013) to determine average emissions per vehicle. Household emissions are based on average electricity kWh usage, natural gas Btu usage, fuel oil Btu usage, kerosene Btu usage, LPG Btu usage, and wood Btu usage per household in 2009 (Energy Information Administration 2013; Energy Information Administration 2014).

- CO_2, SO_2, and NOx power plant emission per KWh are from Leonardo Academy 2011. CO emission per kWh assumes 1/3 of one percent of C emissions is CO based on Energy Information Administration 1994. PM10 emission per kWh from Layton 2004.
- CO_2, NOx, SO_2, and CO emission per Btu for natural gas, propane and butane (average used to represent LPG), Fuel #4 and #6 (average used to represent fuel oil and kerosene) from Leonardo Academy 2011.
- CO_2 emissions per Btu of wood from Energy Information Administration 2014.
- CO, NOx and SOx emission per Btu based on total emissions and wood burning (tons) from British Columbia Ministry 2005; Georgia Forestry Commission 2009.

Appendix 2: Relative community benefits from trees

The urban forest in Mountshannon provides benefits that include carbon storage and sequestration, and air pollutant removal. To estimate the relative value of these benefits, tree benefits were compared to estimates of average municipal carbon emissions, average passenger automobile emissions, and average household emissions. See Appendix I for methodology.

Carbon storage is equivalent to:

- Amount of carbon emitted in Mountshannon in 66 days;
- Annual carbon (C) emissions from 90 cars;
- Annual C emissions from 37 single-family houses.

Nitrogen dioxide removal is equivalent to:

- Annual nitrogen dioxide emissions from 4 cars;
- Annual nitrogen dioxide emissions from 2 single-family houses.

Sulphur dioxide removal is equivalent to:

- Annual sulphur dioxide emissions from 35 cars.

Appendix 3: Tree species list

There is an impressive diversity of species growing in the public areas of Mountshannon.

Table 4: List of tree species and their frequency and contribution to leaf area from the inventory of urban trees in Mountshannon. Species with an asterisk are native to Ireland.

Species scientific name	Common name	Number of trees	Percent of population	Leaf area (m^2)
**Betula spp.*	Birch species	124	30.4	13,600
Acer pseudoplatanus L.	Sycamore	45	10.8	10,100
**Sorbus spp.*	Rowan and whitebeam	35	16	5,600
Fagus sylvatica L.	Beech	22	8.4	5,100
Quercus robur L.	Pedunculate oak	67	5.3	4,500
**Fraxinus excelsior L.*	Ash	11	4.8	4,400
Acer platanoides L.	Norway maple	7	5.3	4,100
Chamaecyparis lawsoniana (A.Murray bis) Parl.	Lawson cypress	20	2.6	3,800
X Cuprocyparis leylandii (A.B. Jacson & Dallimore) Farjon	Leyland cypress	22	1.7	2,800
**Ilex aquifolium L.*	Holly	6	5	1,200
**Pinus sylvestris L.*	Scots pine	6	1.4	1,200
Aesculus hippocastanum L.	Horse chestnut	1	1.4	1,100
*“*Taxus baccata var. fastigiata"*	Irish yew	2	0.5	1,000
Platanus x acerifolia	London plane	3	0.2	600
Abies grandis (D.Don) Lindl.	Grand fir	3	0.7	500
Populus nigra L.	Black poplar	3	0.7	500
**Alnus spp.*	Alder	3	1.2	600
Malus spp.	Crabapple	2	0.7	300
**Prunus avium L.*	Wild cherry	1	1	300
Pinus nigra nigra J.F. Arnold	Black pine	3	0.7	200
Populus tremula L.	Aspen	4	0.5	200
Carpinus betulus L.	Hornbeam	21	0.2	200
Eucalyptus gunnii Hook.f.	Cider gum	4	0.2	100
**Crataegus monogyna Jacq.*	Hawthorn	1	0.2	0
Total		**418**	**99.9**	**62,000**

Appendix 4: Comparison with other Urban Forests

A commonly asked question is, "How does this city/town compare to others?" Although comparison among cities should be made with caution as there are many attributes of a city that affect urban forest structure and functions, summary data are provided from other cities analyzed using the i-Tree Eco model.

Table 5: Comparison of urban forest attributes for other cities.

City	% Tree cover	Number of trees	Carbon storage (tonnes)	Carbon sequestration (tonnes/yr)	Pollution removal (tonnes/yr)
Toronto, Canada	20	10,200,000	1,100,100	46,700	1,430
Calgary, Canada	7.2	11,889,000	404,000	19,400	296
Atlanta, US	36.8	9,415,000	1,220,000	42,100	1,508
London, UK	14	8,421,000	2,367,000	77,200	2,241
Toronto, Canada	20.5	7,542,000	900,000	36,600	1,100
New York, US	21	5,212,000	1,226,000	38,400	1,521
Baltimore, US	21	2,627,000	541,000	14,600	390
Philadelphia, US	15.7	2,113,000	481,000	14,600	523
Glasgow, UK	15	2,000,000	183,000	9,000	283
Washington, US	28.6	1,928,000	474,000	14,600	379
Barcelona, Spain	25.2	1,419,823	113,437	5,422	305
Boston, US	22.3	1,183,000	289,000	9,500	258
Woodbridge, US	29.5	986,000	145,000	5,000	191
Minneapolis, US	26.5	979,000	227,000	8,100	277
Syracuse, US	23.1	876,000	157,000	4,900	99
Torbay, UK	11.8	818,000	98,100	3,310	50
Morgantown, US	35.9	661,000	85,000	2,700	60
Edinburgh, UK	17	600,000	145,611	4,721	100
Moorestown, US	28	583,000	106,000	3,400	107
Wrexham, UK	17	364,000	66,000	1,300	60
Jersey City, US	11.5	136,000	19,000	800	37

A similar analyses of 10,000 trees in the city centre of Dublin (study area of 14.4 km^2) found that tree canopy covered 6% of the study area, total carbon stored equalled 1,920 metric tonnes, and total carbon sequestration equalled 30 tonnes/year (Ningal, 2012).

Source: Tine Ningal, University College Dublin, School of Geography, Planning and Environmental Policy, 2012, http://logmytree.blogspot.ie/2012/10/inventory-of-dublins-urban-trees.html

Appendix 5: General Recommendations for Air Quality Improvement

Urban vegetation can directly and indirectly affect local and regional air quality by altering the urban atmosphere environment. Four main ways that urban trees affect air quality are:

- Temperature reduction and other microclimate effects;
- Removal of air pollutants;
- Emission of volatile organic compounds (VOC) and tree maintenance emissions;
- Energy effects on buildings.

The cumulative and interactive effects of trees on climate, pollution removal, and VOC and power plant emissions determine the impact of trees on air pollution. Cumulative studies involving urban tree impacts on ozone have revealed that increased urban canopy cover, particularly with low VOC emitting species, leads to reduced ozone concentrations in cities. Local urban management decisions can also help improve air quality.

Table 6: Urban forest management strategies to help improve air quality.

Strategy	Result
Increase the number of healthy trees	Increase pollution removal
Sustain existing tree cover	Maintain pollution removal levels
Maximize use of low VOC-emitting trees	Reduces ozone and carbon monoxide formation
Sustain large, healthy trees	Large trees have greatest per-tree effects
Use long-lived trees	Reduce long-term pollutant emissions from planting and removal
Use low maintenance trees	Reduce pollutants emissions from maintenance activities
Reduce fossil fuel use in maintaining vegetation	Reduce pollutant emissions
Plant trees in energy conserving locations	Reduce pollutant emissions from power plants
Plant trees to shade parked cars	Reduce vehicular VOC emissions
Supply ample water to vegetation	Enhance pollution removal and temperature reduction
Plant trees in polluted or heavily populated areas	Maximizes tree air quality benefits
Avoid pollutant-sensitive species	Improve tree health
Utilize evergreen trees for particulate matter	Year-round removal of particles

Appendix 6: Curio - Making i-Tree user friendly

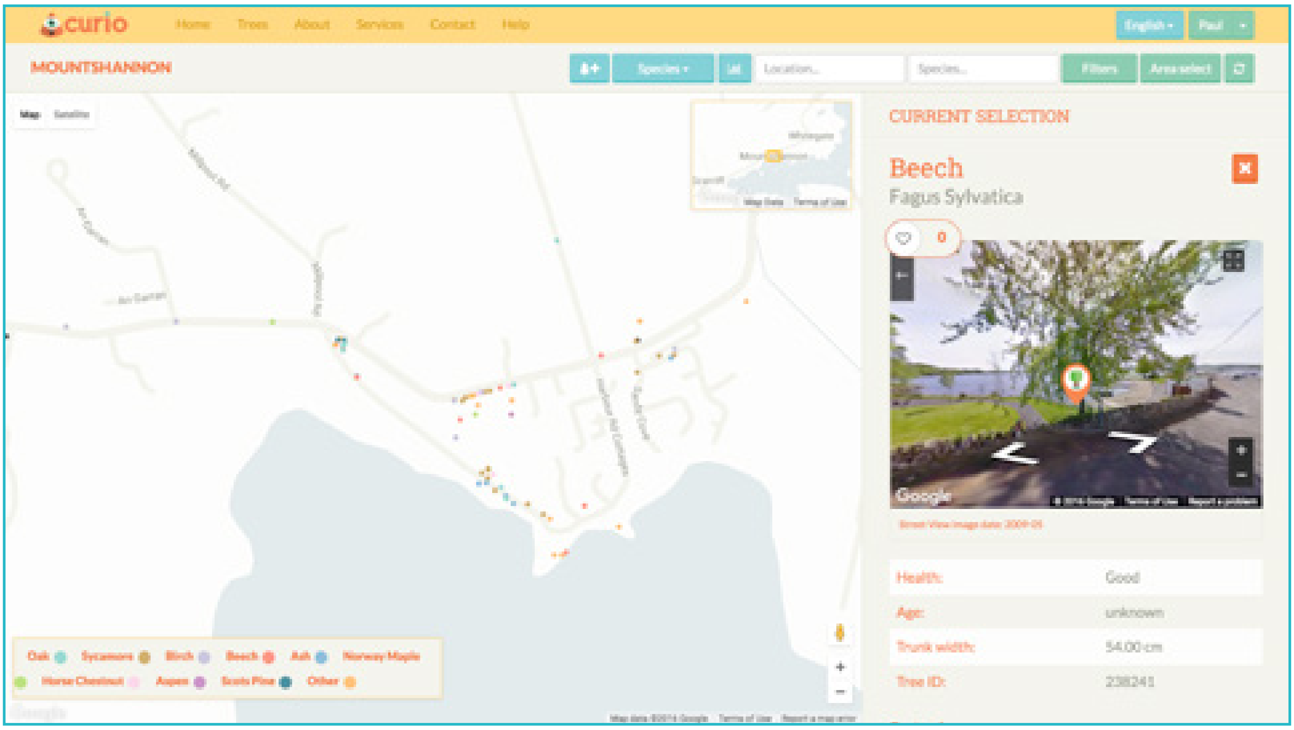
Curio is a web-based tool that links communities and professionals with information about the trees in local areas. Through the principles of open data sharing, Curio makes it possible for users to view information for trees that are nearby or on the other side of the world. At a local level, this enables individuals and communities to share details and experiences about the trees in their midst. This improves the levels of awareness amongst communities of these important aesthetic, cultural and environmental features whilst also supplying additional data that can be used in research, planning and management at both local and higher levels. Such shared understanding is also significant in the creation of healthy and cohesive community spirit and sense of place.

Curio also integrates satellite-based canopy analysis to improve the ability of management organisations to fully quantify the extent of an area's tree canopy cover. This can be significant in monitoring changes in tree health, growth and mortality over wide areas.

Curio also integrates the US Department of Agriculture's i-Tree data models, which allows for the quantification of ecosystem service benefits of the trees in a given area. This information has proved hugely important in demonstrating the real value that trees bring to an area in terms of filtering air-pollution, mitigating against flooding risk, CO_2 sequestration, amongst others.

Curio is available for use at www.curio.xyz

Figure 15: An example of a screen-shot from Curio showing one of the street trees in Mountshannon. A list of attributes about each tree can be seen associated with a picture of the tree as well as its map-based location.



Health: Good
Age: unknown
Trunk width: 54.00 cm
Tree ID: 238243

Appendix 7: The Value of a Tree.

Of concern to all!

A tree is worth

$193,250

according to Professor T.M. Das of the University of Calcutta. A tree living for 50 years will generate $31,250 worth of oxygen, provide $62,000 worth of air pollution control, control soil erosion and increase soil fertility to the tune of $31,250, recycle $37,500 worth of water and provide a home for animals worth $31,250. This figure does not include the value of fruits, lumber or beauty derived from trees. Just another sensible reason to take care of our forests.

From Update Forestry
Michigan State University

THE VALUE OF A TREE

SAVE OUR MOTHER EARTH

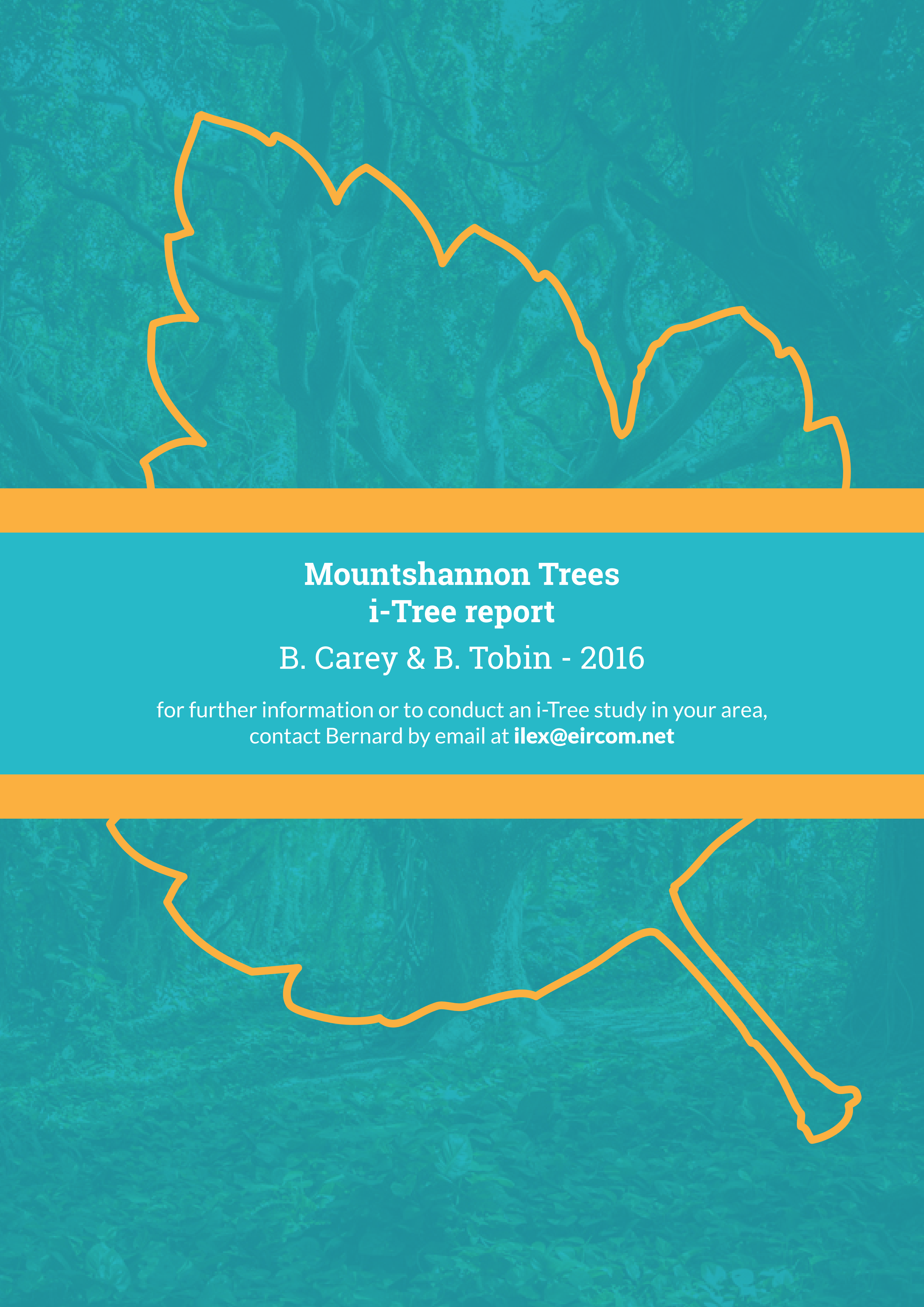
Appendix 8: Top Ten Benefits of Urban Trees

The top ten benefits of urban trees and other vegetation to the urban community, according to David J. Nowak of the US Forest Service in New York, are as follows (the order has been carefully considered and is presented in order of importance to the urban society):

1. Cooler air temperatures / positive energy effects for the built environment
2. Socio-economic / aesthetic amelioration of the city environment
3. Air quality improvement
4. Water quality improvement
5. Greenhouse gas reduction
6. UV radiation reduction
7. Wildlife habitat
8. Noise reduction
9. Products (e.g. timber, food, fiber, ethanol, craft products, jobs)
10. Oxygen production

Notes

Notes



Mountshannon Trees
i-Tree report

B. Carey & B. Tobin - 2016

for further information or to conduct an i-Tree study in your area,
contact Bernard by email at **ilex@eircom.net**