

i-Tree Eco as a tool to inform urban forestry in GB:

a literature review of its current
application within urban forestry policy
and management context

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Executive Summary

Report outline and aims

Urban forests provide multiple ecosystem services (ES) which benefit society. i-Tree Eco is a tool that has been applied worldwide to assess the state of urban forests and to estimate the economic value of several of the ES they provide. i-Tree Eco has been applied in 22 urban areas in Great Britain (GB; to Jan 2018).

A study was carried out to identify what impacts i-Tree Eco has had on awareness, policy and management of the urban forest. This study is split into four parts: Part 1 is *this* literature review. Part 2 is an impact evaluation of six case study projects from across England, Scotland and Wales based upon the opinions of stakeholders. Part 3 is composed of one-page impact summaries for eight individual i-Tree Eco projects, and Part 4 is an Executive Summary drawing together the impacts, challenges and recommendations from Parts 1 and 2. The reports for Parts 1 to 4 are available at: <https://www.forestry.gov.uk/fr/itree-evaluation>.

This literature review aimed to identify both potential and realised opportunities for impact from i-Tree Eco projects in GB, but also barriers to impact. The scope of possible impacts was informed by a review of international experiences with i-Tree Eco projects, current GB urban forestry policy and management. This review is split into five sections:

- 1 The first section introduces i-Tree Eco and urban forestry, including an examination of impacts from previous i-Tree Eco projects.
- 2 The second section explores the policies of the GB devolved nations and attitudes that drive how urban forests are viewed and managed. The role that i-Tree Eco could play in supporting more proactive and sustainable urban forest management is scoped.
- 3 The third section examines the 'policy cycle' and reviews if and how i-Tree Eco can affect policy development each stage of the cycle. This utilises reviews of valuation studies on policy change and examples of previous i-Tree Eco projects to assess opportunities for and challenges to success at each stage of the cycle.
- 4 The fourth section reports on an online literature review of the six i-Tree Eco case studies (investigated further in Part 2 of this project). This section examines each project's background and policy context and provides a preliminary evaluation of impact from changes in policy.
- 5 The conclusion brings together evidence from the previous sections to identify opportunities for and challenges to i-Tree Eco surveys achieving impact in GB.

GB urban forestry

Urban forestry as a field distinct from rural forestry emerged in GB in the 1990s and was associated with improved awareness of the benefits of urban trees. However, local authority (LA) management of urban forests has commonly been described as following a risk-mitigation approach which, constrained by austerity and dwindling budgets and little information on the state of trees, limited their ability to proactively plan for the

long-term sustainability of their urban forest resource. The latest in English, Scottish and Welsh policies recognise the importance of the urban trees. However, strategic management approaches remain largely absent, missing opportunities for urban forests to contribute to achieving other policy targets, such as those relating to public health.

[i-Tree Eco impacts - international review](#)

The application of i-Tree Eco projects globally is driven by a shift towards the ES approach to managing trees as a resource to benefit urban residents. i-Tree Eco is a tool which assesses the state and composition of urban forests, as well as value a set of ES they provide. Around the world, previous projects have had impacts that include raising awareness of the value of urban trees, informing policy creation and securing funding for the urban forest. However, challenges to achieving impact have also been reported from both previous i-Tree Eco projects as well as other ecosystem valuation studies. These barriers to generating impact include the lack of a high-level champion and poor communication limiting uptake of, and engagement with, the project's messages.

[i-Tree Eco impacts - case study review](#)

Six GB i-Tree Eco case studies were selected for an evaluation of what impact they may have had on urban forest management. The main drivers for the first i-Tree Eco projects were to raise the profile of the urban forest and - subsequently - to encourage better urban forest management across local authorities.

The preliminary (literature based) evaluation of the case study projects involved an online search for reports, policies, management plans associated with the i-Tree Eco project and its corresponding urban area. This review found considerable variation in the impacts achieved between the different case studies. Some projects have achieved demonstrable impacts for the urban forest through adoption of new woodland and tree strategies based on findings from i-Tree Eco projects. Others have seen findings utilised by a range of LA departments and have reported moving towards an ES approach to managing urban forests. However, some projects have seen limited or no uptake of findings into new policy, practise or investment in the urban forest.

Collectively, the i-Tree Eco projects have helped to raise awareness of the urban forest at local and national scales amongst different stakeholder groups including local authorities, the public and non-governmental organisations. The quantified benefits and economic valuations provided by the i-Tree Eco projects have provided a platform for these groups to make a stronger case for support for the urban forest.

Future i-Tree Eco projects can expand on the impacts realised so far by aiming to adapt the project design and dissemination of findings to meet their desired objectives, such as informing new policies. This can be facilitated by early identification of key objectives, early collaboration with other LA departments, and tailoring findings and messages to engage with different audiences including the public and NGOs can help secure broader impact from i-Tree Eco projects.

1. Introduction

1.1. Aims and context of this report

This literature review aimed to identify both potential and realised opportunities for impact from i-Tree Eco projects in GB, as well as identify potential barriers to impact and provide recommendations to overcome these barriers and achieve greater impact.

These opportunities for, barriers to and solutions for i-Tree Eco projects were identified from a review of ecosystem service (ES) valuation literature and previous reports from i-Tree Eco projects internationally and in GB. These are set in context with both international and national urban forestry policy to identify the drivers for i-Tree Eco projects and provide a base to assess impacts against. For GB i-Tree Eco projects this report focused on six case studies; Torbay and Sidmouth in England, Edinburgh and Glasgow in Scotland and Bridgend and Tawe catchment in Wales.

This report is Part 1 of 4 of a larger study evaluating the impact from i-Tree Eco surveys in GB. Part 2 reports on stakeholder interviews and an online questionnaire to provide an empirical evaluation of impact focusing on six selected case studies. Part 3 provides short one-page impact summaries for 8 i-Tree Eco projects, while Part 4, the Executive Summary, sums-up the main identified impacts achieved from i-Tree Eco projects, barriers to achieving impact, and recommendations for future projects.

All Parts of this study are accessible at: <https://www.forestry.gov.uk/fr/itree-evaluation>

2. Introduction to i-Tree Eco

2.1. Development and uptake

i-Tree Tools are a group of software programmes developed by the USDA Forest Service. i-Tree Eco is one tool which quantifies key metrics on the composition and structure of the urban forest. These include canopy cover, species composition and condition (crown dieback) of trees and the replacement costs of trees. This information is important to understand the current state of the forest and identify risks to its future sustainability. For instance, a tree stock reliant on only a few tree species is at greater risk from pest and diseases as this may wipe-out a large proportion of the entire tree population. Additionally this information allows emerging issues to be identified as well, such as resiliency to climate change, and whether an aging tree population will soon need replacing in the coming decades. i-Tree Eco surveys collect this data using plot sampling, which is then extrapolated up for the entire city and combined with local weather and pollution data to calculate city-scale ES provision.

These were defined in the Millennium Ecosystem Assessment (2005) as regulating, supporting, provisioning and cultural services. A summary of the range of services provided by the urban forest and those which are discussed in an i-Tree Eco survey are shown in Table 1. i-Tree Eco focuses on a set of three regulating ES provided by urban forests which are currently the most understood and straight-forward to value. These are carbon storage and sequestration, air pollution removal, and avoided water runoff. These services help to mitigate global climate change, improve urban air quality, and reduce water treatment costs and risks from flooding.

Since i-Tree Eco was introduced in 2006 it has been applied in over 100 countries across the world. Its widespread uptake in the USA can be attributed to general embracing of ES valuation and cost-benefit analysis (Seamans, 2013), as well as the rising acknowledgement of the vast services afforded by urban green space (Young, 2010). In GB, the first i-Tree Eco study conducted was in Torbay, England in 2011 and has now been utilised in over a dozen urban areas. It has been applied to large cities and small towns, single greenspaces (e.g. Luton; Fay et al., 2012) or specific place-types within urban areas, such as public open spaces only (Selmi et al., 2016). For instance, **i-Tree Eco has been used to estimate the impact of loss of ES caused by the removal of trees in gardens by homeowners** (Andrew & Slater, 2014). In GB surveys are often a partnership between the country's forestry body (Forestry Commission England, Forestry Commission Scotland or Natural Resource Wales (NRW), Treeconomics, and the local council. The survey work itself is either carried out by Arboricultural contractors, council staff (tree officers) or by i-Tree Eco trained volunteers, such as in London and Sidmouth i-Tree Eco projects.

Table 1. Ecosystem services and disservices produced by the urban forest and those estimated through i-Tree surveys. Services in parenthesis are only delivered in small quantities in urban environments. Ecosystem services are broken down into the four categories defined in the Millennium Ecosystem Assessment (2005), with the additional fifth column listing disservices, which are negative impacts urban trees can have (after Davies et al. 2017a).

Regulating	Provisioning	Cultural	Supporting (Intermediate)	Disservices
Air purification	Woodfuel	Health	Habitats for species / biodiversity	Decrease in air quality
Carbon storage and sequestration	(Biological / genetic resources)	Nature / landscape connections	(Soil formation)	Blocking of light / heat
Noise mitigation	(Food)	Social development/ connections	(Nutrient cycling)	Damage to infrastructure
Storm water regulation		Education/ learning	(Water cycling)	Fruit and leaf fall
Temperature regulation		(Economy)	(Oxygen production)	Fear (stimulation of)
(Disease / pest regulation)		Cultural significance		Allergies (stimulation of)
(Pollination / seed dispersal)				
(Soil protection)				
Colour Code:				
	Service is quantified and monetary value estimated.			
	Service is partially quantified (some aspects of service but not all) with monetary estimate. e.g. Health: value of respiratory illness avoidance calculated using data from air purification assessment, but other health benefits, e.g. supporting mental well-being, not estimated.			
	Service is discussed in report but not quantified/valued. e.g. Habitats for species/biodiversity: important habitat provisioning tree species listed but value specific to city not estimated.			
	Service is not assessed by i-Tree Eco survey or discussed in detail in report.			

2.2. Impacts of previous i-Tree Eco projects

Given the widespread and often high-profile use of i-Tree Eco projects over the past ten years, there has been surprisingly little review of impact arising from these studies. The central underlying rationale to undertaking an ecosystem valuation, using tools like i-Tree Eco, is that they facilitate and encourage greater understanding and prioritisation of often under-valued environmental resources. However, few studies of ecosystem valuation have monitored the impacts of projects, leading to a lack of review and assessment of how worthwhile these exercises are or have been, or how improvements could be made (Laurans et al., 2013). The review of impact from i-Tree Eco studies in GB undertaken in this project will help to address this gap.

The literature review carried out here revealed no published reviews of impact from any i-Tree Eco survey outside of GB. The lack of published reviews on the impact from i-Tree Eco projects is notable given its adoption in cities worldwide. However, it may be that many reviews have been conducted but are not publicly accessible. Despite the lack of dedicated review reports, impacts have been noted in other reports related to i-Tree and from more anecdotal sources.

North America had adopted i-Tree Eco most prolifically and has seen widespread use in many major cities such as Los Angeles, New York and Chicago. Reported benefits include such as **improving appreciation for urban trees** and support for urban forest programs (Soares et al., 2011), including **increasing tree budgets** (Escobedo, n.d.; Bieneman, n.d.; Wells, 2012). Further benefits have also been seen, such as **inspiring greater tree planting targets** (New York and Los Angeles million tree initiatives) and providing an evidence base to allow more specific targets to be set (Ordóñez & Duinker, 2013). i-Tree Eco studies have also **improved strategic management** through highlighting priority planting areas and species (McNeil, n.d.), such as helping to identify priority zones for planting to mitigate against air pollution hot spots in New York (Morani et al., 2011).

Oakville, Canada, was one of the early adopters of the i-Tree Eco model and is an example of a municipality who has embraced the i-Tree Eco model to inform ambitious management, research and engagement strategies. Oakville's first i-Tree Eco study, which took place in 2005, entitled 'Oakville's Urban Forest: Our Solution to Our Pollution' reported a total of 1.9 million trees in Oakville and provided residents annually \$2.1 million worth of benefits from ES. The baseline information about the town's urban forest allowed the town to identify risks which threatened the sustainability of the forest, including vulnerability to an invasive pest and the significant proportion of trees in private ownership (McNeil, n.d.). The town produced an Urban Forest Strategic Management Plan in 2008, a 200 page document containing 66 recommendations (Town of Oakville, 2008). These recommendations included establishing a series of 5-year management plans, tracking of progress using set

indicators at the end of each 5-year plan, and the hiring of an urban forest specialist to manage the tree inventory. The i-Tree Eco tool was described in the report as important in providing baseline information which critically allowed the effectiveness of the 2008 strategy to be assessed (Town of Oakville, 2008).

Since 2005 the town of Oakville has:

- implemented by-laws to protect trees on private land which has helped prevent loss of urban trees (Town of Oakville, 2016a),
- set action plans to tackle threats from pests and disease (Town of Oakville, 2016b),
- and planted over 160,000 trees (Town of Oakville, 2016b).

The 2015 i-Tree Eco survey reports tangible results from these actions, with an increase in 1.3 percentage-points of canopy cover and is now estimated to provide \$2.93 million in benefits annually (Oakville, 2016a). Oakville's Urban Forest Strategic Management Plan is now being revised with these new results and updated recommendations including improving urban forest resilience through reducing dominance of most common species, pre-emptive management to maximise tree life and maintaining an up-to-date inventory of Oakville's trees (Town of Oakville, 2016a; 2016b).

Other studies have assessed outcomes which may be linked to i-Tree Eco surveys. A review of opinion of American municipal foresters found a significant increase in the perceived importance of managing street trees for ES (Young, 2013). Overall, managing ecosystem benefits of urban trees was found to be roughly equal to more traditional motivations, such as beautification, risk management, street tree replacement and recreation (Young, 2013). This may be due to the statement of ecosystem values provided by i-Tree Eco, but it may also be linked to the general atmosphere in science and policy adopting a more ES approach and greater recognition of the importance of urban greenspace (Seamans, 2013).

In GB, there has been a single dedicated review of the impact of an i-Tree Eco study. This was carried out by for the Wrexham i-Tree Eco survey, which took place in 2013 (Jaluzot & Evison, 2016). Wrexham was the first i-Tree Eco project in Wales and generated significant amounts of media attention.

The key impacts from Wrexham i-Tree Eco survey were identified as first **improving understanding of the state of Wrexham's urban forest** and **raising awareness of its value, need for investment and relevancy to other departments**. The report raised the profile of urban forest with elected members, helping to drive a revision to the tree strategy and re-prioritise trees in other departments including housing, planning and public health. This also legitimised further investment into the urban forest, including retaining a tree officer post against the background of

shrinking Local Authority (LA) budgets. This raised profile of the urban forest has helped to influence policy through supporting increased specificity in regards to targets in the tree and woodland strategy. It also has been earmarked to inform wider strategies, such as supplementary guidance documents and within the new Public Service Boards. At a national scale it has also aided **the rationale for including urban forests as a major theme in the Woodland for Wales Action Plan** and the NRW Corporate Plan.

The key drivers of these outcomes of the Wrexham i-Tree Eco project were identified. The presence of a **high-level champion for the project was important** to act as a catalyst to raise interest in the report and translate interest into action in policy. The fact that the survey took place directly prior to a new Tree and Woodland strategy being produced was useful as it allowed results to be immediately referred and responded to in new policy. This **timing was also important** as the development of a new policy created an evidence need which i-Tree Eco helped to fill. **Widespread communication helped raise awareness** of the project, with one page infographic flyers sent out to 1,600 professional and community organisations.

A number of barriers were identified as limiting the potential impact of the i-Tree Eco project. These included organisational and communication challenges; high staff turnover meant there was a lack of continuity through the project, and some communication across local government departments was considered to be poor. Other aspects of communication of results could have been improved, including making greater comparisons to other i-Tree Eco results in GB and using different formats of communications, such as talks or workshops, to facilitate engagement and understanding in different target groups. Other aspects specific to the project design itself were identified as a weakness leading to unfulfilled potential impacts. This included the lack of spatial results which prevented strategic targeting of areas for planting.

In addition to this dedicated review in Wrexham, in GB there have been a small number of papers which indirectly report on i-Tree Eco impact as part of more general urban tree management reviews. An informal review of i-Tree Eco studies in GB took place as a workshop meeting in 2014. Here outcomes from Edinburgh i-Tree Eco survey was introduced, where it was seen to be **an important shift in thinking to managing urban trees for risk-limitation to value-enhancement** (Hambidge, 2014). The Trees and Woods in Scottish Towns study in Scotland (TWIST, van der Jagt & Lawrence, 2015) found the city with an i-Tree Eco study had found this useful in **bringing urban trees to the forefront of debate and providing values which contribute to the city's overarching sustainability vision**. A review of how Scottish cities are addressing the challenges of adapting to climate change found that while the role of urban trees has been stated in national policy, in the case of carbon sequestration there has been little uptake and application of this within city strategies and management practises (Moffat, 2015). However, the two cities who had

undertaken i-Tree Eco surveys, Edinburgh and Glasgow, had adopted the ecosystem-based approach to a greater degree than others. In a review of volunteer participation in the tree surveys for London's i-Tree Eco survey, O'Brien (2015) found involvement **improved volunteers' awareness of tree benefits** and **helped develop tree survey skills and knowledge**.

3. Urban Forest Policy

In this section the current state of urban forest policy is reviewed, with a focus on examining the main drivers behind current policies, and the implications of these policies for supporting sustainable forest management. The review commences with the international perspective, comparing North American and European examples, before moving on to look at policies within each of the devolved nations of GB.

3.1. International

Urban forestry as a concept and approach to managing trees in cities is a relatively recent development. While urban areas may always have contained trees, a planned and integrated approach to their management as a separate field to [rural] forestry and greenspace management only emerged in North America in the 1960s (Konijnendijk, 2003). Early definitions emphasised that the urban forest included all trees in urban areas, from single trees to woodlands, and further emphasised the role of managing urban trees to provide benefit to urban residents (Konijnendijk, 2004). Acceptance of urban forestry as a distinct field and recognition of the importance of its role to manage urban trees in US national and state governments helped grow the practise and research of urban forestry (Konijnendijk, 2004). This earlier interest in managing urban forests in the US, in comparison to other countries, led to adoption of national and state policies governing their existence. It was comparatively early that urban forests became a mandated work area for the US Forest Service, set in the 1978 Cooperative Forestry Act of Congress (Pincetl et al., 2012). Later, a national advisory board was adopted in the US in 1990 (NUCFAC, 2017) while a similar board in the UK was only established in 2014 (UFWACN, 2017a).

Concurrent to the expanding interest in urban forestry in the US, globally interest in sustainability and ES was growing. In particular in the past two decades there has been a shift towards ecosystem-based approaches and the first attempts to place a monetary worth on ES benefits. Early research work to value these services globally raised interest, debate and motivation to value ES (Balmford et al., 2002; Costanza et al., 1997). The ES approach was popularised globally through the Convention on Biological Diversity (CBD; 2000) and the following MEA (2005) global reviews and

classifications. At this time issues of increasing urbanisation and climate change were becoming forefront, raising concerns of the impacts on urban trees.

The combination of the strong basis for urban forestry in the US with an existing focus on community well-being outcomes combined with growing use of the ES concept led to widespread adoption of an ES approach to urban forest management in the US. While trees had long been recognised for being the ‘green-lungs’ of urban areas, research emphasised the multi-functionality of trees, providing environmental, social and economic values to local communities. **This took the focus of urban forestry away from maintenance and management, towards a strategic and integrative approach linking trees to their potential benefits to urban areas, and the opportunity and need to support them** (Konijnendijk, 2004). Research into these links between trees and benefits for urban areas which demonstrated their value for urban areas provided the rationale for local and national government to promote urban forestry (Seamans, 2013). This approach also helped to foster strong partnerships between science and policy (Konijnendijk, 2004). The governmental support spurred the USDA urban forestry field and creation of tools like i-Tree to turn research into a more widely accessible tool for urban forest valuation and management (Young, 2010). The support for evidence to inform policy was enshrined in US law with the addition of urban forests to the Forest Inventory and Analysis (FIA), a program of annual forest sampling (Farm Bill, 2013). The urban project will focus on 100 cities and utilise i-Tree Eco to assess trends.

Today the practise of urban forestry in the USA is “*maturing and becoming a rooted part of community infrastructure*” (Hauer & Peterson, 2016) along with a strong ES approach to management. A review of US municipal foresters found they manage urban forests for ES equally with more traditional services, such as beautification and recreation, as well as tree maintenance (Young, 2010). **The majority of US cities treat trees as part of their overall sustainability plans, maintain tree inventories and nearly half have set goals to increase canopy cover** (City Policy Associates, 2008). Tree ordinances are present in 90% of communities, covering topics including removal of trees, planting guidance, requirements for planting in new developments, (Hauer & Peterson, 2016). Over half of all communities were rated as having a systematic tree program in place (Hauer & Peterson, 2016). While attitudes may have changed towards a more ES based approach, this does not always mean sustainable practises will follow in every urban area (van Wassenaer et al., 2000). The US has recognised challenges to urban forest management including lack of resources, variable approaches to tree management and weak integration with other departments and planning with local surroundings (Nowak et al., 2010).

Similarly in Canada, there has been a strong uptake of the ES approach towards tree planting, as well as use of the i-Tree Eco model as exemplified in Oakville (see above). Here, a national urban forestry strategy produced by the Canadian Urban Forest Network has helped to spur adoption of local strategies at the municipal level

(Davies et al., 2017b). Further, provision of ES is ranked as the second most important consideration for urban forest management, following tree establishment (Fontaine & Larson, 2016).

Urban forestry did not migrate to Europe as a concept until the 1980s, where it took a further 10 years to take hold (Konijnendijk, 2004). However, the increasingly significant and diverse relationships between trees and human well-being being identified by researchers helped generate an interest in urban forestry. In comparison to the US however, there has been much less engagement from policy and planning sectors (Konijnendijk, 2004). Instead the greater influence has been from research organisations and NGOs promoting wider urban tree planting (Konijnendijk, 2004). While many US cities have utilised i-Tree Eco type analyses and adopted management plans (Hauer & Peterson, 2016) by the earlier 2000s relatively few have done so in Europe (Konijnendijk, 2004), though this may be recently improving. **In the UK, the number of i-Tree Eco projects has steadily increased since Torbay was completed in 2011 (Figure 1).** The UK was one of the earliest adopters of urban forestry approach similar to that developing in the US, it has not yet seen the same level of widespread acceptance and prominence in UK policy, particularly at local levels as seen in North America.

Urban forestry has also been growing in interest elsewhere in the world and experiencing similar challenges to implementation. In a review of council worker motivations for tree planting in Australia, Roy et al. (2017) found issues of health and safety, cost-effectiveness and location were the most important factors considered. This is despite both local policy and the council workers themselves stating the main reason to plant trees was for aesthetic values and ES. It therefore appears a common theme that limited resources for urban tree management is limiting capacity to work proactively towards a multifunctional and sustainable urban forest, despite the role of urban trees and woodlands in urban areas being stated in national policies.

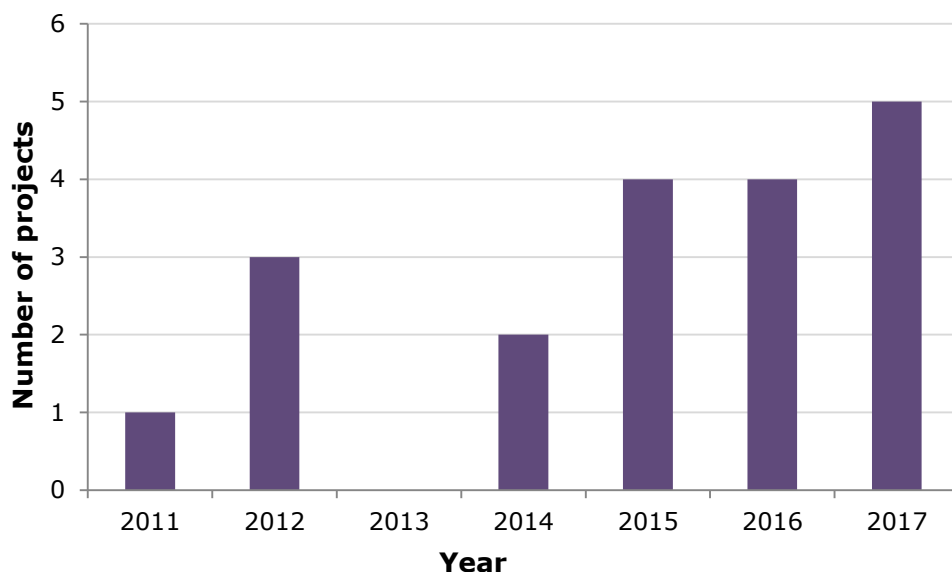


Figure 1. Number of i-Tree Eco projects in each year, since Torbay in 2011 (based upon year in which the project was reported).

3.2. National

In GB, forestry policy has been devolved to the three nations. Forestry policy within Wales is under the mandate of Natural Resource Wales (as of 2013), in England it falls to Forestry Commission England, and in Scotland it currently sits with Forestry Commission Scotland. However, while recent policies from these organisations place increasing emphasis on the social and environmental benefits of urban trees, governance of urban forests is far more complicated. **No single Government department holds overall responsibility for urban trees. Table 2 reviews the main departments whose policies relate to and influence the urban forest.** At the local authority level, responsibility for urban trees is often split between the planning department and a leisure, parks and greenspace team. The strongest protections for urban trees lies within the planning departments, which were provided the power to set Tree Preservation Orders (TPOs) to protect individual trees from development in the Town and Country Planning Act (1990). Planning policies also often state and encourage the use of trees as part of green infrastructure to provide benefits to urban areas and their residents. However, little is mandated with regard to more specific duties for conserving, expanding or managing urban forests. Powers to plant and remove trees are given to planning and transport agencies, and a duty of care applies to all landowners for visitors on their land. A mandate to plant trees lies within the forestry departments (Forestry Commission England, Forestry Commission Scotland, NRW), but whose ability to actively plant trees is focused on publicly owned land for woodland or through partnerships. The Forestry Commission also holds regulatory roles to protect trees, preventing loss of tree cover through tree felling licences, protecting trees from pest and disease outbreaks and further supports tree

planting and woodland management through grant schemes for private land owners. Other departments may have interests linked to trees, such as climate change (mitigation through carbon sequestration and climate change resilience), and environment (protection of biodiversity and veteran trees).

There is an implicit understanding that even policy set at national level will be delivered locally. However there is an acknowledged 'policy-implementation gap' between previous national level policies and local level action (Defra, 2008; Mell, 2014). Within individual LAs, urban tree responsibility can be set within different departments or spread across different groups (Lawrence & Dandy, 2012; Britt & Johnson, 2008) – for example, within Planning and Highways departments, as well as Parks/Green Infrastructure. These teams are first and foremost influenced by a duty of care to prevent injury to the public and damage to buildings. They are able to advise and adjudicate on decisions for TPOs and planning conditions to protect, preserve or plant trees. LAs have the power to plant trees (National Parks and Access to the Countryside Act 1949) but there are no laws governing tree planting or management. These teams can draw upon policies which support protection and tree planting from planning, forestry, climate change and/or environmental departments, there is no duty set in these policies for local authorities to do so. As such, **urban trees often are secondary to other local priorities** (Mell, 2014).

Table 2 reviews the legislation and policies in place for different tree typologies in different scenarios. The table first demonstrates the number of different departments which refer in some way to urban trees. The table further demonstrates the patchy nature of different department's interest and influence in the urban forest. The local authority holds the greatest power to protect and mandate tree planting, yet these powers are limited in use to within developments only. Once developments are completed, trees can remain protected under TPOs, but further planting or tree maintenance is absent. There is therefore limited ability to influence tree planting, protection or maintenance for trees in the majority of urban area not within a planning application. Forestry and environment departments have the greatest mandate for the protection and expansion of the urban forest, but their focus remains primarily on rural forests or protected sites and species. Individual urban trees which are not publicly owned are left with the largest gap, particularly those in gardens where, if not pre-emptively given a TPO or within a conservation area, can be freely removed.

Table 2. The policy and legislation of key government departments linked to planting, maintenance or removal of urban trees. The colours refer to the strength of the law or policy: **darker green** refers to a power to make change to the urban forest or a strong mandate; **lighter green** is a power which may only apply at certain times or to certain trees within the typology; **orange** indicates policies which do not require actions, but encourage and recommend actions. The tree typology on the left-hand side is not exhaustive and there is some overlap between groups, e.g. old trees can be in woodlands or streets, and street trees, amenity trees and woodland can be trees in development areas. In addition, tree owners also have a duty of care to prevent injury to persons or damage to buildings; without management of trees to show fulfilling duty, owners can be held liable for damages. (FC 2007; Dandy 2010; Woodland Trust, 2011; Lawrence and Dandy 2012.)

Tree typology	Planning	Forestry	Environment	Transport (Highways, railways)	Climate change
Publicly-owned trees					
Trees along streets & highways	Encourage planting	Felling licence for tree removal	Encourage planting of urban trees	Power to maintain trees on transport corridor	
Trees in parks and civic areas	Encourage planting	Exempt from felling licence	Encourage conservation and active management		
Woodlands & forests	Protection for ancient woodland	Planting duty; UK Forestry Standard	Encourage conservation and active management; some types of woodland protected; funding for planting and management		Encourage planting
	Encourage protection and planting	Felling licence for tree removal			
Old trees	Encourage protection	Felling licence may apply	protection encouraged, required if providing habitat for protected species (e.g. bat roost)		
Hedgerows	Protected from removal		Protected from removal; funding for planting and management		
Trees within planning applications	TPO, Conservation Areas & Planning conditions protection for veteran trees encouraged	If a major development Forestry department is a statutory consultee			
Privately owned trees					
Hedgerows	Protected from removal		Protected from removal; funding for planting and management		
Amenity, garden & orchard trees		Exempt from felling licence	Orchards protected; funding for planting parkland trees		
Woodlands and forests		Planting support (grants) and felling licenses	Some types of woodland protected; funding for planting and management		Encourage planting
Young trees or small trees		Exempt from felling licence			
Old trees		Felling licence may apply	Protection encouraged, required if providing habitat for protected species (e.g. bat roost)		
Trees within planning applications	TPO, Conservation Areas and Planning conditions protection for veteran trees encouraged	If a major development then the Forestry department is a statutory consultee			

As concepts, urban forestry and ES approaches have been widely recognised and adopted in the UK. For instance the UK was a leader in adopting the ecosystem valuation approach, following on from the MEA to produce a UK National Ecosystem Assessment (Watson et al., 2011). The UK was one of the first to address urban forestry as a distinct field to rural forestry and has a strong advocacy base from NGOs supporting the urban forestry agenda (Konijnendijk, 2004). These advocacy groups have helped to fill the gap between national government and local government by acting as 'conduits' of information on evidence and policies (Mell, 2014). Despite this, the adoption of practical policies at national and local levels remains in a reactive, maintenance approach to urban forestry rather than a proactive approach (Britt & Johnson, 2008; van der Jagt & Lawrence, 2015).

Urban forests came into contemporary interest through the 1980/90s through the influence of the American approach to urban forestry (Konijnendijk, 2004), ES approach, reviews of the state of management such as *Trees in Towns* (DoE, 1993) and city-wide forestry projects, such as the Forest of London project (Watson et al., 2011). There also grew an emphasis on planting native species for biodiversity benefits (Moffat, 2016). GB countries began to recognise the public benefits of urban trees, and initiate programmes to support their positive management and use by the public. For instance, England's Community Forests, Wales' Cydcoed woods, and Scotland's Woods in and around Towns (Lawrence & Dandy, 2012). However, since then there has been a reported decline in investment in urban greenspace and, by implication therefore, urban trees (Urban Greenspaces Taskforce, 2002).

Potential barriers to adoption of urban forestry policies and practices in GB include:

- **'Hesitant' expansion of foresters to urban realms** - Taken time to integrate the strong forestry knowledge with the more social dimensions of an urban forest system (Konijnendijk, 2004).
- **Poor communication between science and policy** - In the US the interest and investment in urban forest evidence, research and development of positive policies has been facilitated by strong state departments focused on developing and disseminating state of the art information. While GB is closer to mirroring this than other European countries, it has not reached the same level as the US (Konijnendijk, 2004). Moffat (2016) argues that poor communication of the value of urban forests in GB has hindered recognition of these benefits and motivation to invest in its protection and enhancement.
- **Budget limits** - While the benefits of urban forests have been promoted across government levels, and in particular higher level government has stated the importance in protecting and enhancing this resource, the ability of Local Authorities to achieve this is limited due to lack of resources and time (Britt & Johnson, 2008).

- **Split responsibilities for the urban forest** – The ‘ownership’ of the urban forest is complex within urban systems and different interested parties may have different opinions on the importance of trees in urban areas. In addition to competing interests, some aspects of urban forestry management may fall between different groups, for example, strategic planning for trees which leaves them instead mainly influenced by removal policies (Table 2; and Lawrence & Dandy, 2012).
- **Lack of knowledge on urban forest state, management and planning** - Due to the delayed uptake of the urban forestry in Europe, the knowledge and tool base to understand local systems to inform management planning is limited in comparison to that in the US (Konijnendijk, 2004). Many local authorities identify a lack of information and a need for improved datasets to support coordinated and long-term planning (e.g. Ipswich Borough Council, 2010; Wyre Forest Borough Council, 2009). The adoption of i-Tree Eco and other survey and valuation techniques, such as aerial imagery analysis and CAVAT valuation method, over the last two decades may be helping to alleviate this barrier.

3.2.1. England

In the 1990s interest was growing on the state of urban trees and their management, first through a review of English local authority management of trees (Trees in Towns; DoE, 1993) and then later through policy in ‘A new focus on England’s Woodlands’ (FC, 1998). This policy included urban woodlands in its remit, with explicit policies focusing on the benefit of using woodland to restore and regenerate brownfield sites, and create new woodlands on the urban fringe. The requirement for better understanding of the state of these systems was outlined in Planning Policy Guidance 17 (DCLG, 2002) which emphasised the need for local authorities to assess the quantity and quality of their green spaces, along with assessment of individual community needs from greenspace.

‘A new focus on England’s Woodlands’ (1998) was replaced in 2007 by ‘A Strategy for England’s Trees, Woods and Forests’ which set out a 50 year strategy (Defra, 2007a). The main focus was to ensure a sustainable, resilient resource, and to protect and enhance the biodiversity, well-being and economic values of forests. Urban forest creation targets were outlined along with rural area targets, a particular focus for urban forest creation was to aid adaption to climate change. The delivery plan (Defra, 2008) also promoted research into improving understanding of the values of trees in urban areas, with a focus on climate change, but also recognises the possible many other benefits of urban forests. The delivery plan noted that the benefits of trees are often outweighed by the cost and ‘nuisance’ of tree maintenance. At the same time, an UK-wide air-quality strategy showed the role of tree in air pollution mitigation (as well as creation) was not recognised; trees and vegetation were mentioned only in

that they may be vulnerable to air pollution and should be protected from high levels, rather than a potential mitigating factor of it (Defra, 2007b).

In 2008, 'Trees in Towns II' was published, highlighting a severe lack of strategic planning in urban tree management (Britt & Johnson, 2008). This report **highlighted the lack of knowledge that LAs had of their tree resource, and that trees were viewed primarily as a risk to be mitigated, rather than a source of benefit to be enhanced**. For example, only a fifth of Local Authorities had estimates of their total canopy cover and less than a third had information on the extent of woodland they managed. While some improvements had been made since the previous Trees in Towns review in 1993, such as an increase in the number of Tree and Woodland strategies in place (up to 70%), only 25% of these contained specific targets. A total of seven authorities had conducted cost-benefit analysis of their trees. The report itself largely decries the lack of information on urban forests as a risk to safety rather than to assess benefits from trees, but also advocates for proactive and strategic planning approach. The Trees in Towns II review revealed clear differences in urban forest management approach in England to the US. A review in the US at the same time found 70% of cities had full tree inventories and 32% had monetary values for their tree population (City Policy Associates, 2007).

Since Defra's 2007 England's Strategy for England's Trees, Woods and Forests, successive administrations have made small updates to England's urban forestry approach. Broader policies have also touched upon urban forests and their benefits without directly setting aims or targets. For instance the National Planning Policy Framework (NPPF; DCLG, 2012) outlines 13 target areas, 11 of which urban forestry benefits can contribute to. However, the NPPF has little mention of urban forests and its value, leaving the onus to linking these targets to urban forests to justify work and investment on them to the urban forest practitioners themselves.

In 2012, the incoming administration commissioned a review of forest policy in England through the Independent Panel on Forestry. The panel described the ES values of the urban forest and emphasised the need for better information and valuation of this resource (Independent Panel on Forestry, 2012) – **with Torbay's i-Tree Eco project mentioned as an exemplar of this approach**. The government's response to the Panel's recommendations suggested a target of pan-England forest cover increase to 12% (from 10%). The urban value of trees and the multiple benefits of woodlands were mentioned only briefly. The government's statement did reference i-Tree Eco as valuation tool as helping local authorities to find new funding avenues for urban forests (DEFRA, 2013), though the emphasis was on diversifying funding sources rather than acknowledging the urban system as a valuable resource.

The 25 Year Environment Plan recognises the opportunity for urban tree planting to provide benefits to society; it also restates the government's commitment to plant 1 million urban trees (HM Government, 2018). The Plan advocates a natural capital

accounting framework and encourages further work to understand the benefits of natural capital and the incorporation of natural capital into decision-making across government.

3.2.2. Scotland

In 2000 Scotland's view on forestry was outlined in the Scottish Forest Strategy (Scottish Government, 2000). This policy recognised the multiple benefits of woodlands spanning environmental, economic and social realms, but largely centred on the economic and community benefits of woodlands. The values of both rural and urban woodlands were discussed, with priority actions for urban woodlands to improve landscape quality and provide recreational activities. The social and community focus of woodlands established in the Scottish Forest Strategy continued into the Woods in and around Towns (WIAT) initiative adopted in 2005, with planting targets prioritised to low accessibility and high deprivation areas (FC Scotland, 2015). This strategy expanded on the previous policy to emphasise the need for greater integration of woodlands and trees into planning, and the need for better information on the state and quality of urban woodland resources.

The full scope of urban forest benefits were later recognised in the update of the Scottish Forestry Strategy in 2006 (Scottish Government, 2006). In particular ES values specific to urban trees were mentioned and benefits were expanded to include health and air pollution, which were assigned specific targets linked to the urban environment. For example, targets promoting the use of trees in mitigating air pollution and using woodland creation as a tool to address public health inequalities. The use of the urban forest in contributing to these targets was then underpinned by a number of guidance documents aimed at specific ES, such as 'Woods for Nature' (FC Scotland, 2008) and 'Woods for Health' (FC Scotland, 2009a). However these documents do not address all benefits of urban woodlands, even those identified in the Forestry Strategy. For example, while the 'Woods for Health' strategy lists mental and physical well-being benefits, as well as social and community enhancement, while the role of trees in removing air pollution, a target within the 2006 Forestry Strategy, is not mentioned. Later, 'Right Tree in the Right Place' advice document was published which provides guidance on producing forest and woodland strategies (FC Scotland, 2010) and lists a number of benefits and objectives which should be considered when planning for woodland creation, though the document's focus was predominantly rural.

A drive for increasing tree cover in Scotland was emphasised within the 'Scottish Government's Rationale for Woodland Expansion' (FC Scotland, 2009b). A focus towards the social and recreation benefits of woodlands continued through with the strategy identifying the growth in knowledge of social benefits of woodlands as a driving factor in setting new planting targets. This included an urban specific target of an additional 10,000 ha. WIAT remains a key policy programme for Scotland, now in

its 4th phase (2015-2020; FC Scotland, 2015). It continues to support the creation and improved management of urban woodlands to improve the quality of urban environments and provide opportunities and benefits for urban residents.

During these developments in Scottish forestry policy, planning policies were also being updated, which generally supported, but did not strengthen or engage with forestry targets. The National Planning Framework was updated in 2009, which laid out large-scale initiatives such as the Central Scottish Green Network (Scottish Government, 2009). The Scottish Planning Policy of 2014 encouraged woodland creation and tree planting as part of developments (Scottish Government, 2014). It also underlined the need for a good information base, stating that development plans should be informed on up-to-date audits of resources. The most recent relevant policy to be adopted was the Land-use Strategy for Scotland (Scottish Government, 2016). This policy triggers a review of Scottish Forestry Strategy. The Land-use Strategy is centred on the sustainable development principles to: support multiple benefit land-uses, improving accessibility and recreation opportunities, and improving understanding of benefits in daily life from land uses. This policy, more than its predecessors, utilised an ecosystem-service based approach, and quantifying these ES values using natural capital and ES mapping techniques.

3.2.3. Wales

The Woodlands for Wales strategy, enacted in 2001, was reviewed and updated in 2009 and remains the main document for Welsh forest management (Forestry Commission, 2001, 2009). A long-term strategy, Woodlands for Wales was accompanied by an action plan that covered electoral cycles – the latest having been published in 2016. The 2001 publication held five strategies, which took a broad view of the uses and benefits of woodlands including the health aspects of woodlands, economic values and environmental benefits. However there was a focus on designated sites rather than urban woodland and trees in general.

In the 2009 update to the Woodlands for Wales strategy, four themes were identified covering climate change, social value of woodlands, economic values, and environmental quality (Forestry Commission, 2009). Overall it takes a more holistic view of the values of urban forests than the previous document. The policy set out six outcomes to achieve, of which one is dedicated purely to urban woodlands, aiming for “*Urban woodlands and trees deliver a full range of benefits*”. This update was followed by a number of supporting documents ranging from health and well-being, to education, to water and soils. The current Woodlands for Wales Action Plan (2015-2020) includes as a priority action to “*Deliver increased and safeguard existing tree cover in towns and cities and support sustainable urban tree management*” (Welsh Government, 2015a).

In 2014, Wales achieved a world-first by producing a review of canopy cover in its urban areas (NRW, 2014). This was borne out of the pro-active approach encouraged

in the Woodlands for Wales strategy and aimed to help fill a previously identified gap (Britt & Johnson, 2008) in local authority knowledge on the urban forest resource. This provided statistics for canopy cover in each town and overall identified a decline in canopy cover in roughly a quarter of towns. This report gave Wales the most in-depth knowledge of the state of its urban forest out of the three countries, and was repeated in 2016 to enable changes over time to be tracked, at ward level.

A major change in Welsh policy has occurred in the past two years with the adoption of the 'Sustainable Development Acts'. These three separate acts; Well-being of Future Generations (2015), Planning Act (2015) and the Environment Act (2016), are aimed to be used in a collaborative and supporting form (Welsh Government, 2015b; 2015c; 2016). These Acts place a duty on Welsh public bodies to enshrine all their actions with sustainable development principles. An outcome of the Well-Being and Future Generations act is the creation of Public Service Boards (PSBs) which replace the previous Local Service Boards, and require input from key sectors of public bodies. As a requirement this will include a member of the NRW. Local authorities, Public Health boards, National Park Authorities and NRW are amongst over 40 public bodies that are under a wellbeing duty that requires them to carry out sustainable development including by:

- a. setting and publishing objectives ("well-being objectives") that are designed to maximise its contribution to achieving each of the well-being goals, and
- b. taking all reasonable steps (in exercising its functions) to meet those objectives.

The framework and duties put in place under the new legislation in Wales present an opportunity to state the benefits and opportunities for managing urban tree cover in such a way that the well-being of future generations is considered from the outset.

The Environment (Wales) Act 2016 puts a new, more integrated approach to managing natural resources in order to achieve long-term sustainability. The Act provides an iterative framework to ensure that managing our natural resources sustainably will be a core consideration in decision-making. These include:

- The State of Natural Resources Report – A report by Natural Resources Wales (NRW, 2016a) to assess the extent to which natural resources in Wales are being sustainably managed, and recommend a proactive approach to building resilience.
- A National Natural Resources Policy – the Welsh Government's national policy to sets out the priorities, risks and opportunities for managing our natural resources sustainably. The policy will take into account the findings of the State of Natural Resources report.
- Area statements – NRW will produce on a local basis statements that describe how the priorities, risks and opportunities identified in the National Policy will be addressed.

The Environment (Wales) Act is intended to support improved resilience of natural resources and their use by society for a range of benefits for the long term. In this way it supports the Wellbeing of Future Generations (Wales) Act 2015, which strengthens governance arrangements for improving the well-being of Wales to ensure that present needs are met without compromising the ability of future generations to meet their own needs.

4. i-Tree Eco in the Context of the 'Policy Cycle'

This section reviews the opportunities for i-Tree Eco studies to impact on the policy cycle. To explore this, a framework of the policy cycle as defined with Defra's Evidence Investment Strategy (Defra, 2011) has been applied. Evidence should underpin each stage of policy development. For each stage of the policy cycle, the potential role i-Tree Eco studies could contribute to inform policy and its delivery is reviewed. Potential barriers to i-Tree Eco projects performing these functions are also assessed. While providing evidence to guide policy and management is one common aim of i-Tree Eco projects, this is not to say that if no policy impact is realised that the project has had no impact at all. There may be many valuable impacts not represented directly in policy, such as awareness in non-policy related fields. Further it may take time for many changes in policy to occur, so while a direct impact in policy may not have occurred, significant changes may have occurred which could in future lead to policy changes.

A summary of the policy cycle and where i-Tree Eco projects can support decision-making is provided in Figure 1, with each step of the cycle reviewed in more depth below.

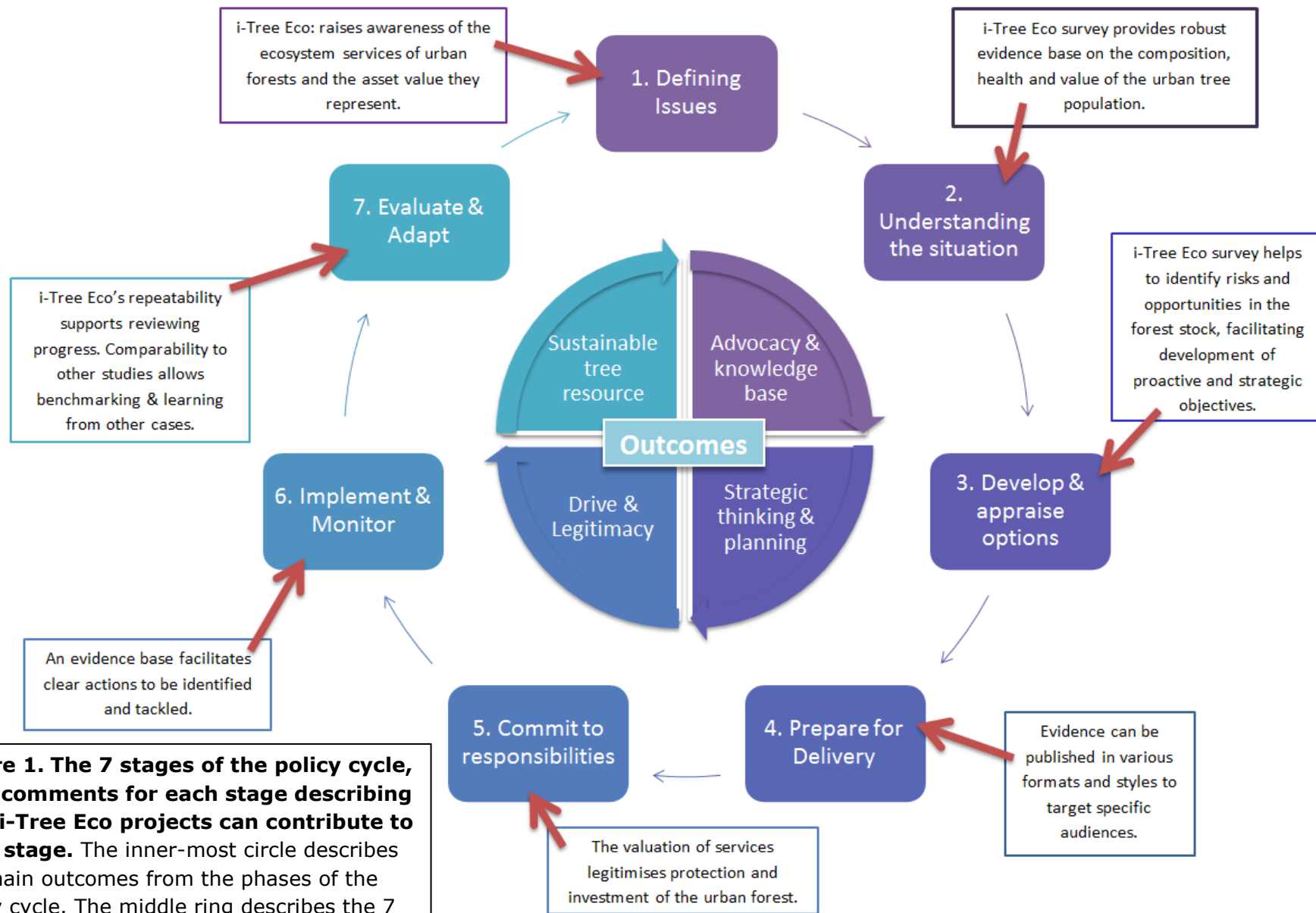


Figure 1. The 7 stages of the policy cycle, with comments for each stage describing how i-Tree Eco projects can contribute to each stage. The inner-most circle describes the main outcomes from the phases of the policy cycle. The middle ring describes the 7 stages of the policy cycle. The outer ring describes how at each stage i-Tree Eco projects can support this stage achieving

4.1. Defining issues

In this first step of the policy cycle, the issues towards the management of urban forests can be reviewed and priority areas can be identified. As there has been a lack of an evidence base for urban forests, identifying possible threats to their long-term future has been difficult. This has in part led to the risk-based approach to urban forestry with little capacity to review and evaluate trends in the forest stock to identify and react to issues. Here the collective i-Tree Eco surveys in GB along with a growing body of research highlighting the diverse benefits realised from urban forests in the past two decades, have played an important role in bringing to the attention of decision-makers that issues in urban forest may exist, and these issues may have significant consequences now and further compounded into the future. Additionally an important role of i-Tree Eco could include demonstrating the value of the urban forest to other departments within local authorities, such as health and planning. Often the ES provided by urban forests can contribute to targets to improvement of health and well-being, but these opportunities are often not realised or engaged within by policy and decision makers (Baró et al., 2014).

Within a specific location, i-Tree Eco provides statistics on the state of the urban forest, its age, health, pest and disease risk, and overall extent. **i-Tree Eco is readily comparable between cities, allowing for bench-marking of cities, proven to be useful for cities to assess how the 'well' their current state is** (Jaluzot & Evison, 2016). The i-Tree Eco analysis identifies risk to the urban forest, for instance, by identifying a high proportion of a certain tree species highlights a vulnerability to lose significant portion of tree canopy from a pest and disease outbreak (McNeil, n.d.). The effect of this loss can be valued using CTLA and CAVAT measurements which provide structural and amenity replacement cost. Milwaukee's use of i-Tree Eco in 2008 revealed a large number of ash trees vulnerable to the emerald ash borer pest and a more intensive mapping survey took place to locate each tree and allowed an in-depth management strategy to be adopted (American Forests, 2012). **i-Tree Eco studies can bring issues into discussion which previously may not have been seen as relevant or significant, such as the value of avoided runoff ES in Wrexham's i-Tree Eco study** (Jaluzot & Evison, 2016).

A key challenge within this field has first been the acknowledgement that threats and risks to the sustainability and productivity of the urban forest are present, as this then legitimises the commissioning of an i-Tree Eco survey to identify and inform what these issues are. Costs of assessment and valuation can be expensive, especially for local authorities who already have difficulty completing full surveys of tree stock (Britt & Johnson, 2008), which can make commissioning a large scale survey difficult (Billé et al., 2012). However, this challenge is being overcome in GB as i) growing research on the multiple benefits afforded by urban forests, ii) policies encouraging greater focus on urban forests and their benefits, and iii) previous reviews of the state of urban forest,

such as the Trees in Towns II report, highlight the poor state of current management approaches.

4.2. Understanding the situation

This stage of the policy cycle refers to how i-Tree Eco can provide a knowledge base, for many cities providing the first numbers on the composition, structure and health of their urban tree resource. Presence of tree inventories is often listed as a key indicator of a sustainable forest strategy (Ordóñez & Duinker, 2013; van Wassenae & Satel, 2012). Laurans (2013) considers this to be the main function of tools like i-Tree Eco; to providing information to guide decision-makers. As a peer-reviewed, widely applied tool, i-Tree Eco provides robust, reliable measures of urban forest structure. It is however, important to acknowledge its limitations which should be addressed with i-Tree Eco reports themselves to highlight absent values. GB tree officers have expressed the importance of data to back-up their plans for planting and justify investment in the urban forest **“this is why things like i-Tree are so valuable because it is starting to put a value that everybody understands – money – onto the services that trees are delivering. That changes the perception of them quite a lot”** (quote stated within Davies et al., 2017b).

i-Tree Eco quantifies and monetises only a subset of the services provided by urban trees (Table 1). However, many local authorities may not be aware of these services and the value to achieving wider policy aims. For instance, often greenspace policy is focussed on social and recreational benefits, while i-Tree Eco estimates the value for regulatory ES only (Selmi et al., 2016). But urban forests can additionally help contribute to diverse policy targets both within forest strategies, and in other departmental strategies, such as public health (Nowak, 2006; Escobedo et al., 2011). i-Tree Eco can help identify where these linkages can be made, though it depends on how the results are demonstrated and capacity between government departments to realise the potential impact of these linkages. In the evaluation of Wrexham’s i-Tree Eco survey, the use of public service boards as a forum where different public bodies can discuss issues provides an avenue for collaborative thinking and planning on assets for mutual benefit (Jaluzot & Evison, 2016). A further strength of i-Tree Eco is it encourages a long-term focus. Information on current species diversity and age structure can allow potential future weaknesses in urban forest resilience to be identified. This can help proactive planning and planting in the urban forest which is neglected in current management approaches (Britt & Johnson, 2008; van der Jagt & Lawrence, 2015).

Challenges here may occur if the validity of the valuation of ES is called into question. The estimation of the non-market value of ES is still relatively recent, particularly at the local level. For this reason values may not be seen as accurate or grounded enough to establish policy changes on (Billé et al., 2012). This was a concern for the initial application of the i-Tree Eco models in GB, as the models were developed in the USA. For the first i-Tree Eco evaluation in GB, Torbay, one main focus was to review and

establish its suitability to GB. This and subsequent i-Tree Eco reports have emphasised that while the models are developed in the US, they have been adapted to GB environment and values. Separate to the i-Tree Eco model, valuations may be called into question due to weaknesses in accounting for small scale and locality variability in services (Baró et al., 2014).

Additionally, as often little is known about the composition of the urban forest and even less on their ES value, information provided in an i-Tree Eco survey may be difficult to interpret by decision-makers as they have little to compare such values against. Additionally, i-Tree Eco focuses primarily on regulatory ES, rather than those harder to quantify such as aesthetic and existence values (Hotte et al., 2015). Care must be taken to ensure that these and other significant values are not forgotten about in comparison to the now more readily quotable regulatory services.

4.3. Develop and appraise options

i-Tree Eco projects can help to develop and appraise options for policy or management by either providing the evidence base to infer impacts from proposed actions, or to be directly applied to assess different options. For example, **i-Tree Eco has been used to predict future impacts**; McPherson et al. (2011) used i-Tree Eco to estimate Los Angeles proposed million tree planting scheme would provide benefits worth between \$1.33 to 1.95 billion over the project lifetime. **i-Tree Eco has been used to run a cost-benefit analysis of four species** from the Torbay i-Tree Eco study (Sunderland et al., 2012). Further, **i-Tree Eco has been used to appraise different planting strategies**, for example Baltimore's used i-Tree Eco study to assess the impact of different planting strategies to achieve their goal of 40% canopy cover (Bodnaruk et al., 2017). This predictive and appraisal use of i-Tree Eco has not yet been applied in GB, with the exception of two studies where it has been used to explore the impact of private householder removal of trees (Andrew & Slater, 2014) and how different housing age is associated with tree cover (Shields & Slater, 2017).

A difficulty with valuation studies may be that they are not focused at a scale optimal to inform decisions on local planning (Billé et al., 2012; Selmi et al., 2016). **i-Tree Eco results are summarised for the entire city due to its plot-sampling procedure, which means the output cannot be spatially mapped to identify hot-spots or gaps in ES provision.** This may then make it difficult to apply the information to site-specific cases. To take air pollution as an example, the air pollution removal of the surveyed urban forest information is summarised by i-Tree Eco for the whole urban area. In contrast other air pollution reduction measures for cities are often targeted for specific roads/sites to reduce air pollution to meet EU targets (e.g. in Edinburgh; Defra, 2015) or to reduce pollution for vulnerable sites like hospitals (London Air Quality Strategy; City of London, 2015). This may make it difficult to target specific areas for urban forest use as air pollution reduction as it's not known at that local scale what the current air pollution removal by trees is and what it could be.

Another difficulty is while i-Tree Eco summarises for a geographic area, it also summarises for the entire human population for the urban area. In reality the benefits of urban forest will vary significantly depending on demographics and the local environment, which will alter the demand for ES. For example, urban residents living in more deprived areas may be exposed to higher levels of air pollution, and so the benefit of trees in this area would be significantly greater than the presence of the same trees in less deprived and polluted areas. Further those of lower economic means may have less opportunity to travel further to natural and greenspaces and so may rely heavily on local greenspace environments for recreation and relaxation, supporting overall wellbeing and health. If the effects relative to the population classes were identifiable, the variation in benefits may help drive more targeted urban forest policies (Billé et al., 2012).

A further criticism of i-Tree Eco can be that review of ES may overlook tackling the root causes of the problems which urban trees mitigate against. For instance, urban air pollution is largely caused by traffic, and so a solution to this problem would be to reduce driving, rather than mitigate it through planting urban trees (Baró et al., 2014).

4.4. Prepare for delivery

At this stage of the policy cycle, decisions on policy and management have been outlined and must be written up and published in form(s) to deliver its messages to its target audience(s) successfully. i-Tree Eco surveys produce a large number of outputs in the form of graphs, tables and statistics. Much of this is not relevant to report audiences and these direct outputs from the software must be reproduced and re-written to improve accessibility. How this is done will affect which audiences read any project publications and their ability to understand and apply the knowledge elsewhere. Further, how the report itself is communicated within and outside the LA will affect its uptake. Poor communication of the report could be caused by simple lack of putting the information out there, lack of perceived relevance by recipients and/or turnover of staff meaning information is not passed on (Kimball et al., 2014).

The key factor to possible failure in this phase is that findings from i-Tree Eco reports are not adequately presented and disseminated to audiences to facilitate the likelihood of information being read, understood and, if relevant, applied to their own work. **Effective communication of the urban forest value via i-Tree Eco surveys may be the main stumbling block for i-Tree Eco projects** (Moffat, 2016). Previously i-Tree Eco reports have been criticized for not presenting findings in an easily interpretable format in comparison to others, such as Victoria's Business District i-Tree Eco Report (Moffat, 2016). As i-Tree Eco surveys have developed, the approach to presenting information has evolved, these changes and potential for further improvements should be a key consideration of this review.

The potential impact of i-Tree Eco surveys could also be limited by a narrow view of potential audiences for the work. For instance, a focus on that specific local authority

only, while the information in i-Tree Eco surveys can be useful to the public to improve their understanding of their tree resource, other local authorities to guide their development, and NGOs which advocate for better management and protection of urban forests. In particular, **groups outside local and national governments can be important distillers of information, utilising it in their own reports, and creating the political will for change and hold local authorities to account** (Johnston & Hirons, 2014). For instance, in some American cities non-profits have played a greater role in funding tree research and planning than their local governments (Seamans, 2013).

4.5. Commit to responsibilities

This stage in the policy cycle, the step from evidence and advocacy to meaningful changes in policy and management plans, is seen as a key motivation for undertaking ecosystem valuation projects, but there is little evaluation of projects to identify if this step actually takes place. This step of commitment to responsibilities may often require a cultural change in attitude, driven by the raised awareness and evidence provided in earlier stages, this may realise a shift in perspective of urban forests from an unimportant, risk-management issue, to a worthwhile opportunity for improved benefits. Evidence of this shift in attitude will identify if this stage has been successful (Young, 2013). For instance a valuation of greenspace in the Netherlands was found to led to authorities prioritising these spaces to a higher degree (Juaneé Cilliers & Timmerman, 2013).

An i-Tree Eco study can support the follow through of advocacy to management and policy change by providing specific data to back up claims, without which proposed changes do not develop the necessary political support (Hahn et al., 2008). These values allow decision-makers to justify investment in urban forest within difficult funding environments. Further as publicly accessible documents, the values provide public and non-government bodies the ability to argue on the behalf of the urban forest. In America, NGOs have played a major role in helping to make urban forest management an issue and to guide policy and management guidelines (Seamans, 2013).

i-Tree Eco projects can be facilitated into informing policy by timing with the development of new woodland and tree strategy documents. These new policies can then immediately draw upon the information provided by i-Tree to evaluate the state of their urban forest and devise objectives from this. **Wrexham's i-Tree Eco evaluation found the fact that the renewal of their Tree and Woodland strategy took place shortly after the i-Tree Eco survey the main take-away lesson to facilitate significant application of the survey's findings** (Jaluzot & Evison, 2016). It may be more challenging to incorporate the study results if the project is not timed with a policy renewal, as the results may become out of date and the interest in urban forests may have dwindled when it becomes time for the policy to be renewed.

Another challenge at this stage of the policy cycle is to achieve meaningful input into policy and management. At the policy level the adoption may be restricted to symbolic or political use, where benefits are mentioned but goals remain vague providing little impetus for on-the-ground change (Dunlop, 2014; Turnpenny et al., 2014). This lack of meaningful action is discussed in English forestry policy, where the Delivery plan for England's Trees, Woods and Forests (2008) states: "**Although trees and woodlands are often embedded in regional planning strategies, implementation of relevant policies can be limited**" (Defra, 2008). Additional challenges to meaningful change could be due to a minimal change in attitude, with the focus remaining on trees as sources of risk and disservice (Seamans, 2013). Attitudes may be difficult to change if the proposed changes do not align with pre-existing plans and political strategies (Billé et al., 2012).

4.6. Implement and monitor

This stage of the policy cycle refers to the enactment of policy and management targets which is then followed with keeping track of progress to achieving objectives. i-Tree Eco plays a role here in providing a means of monitoring the change in state of the urban forest. In a review of Chesapeake Bay municipalities with canopy cover assessments, nearly half had used the information to provide a baseline to evaluate their progress towards set goals (Kimball et al., 2014). In a specific example, **the city of Sydney has used i-Tree Eco surveys to monitor progress towards existing canopy cover targets** (City of Sydney, 2013). Elsewhere, in Toronto, permanent i-Tree Eco plots are being used to assess the impact of climate change on species composition (City of Toronto, 2013). Toronto has also selected key indicators measurable through i-Tree Eco studies (e.g. tree size, tree condition, species diversity) to monitor the sustainability of their urban forest (City of Toronto, 2013).

A challenge here can be organisational instability in terms of staff turnover and ending of terms of elected officials. In America, tree strategies have stalled when the mayor championing them was not re-elected (Young, 2011). This was a weakness identified in the Wrexham i-Tree Eco project evaluation (Jaluzot & Evison, 2016). Further constricting local authority budgets may make any sustained or positive investment in the urban forest difficult with many competing uses of funds. Overall there has been a decline in green infrastructure (Urban Greenspaces Taskforce, 2002), and tree budgets specifically have remained static with a loss in external funding by over a third (Britt & Johnson, 2008). The disservices and costs of tree maintenance can mean that any expansion of urban forest management can be opposed, by both decision-makers and the public. For example some New Yorker's complained of the use of money in tree planting and maintenance costs in the city's Million Tree initiative (Seamans, 2013). This may restrict the implementation on the ground of policy targets.

4.7. Evaluate and adapt

This last stage of the policy cycle identifies what outcomes have been realised by the policy, and identifies where changes may need to occur to better achieve goals. Similarly to the previous phase, i-Tree Eco can be used here to review the changes in the state of the urban forest. It can also be used at this stage to appraise different options to move forward with, such as different planting and removal targets discussed earlier (Andrew & Slater, 2014; Bodnaruk et al., 2017). Further it can be used to assess impact from possible natural catastrophes, such as storms or pest and disease outbreaks (Kimball et al. 2014). For example **the Devon Ash Dieback Action Plan inferred the potential costs of loss of ash trees from emerald ash borer outbreak using valuation of ash trees from i-Tree Eco projects** (Wolton, 2016).

As a comparable and repeatable tool, results between subsequent i-Tree Eco studies within and between different cities can be compared. As the number of i-Tree Eco studies in GB has grown, local authorities have found it useful to place their results in context to other areas, to compare issues and opportunities for improvement (Jaluzot & Evison, 2016). At this stage within the policy cycle, a repeated i-Tree Eco survey could be applied to track changes in the urban forest. Oakville in Canada report one the main uses of i-Tree Eco is to trace the effectiveness of their tree strategy (Town of Oakville, 2008).

5. Case Studies Review

The following section reviews the each of the case study locations in terms of their i-Tree Eco project, the state of urban forest knowledge prior to the survey, the communication of results in media and reports, as well as related policy before and after the survey. As i-Tree Eco has developed, subsequent projects have used different versions with different abilities to measure and value services. As such, the projects below are listed chronologically. There was less information available on the more recent projects due to the shorter time for any publications to have been developed and published since their i-Tree Eco report was published. A list of which ES were quantified in each project is shown in Table 3.

5.1. Torbay, England (2010)

i-Tree Eco survey – set-up and outputs

The Torbay i-Tree Eco project was the first application of i-Tree Eco in the UK. Torbay's i-Tree Eco project utilised version 3.1 of i-Tree Eco, which along with statistics on the number and health status of the urban forest, reported quantification of three ES: air purification and carbon storage and sequestration (Table 3). The report also discussed the health benefits of urban trees and woodlands, the risks to tree stock from pests and

diseases, and used CTLA method to give a replacement value of the tree stock. The survey found a canopy cover of 11.8% and a stock of 818,000 trees (Rogers et al. 2011). The three ES valued were estimated to provide Torbay with an annual benefit worth £345,811. Treeconomics produced a 46 page report detailing methodology and results (Rogers et al., 2011a). An assessment of the use of the i-Tree Eco model, its limitations and scope for further use, was also presented (Rogers et al., 2011b).

State of knowledge prior to i-Tree Eco survey

There was little evidence of an urban forest focus in Torbay's local policies around this time. A climate change strategy (Torbay Council, 2008) did not mention of the role of trees in mitigating climate change. Torbay's Local Biodiversity and Geodiversity Action Plan (2006-2016; Torbay Biodiversity Steering Group, 2006) did specifically address the urban realm as an environment, and identified the loss of highway trees as a threat to biodiversity.

Use in media and reports

As the first use of i-Tree Eco in GB, and therefore providing the first monetary valuation of an urban tree stock in GB, the Torbay i-Tree Eco project generated high media attention. This ranged both from public-facing newspaper articles, to field-specific website articles and reports. Within Torbay council it was referenced within a newsletter within the planning department.

A scientific article authored by Tim Sunderland (Natural England Economist on the project steering board), Kenton Rogers (of Treeconomics) and Neil Coish (of Torbay Council) was produced from the project (Sunderland et al., 2013). This took the results of four tree species from the Torbay survey and used a cost-benefit approach to appraise the relative value of these tree species.

Google scholar listed 20 articles which cite the Torbay i-Tree Eco report. These citing articles (mostly scientific journal articles) arose from USA, Europe and Australia, indicating a global impact of the survey. Outside of these academic papers, the Torbay i-Tree Eco data had been used extensively within other reports. For example, it had been used often as a case study, such as within the UK Natural Environment Audit (Watson et al, 2011) as well as within reports from the Landscape Institute and Town and Country Planning (2012) and Woodland Trust (Europe Economics, 2015). It had also been utilised in wider strategic documents for the region, such as the Ash Dieback Action Plan for Devon (Wolton, 2016). At a national level, it was used by the Independent Panel on Forestry (2012) to underline the value of urban trees. Most recently, off of the back of the i-Tree Eco study, a project received funding in 2017 to establish an i-Tree Eco walking trail around the town's trees.

State of local policy

Before i-Tree Eco survey

At the national scale, the over-arching policy at the time was the 'A Strategy for England's Trees, Woods and Forests' (Defra, 2007). However, the more direct policy which helped initiate and select Torbay for the pilot was the South West Regional Forestry Framework. This framework drew from the quality of life theme from the national strategy identifying key points which i-Tree Eco tied into: developing a 'business case' for trees in urban and rural areas, using local campaigns for advocacy, and encourage LAs to develop urban tree strategies. The main objective of Torbay's i-Tree Eco survey was to raise awareness and boost local and council interest in valuing and managing their urban forest stock.

After i-Tree Eco survey

Following the i-Tree Eco survey Torbay produced a '**Tree and Woodland Framework for Torbay**' (Torbay Council, 2013). This strategy fed off of both DEFRA's Strategy for England's Trees (2007) and the Trees in Towns II report (Britt & Johnson, 2008). The policy discussed some of the findings of the i-Tree Eco survey and set general targets towards establishing a sustainable tree resource. Specific targets include selecting where possible large growing species, expanding the tree population in line with biodiversity enhancement (green corridors), and raising public knowledge and awareness of trees. It also discussed adopting a pro-active tree management approach and making efforts to update its tree database. However the main focus of these surveys was to better identify and manage tree risks. Since the i-Tree Eco survey Torbay has also renewed its climate change strategy (Torbay Council, 2014) but this did not mention the i-Tree Eco project or the role of urban trees in climate change mitigation. **Torbay is now reaching the time period when a repeat i-Tree Eco survey is recommended** by the i-Tree methodology (www.itreetools.org). Indeed, **Torbay's local authority is currently considering such an undertaking** (Pers. Comm. Kenton Rogers, 2017).

5.2. Edinburgh, Scotland (2011)

i-Tree survey – set-up and outputs

The pilot project for i-Tree Eco in Scotland took place in Edinburgh and was conducted in 2011 by Forest Research. The Edinburgh i-Tree Eco used the same version of i-Tree Eco as Torbay (version 3), with monetisation values limited to air purification, carbon storage and carbon sequestration (Table 2). Edinburgh was found to have a relatively high canopy cover (17%) in comparison to other surveyed cities. The full (45 page) and summary (two page) reports were produced by Forest Research in 2012 (Hutchings et al., 2012). These reports area have since been re-written by Forest Research to incorporate extended ES by re-analysing the 2011 survey data using the more recent version 6 of i-Tree Eco.

Use in media and reports

Despite being one of the earliest i-Tree Eco studies in GB and the first in Scotland, there appears to have been little media attention towards Edinburgh's i-Tree Eco survey. While it had been listed in other reports on ES and green infrastructure as one of many i-Tree Eco studies there is little specific overview of Edinburgh's i-Tree Eco project. One exception to this is the Scottish Forum for Natural Capital (2014) which praised Edinburgh's evaluation as a case study in treating ecosystems as assets. Along with other i-Tree Eco projects, findings have been cited in the Living Ash project to review impact of chalara on non-woodland trees (Tree Council) and in a comparison of urban forests in Rumble et al. (2014). The City of Edinburgh Council's (CEC) website currently does not mention the i-Tree Eco project. **The findings have also been used to encourage individuals and businesses to support tree planting in Edinburgh by the TreeTime Edinburgh initiative** (TreeTime Edinburgh, 2017).

State of knowledge prior to i-Tree Eco survey

Edinburgh has a long history of surveying its urban tree stock, with estimates as early as 1972 (Good & Munro, 1981). This places it in a much more informed state than the other case-studies, though this is likely due to it being the largest urban area considered here (larger urban areas are more likely to have an urban forest strategy in place (van der Jagt & Lawrence, 2015). From Edinburgh's tree population numbers (published in later policy documents) there were visible increases and declines in urban forest cover. However, different methods of assessing tree stock were used in different years, making comparisons difficult. For example, woodland cover in 1972-1980 was measured in hectares, then in the 1990 only the numbers of street trees were published. In 1992 the 'Urban Forestry Strategy for Edinburgh' set an aim to achieve a 30% decline in carbon dioxide emissions, and established the 'Urban Forest Project' (CEC, 2008). This project set out to plant 250,000 thousand trees in the late 1990s.

Table 3. Ecosystem services included in the i-Tree Eco reports for the six case studies.

i-Tree Eco Survey	Air Purification	Carbon storage & sequestration	Storm water regulation	Temperature regulation	Disease / pest regulation	Human health	Cultural significance	Habitats / Bio-diversity provision	Replacement value
Torbay (2010)	Y	Y	N	N	Y ¹	Y ²	N	N	CTLA
Edinburgh (2011)	Y	Y	N	N	Y ¹	Y ²	N	N	CTLA
Glasgow (2013)	Y	Y	Y	N	Y ¹	Y ²	CAVAT ³	Y	CTLA
Bridgend (2014)	Y	Y	Y	Y ¹	Y ¹	Y ²	CAVAT ³	Y ¹	CTLA
Sidmouth (2014)	Y	Sequestration only	Y	Y ¹	Y ¹	Y ²	CAVAT ³	N	CTLA
Tawe catchment (2014)	Y	Y	Y	Y ¹	Y ¹	y ²	CAVAT ³	Y ¹	CTLA

1. Discussed only

2. Assesses health benefits related to air pollution only

3. CAVAT: Capital Asset Value of Amenity Trees (Replacement cost based upon amenity value)

State of local policy

Before i-Tree Eco survey

The main policy driver for Edinburgh's i-Tree Eco was the 'Woods in and Around Town' scheme (WIAT; FC Scotland, 2015). This focused on improving and creating forests in urban areas, highlighting the social and recreational benefits of these habitats. As part of this policy there was a drive to improve and sustain an evidence base for the state of urban forests. The decision to commission an i-Tree Eco survey was based off of the success from Torbay's i-Tree Eco project, and the aim to replicate this with a Scottish example to raise awareness of urban forests closer to home. Scotland's overarching forest strategy, the Scottish Forestry Strategy (Scottish Government, 2006) has little mention of urban forests. Instead urban forest policy was and continues to be led by WIAT, now in its 4th phase (FC Scotland, 2015).

After i-Tree Eco survey

In the same year the Edinburgh i-Tree Eco Report was published, Edinburgh produced its Forestry and Woodland Strategy (ELFWS, 2012-2017, Lothians and Fife Green Network Partnership, 2012). This policy tied in with aims for the Central Scottish Green Network objectives outlined from the National Planning Framework (Scottish Government, 2009) which recommended new Forestry and Woodland Strategies to facilitate woodland growth. The ELFWS set out targets to increase the amount of woodland in positive management, highlighted the use of urban trees in treating problem air-pollution areas, and set a woodland growth target of 180-250 ha per year.

Many of the ideas in the ELFWS were targeted in Edinburgh's Trees and Woodland Action Plan (CEC, 2014). **This plan contained a detailed section summarising the results of Edinburgh's i-Tree Eco study, with the presentation of i-Tree Eco results stated as one of the four objectives for the plan itself.** The Action Plan expanded on ELFWS goals, with specific actions listed including adopting a tree valuation system to inform decision-making and expand their tree database. The policy lists strategic street tree and woodland planting approaches including reference to use in air pollution mitigation, climate change and disease resilience, flood management, slope stability, landscape enhancement, heritage and biodiversity.

There is also evidence that the report is being used to prepare other department's policies. For instance Edinburgh council commented on a consultation draft of the Scottish Climate Change Adaptation Programme, using results of their i-Tree Eco project to push for stronger acknowledgement of the value of ES and the threat of climate change to these services, as well as further research into ES values (CEC, 2013).

5.3. Glasgow, Scotland (2013)

i-Tree Eco survey – set-up and outputs

The Glasgow i-Tree Eco project took place in 2013 and used i-Tree Eco version 5. The project was funded by Glasgow City Council and Forestry Commission Scotland. The project was one of many initiated in Glasgow as part of the EU's Strategies Towards Energy Performance and Urban Planning (STEP UP) Programme. A full report (57 page) was produced by Forest Research and Treeconomics (Rumble et al., 2015) along with a 2 page summary report.

Use in media and reports

Glasgow's i-Tree report appears to have not been widely distributed. In comparison to other studies, it had little mention in the media, but had been cited in reports or scientific studies along with other i-Tree Eco projects. It was also used by Rumble et al. (2014) as one of four case study i-Tree Eco projects. It was also used by the Living Ash Project in a report on estimated impact of chalara in non-woodland situations (The Tree Council, 2015). Here Glasgow was cited along with Edinburgh, Torbay, Devon highways and Wrexham studies, though Glasgow had the highest estimated proportion of ash trees, demonstrating the greatest risk from chalara.

State of knowledge prior to i-Tree Eco survey

There is little information available about the state of knowledge Glasgow held on its urban forest prior to the i-Tree Eco survey. In the mid-2000s a Park and Open Space strategy actioned for a tree database to be set up and a strategic plan to be initiated for trees in public spaces (GCC, 2004). Unfortunately the current state of this database or the strategic approach taken from this action was not available at the time of this review. However, there had been clear interest around urban trees in Glasgow with commissioning of reports exploring role of green infrastructure in reducing the urban heat island effect (GCVGNP, 2013).

State of local policy

Before i-Tree Eco survey

At the national level the main driving policies were the Scottish Planning Policy and the WIAT programme. A key other driver however was the EU STEP UP programme, which focused on energy policies, particularly the carbon sequestration role of trees in urban areas.

At the local level the Glasgow and Clyde Valley Forestry and Woodland Strategy was published in the same year the i-Tree survey work took place (Land Use Consultants, 2013). This included aims for tree cover expansion around the urban fringe and planting to increase urban forest resilience. It also encouraged consideration of ES that trees may offer to particular sites, such as air pollution removal and flood

mitigation. The potential of trees for ES are also mentioned in Glasgow's Air Quality Action Plan (GCC, 2009), which includes an action to investigate the potential of tree planting to mitigate air pollution.

After i-Tree Eco survey

Since the i-Tree Eco survey a number of relevant policies have been produced, though none provide a specific city level policy on urban forest management. In 2016 Glasgow reported on its duties towards climate change (GCC, 2016). Here Glasgow states it is using a strategic tree planting programme to prevent a net loss of tree stock, but specifying for ES values than simple quantity of trees. **The report also states that the i-Tree Eco project will be used to inform strategies for woodland creation and management, and that i-Tree Eco information underpins planning for the council's approach to urban tree management.** Unfortunately more detailed information on what this management is was not available at the time of this review.

The most specific policy with respect to trees was the Supplementary Guidance 7: Natural Environment (GCC, 2017), which discussed how trees should be treated in relation to development decisions. The guidance affirms a presumption in favour in retaining trees on development sites and that developments should aim to enhance ES of their site. This approach may reflect the more recent Scotland Land-use Strategy (2016) which states ES functioning should be incorporated into decision-making. The i-Tree Eco project is not mentioned specifically in this document. The results of the project do appear to have been taken up more within other outputs of the STEP UP programme. Glasgow's Energy and Carbon masterplan (GCC, 2014) discusses the role of urban trees in mitigating climate change through carbon sequestration and storage, citing the i-Tree project. This report also looks at the potential role of Glasgow's forests as a sustainable source of timber. More recently, Glasgow was preparing a new Open Space Strategy, whose consultation draft made no mention of the i-Tree Eco project despite discussing valuation projects in other areas, such as the Mersey Forest.

5.4. Bridgend, Wales (2014)

i-Tree Eco survey – set-up and outputs

The Bridgend i-Tree Eco survey was published in 2015. This survey utilised the latest version of i-Tree Eco at the time (v5) to calculate the value of Bridgend's urban forest, including stormwater run-off as quantified ES. It also included CAVAT values to be calculated which provide a replacement cost reflecting the amenity values of trees. The survey covered the main urban areas within the Bridgend CB, covering Bridgend, Maesteg, Pyle, Porthcawl and Pencoed, but remained the smallest urban agglomeration area to have undertaken an i-Tree Eco to date, with an area of 4,440

ha compared to Edinburgh 11,468 ha and Torbay 6,375 ha. It calculated a tree cover of 12% (533 ha) providing £950,000 worth of ES annually (Doick et al., 2015a).

The output from the survey produced by Forest Research was a 74 page full report (Doick et al., 2015a) and a two page summary report. Both the Bridgend and Tawe catchments reports differed from previous FR reports in including sections on the legislative contexts in Wales. NRW also produced a single page infographic of the results (NRW, 2016b).

Use in media and reports

There had been little use of the Bridgend results in other reports or publications. When the project was cited it is usually listed as one of many i-Tree Eco surveys in GB (e.g. Wildlife Trusts Wales, 2016a). This was likely due to the fact that it is a recent publication with less time for other reports to reference it. However the fact that it was not the first survey in the country, may have meant it received less media interest and less uptake in arboricultural and green infrastructure fields as in Torbay and Edinburgh. The Bridgend i-Tree Eco projects media appearances appeared to have been limited to a local newspaper and a local community blog. Those involved published short pieces on their site, including NRW (2016b) and the contractor, Barton-Hyett who used it as a case-study exemplar on their website (Barton-Hyett, 2016).

State of knowledge prior to i-Tree Eco survey

Prior to the i-Tree Eco survey Bridgend had good quality data available for their county provided through "Tree Cover in Wales' Towns and Cities" produced by NRW in 2014 (NRW, 2014). This provided canopy cover estimates in urban areas in Bridgend and calculated the percentage loss of woodland cover and large trees within each site. This sets up Bridgend with a very recent and top-down survey of their woodland, identifying where they sit in comparison to other urban areas in Wales stratified by size and deprivation. A dedicated report for Bridgend reviewing their results from the larger national report was produced in 2016 (NRW, 2016c)

State of local policy

Before i-Tree Eco survey

The context for Bridgend's i-Tree Eco project includes the Welsh Government's strategy 'Woodlands for Wales', which lists improved urban tree cover in order to provide multiple benefits amongst key outcomes (Forestry Commission, 2009). The decision to move forward with Bridgend i-Tree Eco was in part influenced by a pilot approach by NRW in the Rhondda region designed to inform aspects of the Environment (Wales) Act 2016 (Welsh Government, 2016a).

At the local level, the over-arching policy is the Bridgend Local Development Plan (2006-2021) which has been reviewed in 2012 and annual monitoring reports

provided (BCBC, 2012). It aims to “*conserve and enhance the natural environment of the County Borough*” (Strategic Policy 4). Within this this ‘Policy ENV5’ addresses Green Infrastructure and states that “*Green infrastructure will be provided through the protection and enhancement of existing natural assets and the creation of new multi-functional areas of green space*”. Woodlands are mentioned specifically, but only in terms of local nature conservation and mitigating impacts of air pollution and global climate change. It states negative impacts on trees and woodlands should be minimised. The urban forest and social elements of woodlands is not addressed.

Trees and woodlands are specifically focused on in Supplementary Planning Guidance (SPG) 7: Trees and Development (BCBC, 2007). It provides guidance on tree management and guidance, particularly in relation to new developments. It aims to minimise tree removal, encourage tree planting (in particular, planting the right tree in the right place), proper survey of trees prior to actions. Bridgend’s Local Biodiversity Action Plan (revised 2014; BCBC, 2014) mentions a range of values from trees, including reducing run-off, carbon storage, water purification, habitat provision. In particular it focuses on urban areas, where it highlights the importance of greenspaces in provisioning large trees and the threat to these areas from infill development. It lists tree planting as a main opportunity, but no actions or specific objectives are detailed.

After i-Tree Eco survey

Since the i-Tree Eco study was published in early 2016, only a couple of policies have been updated and published in this time. New policies which have been published include the **Bridgend Transport Strategy** (BCBC, 2015) **which mentions the i-Tree Eco survey and links between trees and air pollution**. An Annual Monitoring Report for the Bridgend Local Development plan was published in 2016, but there is no mention of the i-Tree Eco survey (BCBC, 2016), though this is not unexpected as does not directly tie in to any of the targets listed.

5.5. Sidmouth, England (2014)

i-Tree Eco survey – set-up and outputs

Sidmouth Arboretum, an independent association established in 2010, carried out the Sidmouth i-Tree Eco. The Sidmouth Arboretum aims to make Sidmouth a civic arboretum, where the arboretum encompasses the entire town and its trees, rather than a single separate site. Through this it aims to maintain and enhance the area through tree planting and protection. An i-Tree Eco survey was carried out in 2014 across the area of Sid Vale, which includes the urban areas of Sidmouth, Sidford and Sidbury, but also extends into the large amount of surrounding rural areas. The survey was organised and carried out by Sidmouth Arboretum using volunteer surveyors with training from Treeconomics. The project was funded by the Sid Vale Association, Sidmouth Town Council and East Devon AONB. Sidmouth Arboretum

produced a 12 page summary report (Sidmouth Arboretum, 2014). The report was less technical than reports produced by Forest Research and Treeconomics for the other case studies and a full analysis of ES was not conducted.

Use in media and reports

The project had limited uptake in wider media. The project and other tree issues were discussed locally through the Sidmouth Arboretum, such as the Sidmouth Tree Summit in 2015. More widely it was used within the Devon Ash Dieback Plan (Wolton, 2016), where it highlighted the importance of ash trees citing the high proportion of ash in Sid Vale's canopy identified in the i-Tree Eco study. The i-Tree Eco report was accessible via Sidmouth Arboretum's website.

State of knowledge prior to i-Tree Eco survey

Within the urban areas of Sid Vale there is little information available on existing surveys or knowledge on the extent and state of the urban tree population. Sidmouth ward was included in a district-level survey of open space, where Sidmouth, due in part to its role as a tourist location, proved to be well-provisioned with high quality parks and recreation grounds (EDDC, 2012). With specific regard to trees, knowledge within Sidmouth may be higher than other towns due to its status as an arboretum town which manages a notable tree database and holds public tree walks.

State of local policy

Before i-Tree Eco survey

Main local policies include the East Devon District Council Local Plan (EDDC, 2016) which refers to the amenity, biodiversity and climate change services of urban trees. The plan emphasises that trees are to be planned for in new developments and protected during construction activities. More specific to the urban forest, a supplementary guidance document (SPG 13. Trees and Development) was adopted in 2005. This outlines existing national policies regarding trees and sets standards for how development applications should consider trees, and how development should take place near trees to prevent damage to trees (EDDC, 2005). The main policy drivers cited within this are a series of Planning Policy Guidance Notes (PPGs) released by the UK government to guide the planning process at the local level.

After i-Tree Eco survey

There appears to have been no new or updated policies since the Sidmouth i-Tree Eco project. New policies are under way with Sidmouth drafting its first neighbourhood plan in 2017. Sidmouth Arboretum's work supporting healthy urban trees has been noted within submissions towards the neighbourhood plan.

5.6. Tawe catchment, Wales (2014)

i-Tree Eco survey – set-up and outputs

The Tawe catchment i-Tree Eco project assessed urban areas of the City and County of Swansea (CCS), Powys County and Neath Port Talbot County Borough. Survey work took place over 2014 and used i-Tree Eco version 5. The Tawe catchment i-Tree Eco project was partnered by the councils of the survey areas listed above and Welsh Water. The project was funded by NRW whose rationale for the project was one of many pilot projects as examples to deliver the Welsh Government's Environment Bill to gather evidence and identify opportunities to improve sustainable management of resources. The Tawe i-Tree Eco project was selected as one of many projects in the Tawe Catchment Trial. This aimed to explore how the natural resources of the catchment area are managed and assess the multiple uses of these resources. The project in Tawe was also underpinned by the emerging Well-being of Future Generations Act (2015).

A full length (99 page) technical report and two page summary was produced by Forest Research and Treeconomics (Doick et al., 2016b). NRW produced a 1 page infographic on the results.

Use in media and reports

The Tawe catchment appeared to have little use in media, but had been used by NGOs and commercial organisations. The value of air pollution removal in the Tawe catchment, as well as in Wrexham and Bridgend, were used by the Wildlife Trusts Wales in a response to a Welsh Government consultation document about air quality and noise management in Wales (Wildlife Trusts Wales, 2016b). This consultation document itself did not discuss the potential role of trees for mitigation of air pollution or noise (Welsh Government, 2016b). The report (along with Bridgend's) was also picked up by a community housing association, who incorporated it into a Social Impact Methodology (Wythenshawe, 2016).

State of knowledge prior to i-Tree Eco survey

As for Bridgend, canopy cover was assessed in Swansea as part of NRW's 2014 study, Tree Cover in Wales' Towns and Cities. NRW produced specific reports for each urban area from this study, which broke down tree canopy cover and trends for town and ward level (NRW, 2016d,e,f). This provided fine-scale information for these urban areas, while also setting within national context and trends. Swansea city was found to have a canopy cover 19.8%, above the national average of 16.8%. Port Neath Talbot and Powys counties were both found to have under the national average, with 16.6% and 15.6% respectively. In the City and County of Swansea Council's (CCS) Tree Strategy (2016), it states it had mapped 28,000 individual trees within a total estimated stock of 250,000 trees (CCS, 2016a). It is not clear what information Powys

and Neath Port Talbot councils held on their tree stock, above the information from Tree Cover in Wales' Towns and Cities.

State of local policy

Before i-Tree Eco survey

Local policy in the Tawe catchment is split between the councils of the tree urban areas: Swansea, Powys and Neath Port Talbot. The key policy document during the initiation of the Tawe catchment i-Tree Eco project, as for the Bridgend project, is Woodland for Wales (Forestry Commission, 2009). The Tawe catchment project itself however was more specifically linked to the recently adopted Environment Bill. The Tawe i-Tree Eco project was selected as one of many projects in the Tawe Catchment Trial. This aimed to explore how the natural resources of the catchment area are managed and assess the multiple uses of these resources. The project in Tawe was also underpinned by the emerging Well-being of Future Generations Act (2015).

CCS's Unitary Development Plan (2008) provided some notice to trees, including stating the need for accurate tree surveys and emphasises minimising impacts and removal of trees as part of developments. In Swansea County and City, i-Tree Eco was actioned within the Environmental Forum's Environment Strategy Action Plan (2014-16). This was included under a main target to improve data holdings on natural environment and to monitor changes. Other targets within this included to develop a green infrastructure strategy and to maintain and enhance the natural environment.

Powys County Council was preparing its Local Development Plan during the i-Tree Eco project. A draft prepared in 2015 mentions that important tree resources should be retained and where possible enhanced (Powys County Council, 2015a). In a topic paper for the Local Development Plan on Natural Heritage, Powys County Council lists national legislation which are relevant to trees. This included a requirement in Planning Policy Wales (Welsh Government, now updated (2016)) to utilise powers to conserve woodland and plant trees where appropriate. Within this topic paper Powys Council states the importance of tree to provide a variety of benefits.

In Neath Port Talbot County Borough Council there is no specific tree strategy, but has an Environment Strategy for the 2008-2026 period (NPTCBC, 2008). The environment strategy makes little mention of trees, but does state the council will survey their environmental assets to inform development of specific management policies. Trees are more specifically mentioned with Neath Port Talbot's Air Quality Action Plan, where trees are selected as one action to take forward (NPTCBC, 2012).

Results from NRW's Tree Cover in Welsh Towns and Cities were broken down in bespoke reports for each of the three urban areas (NRW, 2016 c,d,e). These mentioned the benefits of Wrexham's i-Tree Eco report and stated these reports were being completed for Tawe catchment. They include recommendations including focusing tree planting in deprived areas and encourage improved understanding of

where trees can be planted and where the greatest priorities for planting lie in order to better inform targets for urban canopy cover.

After i-Tree Eco survey

Following Tawe's i-Tree Eco project, **CCS have produced two tree policy documents; a Tree Policy for council-owned trees and a guidance document on the protection of trees on development sites** (CCS, 2016a, 2016b). Both documents make no mention of the i-Tree Eco project, though it may have been too close in timing to the report publication. The documents have little mention of the ES value of trees. This is most notable in the Tree Policy document, which only briefly states the carbon sequestration and air pollution role of urban trees. It states the aim of the strategy is to: "*ensure the safety, maintenance, care, protection and longevity of the authority's tree stock*". The policy itself mainly focuses on outlining the responsibilities of the council in regard to maintenance of tree stock. Recently **CCS has also undertaken a review of their approach to TPOs which discussed i-Tree Eco results** (CCS, 2016c).

The project has also been referred to in more general policies, such as the Swansea Local Development Plan. Here, in a topic paper for this plan on green infrastructure, it referred to the i-Tree Eco project as an example of the benefits of undertaking valuation studies of ES and called for more work in this area (CCS, 2016d). An adopted supplementary guidance document on tree protection on development sites has also been produced (CCS, 2016e), which sets a wider policy context for tree preservation, describes value of urban trees and outlines standards for tree protection.

In contrast to CCS, there is little update to policies or mention of the i-Tree Eco project from Port Talbot or Powys county councils. Since 2013 Neath Port Talbot Council has published a series of Supplementary Planning Guidance documents in relation to their Local Development Plan (NPTCBC, 2016a). The documents published so far include pollution (2016), open space and greenspace (2017), and design (2017), but none mention the i-Tree Eco project (NPTCBC, 2016b, 2017a, 2017b). The amenity value of urban trees was mentioned briefly within the open space and greenspace document, and their visual value in the design document. The Local Development Plan itself was only adopted in 2016. This plan does not mention the i-Tree Eco project or the role of trees in providing ES (NPTCBC, 2016a).

Powys County Council is still in the process of finalising its Local Development Plan. A topic paper produced in 2015 in relation to the Local Development Plan also does not mention the i-Tree Eco project but briefly mentions some ES values, and focuses on the use of Tree Preservation Orders to protect trees (Powys County Council, 2015b).


5.7. Case study impact summary


The review of the case study i-Tree Eco projects identified a range of impacts which differed between the case studies. Table 4 (below) provides a summary of impact achieved in each project and illustrates the variation between projects in terms of what impacts were achieved and at to what degree of magnitude. Impacts are categorised within four impact categories (after Meagher et al., 2008).

More detailed summary of impact generated by each case study as identified through this literature review and within Part 2 of this project (Hall et al., 2018) are available as one-page Impact Summary reports (Part 3).


Table 4. Summary and scale of impact achieved to date identified in this literature review for each case study project.

Impact Category	Torbay 2010	Edinburgh 2011	Glasgow 2013	Bridgend 2014	Sidmouth 2014	Tawe catchment 2014
Conceptual <i>Changes in understanding, attitudes and ways of thinking about an issue or problem or solution</i>	More proactive approach to urban forestry.	Raised urban forest profile and ES approach to urban forest management.	Raised urban forest profile and ES approach to urban forest management.		Volunteer surveyors and public engagement event days.	
Capacity <i>Increases in capacity, skills, expertise and funding</i>	Wide impact on urban forest research and cited in national level reports and policies. Aided development of i-Tree trail in Torbay	Some use in external reports. Used to make argument for trees in national policy. Findings used to support local tree planting initiative.	Some use in external reports.	Some use in external reports.	Some use in external reports.	Used to inform review of TPOs. Some use in external reports.
Connectivity <i>Improved links between researchers and stakeholders</i>			Informed wider council policies (climate change).	Informed wider council policies (transport).		Informed wider council policies (Local Development Plan).
Instrumental <i>Direct influence on a specific policy or practice</i>	Informed tree and woodland strategy.	Informed tree and woodland strategy.	Stated as being used to inform urban forest management strategies.		Plan to develop community tree strategy.	

 = evidence of high impact

 = moderate impact

 = minimal impact to date or some evidence of plans that are likely to lead to impact

 = no published evidence of impact yet

*Note, the lack of an impact in any one cell within the table does not mean no impact has been achieved. This review focused on published forms of impact which were available online, forms of impact such as changes in council attitudes to urban trees, improved connectivity between council teams or policies in development are unlikely to be picked up by this approach. Please see Hall et al., (2018) for a review of impacts identified through stakeholder interviews and questionnaires.

6. Conclusion

This literature review aimed to identify the opportunities for and barriers to impact from i-Tree Eco projects in GB. The scope of possible impacts from i-Tree Eco was informed by a review of the current state of urban forestry policy and management in GB. The opportunity for and barriers to achieving impact from i-Tree Eco at each stage of the policy cycle was reviewed using evidence from urban forestry and ES valuation literature. A review of existing i-Tree Eco projects identified a number of impacts which have been achieved in GB and abroad. This conclusion section summarises the main identified opportunities for achieving impact from i-Tree Eco in GB, both identified from wider ES valuation studies and those which have already been achieved by existing i-Tree Eco projects. Potential and identified challenges to achieving impact are also summarised and finally recommendations for future i-Tree Eco projects are presented.

The literature has focused specifically on six case study i-Tree Eco projects in GB, whose impacts were further investigated from stakeholder interviews in Part 2 of this study - impact evaluation report (Hall et al., 2018). Findings from both this literature review and the impact evaluation are summarised in Part 4 of this study - 'Understanding the role of i-Tree Eco in protecting and expanding the urban forest: executive summary' report (Forest Research, 2018).

6.1. Opportunities for impact from i-Tree Eco in GB

The main areas of opportunity for impact from i-Tree Eco projects identified in this report are summarised in this section. Areas of opportunity were identified from i) the policy review section using examples of wider valuation studies, ii) evidence from international and GB i-Tree Eco projects, and iii) from the six i-Tree Eco case studies. These three report sections provide a preliminary evaluation of the impact achieved by the GB case studies as well as a comparison to what has been achieved by international projects. The review of opportunities is summarised according to four impact categories (Meagher et al., 2008):

- Conceptual - Changes in understanding, attitudes and ways of thinking about an issue or problem or solution
- Capacity - Increases in capacity, skills, expertise and funding
- Connectivity - Improved links between researchers and stakeholders
- Instrumental - Direct influence on a specific policy or practice

It is important to note that this review looked at published examples of impact, for example, new local authority (LA) policies or reports, and reports by other organisations such as third sector organisations or other public bodies which utilised the i-Tree Eco project findings. This report is therefore limited to those impacts which have led to outputs made publicly available online. As a consequence, the research

tended to find more impact from earlier projects that have had more time to generate impact. Due to this limited scope here, this does not present a full review of all impacts or challenges face by i-Tree Eco projects. A review of stakeholder opinions of i-Tree Eco projects provides additional perspective and insights into impacts, and barriers to impact, experienced in i-Tree Eco projects (see Part 2; Hall et al., 2018).

Conceptual

Informing policy and management approaches to urban forestry

i-Tree Eco projects can help to balance the risk-adverse approach common in urban forestry management in GB, as it provides data to support an 'ecosystems' or an asset management approach. This change in the way of thinking about urban forests is seen as a first step towards incorporating ES values into decision-making. In some of the i-Tree Eco case studies there was some evidence that this was occurring in post-project policies. For example, Edinburgh and Glasgow have been described as adopting a more ES approach to urban forestry in comparison to other local authorities (Moffat, 2015). In policy, Torbay Council stated that it will take on a more pro-active approach to management (Torbay Council, 2013), and Glasgow City Council said it is working towards preventing a net loss of tree ES (GCC, 2016).

Raising awareness of urban tree benefits

Improving both council workers and the public's understanding of the benefits urban trees provide to society could be a major impact from i-Tree Eco projects. Within councils, raising awareness of urban tree values can help to raise the profile of urban tree benefits (as was seen for Edinburgh and Glasgow, van der Jagt & Lawrence, 2015), which can then create further impacts for policy and funding changes.

Public engagement in data collection and public facing promotion of the findings can help raise awareness, interest and advocacy for the urban forest. For example, using volunteer surveyors can help to raise awareness of tree benefits and help develop survey skills (O'Brien et al., 2015). Making the findings accessible can help stakeholder groups to influence policy and tree management (Wandsworth Tree Warden Network, 2017). From the case studies reviewed, only Sidmouth used volunteer surveyors to collect data, and they plan to use findings to develop a community tree management strategy (Sidmouth Arboretum, 2014). They also held event days associated with their i-Tree Eco project for dissemination to the wider public. Aside from this there was little evidence of i-Tree Eco projects making public engagement a priority or seeing any impact in this area.

Demonstrating role of ES valuation studies

i-Tree Eco is one of the first ES valuation tools in the GB which has seen wide use and media interest. This has supported the development and application of the ES valuation approach with i-Tree Eco projects used as case studies in national reports (Watson, 2011; Scottish Natural Capital Forum, 2014) as well as increased support for

valuation studies at the local scale (CCS, 2016d). This outcome from i-Tree Eco projects can help to overcome a challenge associated with valuation projects that the assessments are not seen as valid or robust (Billé et al., 2012; Baró et al., 2014). As the UK's pilot project, the Torbay study played an important role in this respect, addressing concerns of suitability-for-use in the UK.

Further, there is opportunity for i-Tree Eco to contribute data and values to inform local natural capital accounts, a form of assessing environmental resources, the benefits they provide and their values. Natural capital accounts have been adopted by the UK government, with natural accounts for the UK and support for the approach within the 25 Year Environment Plan (HM Government, 2018). Incorporating i-Tree Eco within natural capital accounting is a logical next step for i-Tree Eco to have significant impact in GB. While there are no examples of this occurring at the time of writing, two projects with this ambition are forthcoming. Firstly, the i-Tree Eco project for Cardiff, Wales is set to record its results within a NCA framework in their imminent report. Secondly, a pan-Greater Manchester i-Tree Eco is currently being developed and the project champions anticipate that it will feature as a case study in Defra's 25-Year Environment Plan - Urban Pioneer.

Capacity

Making the case for urban forests

i-Tree Eco provides a platform for acquiring quantitative information on the extent and condition of an urban forest, from which many impacts stem. For example, this information is essential for generating a sustainable urban forest management strategy (Ordóñez & Duinker, 2013; van Wassenaar & Satel, 2012). The evidence base provided by i-Tree Eco provides data to justify arguments in support of urban forests, such as greater protection or investment in their expansion. Interviews with tree officers have shown that they find the information helps strengthen their arguments and the monetised estimates helps make the information more understandable to wider audiences (Jaluzot & Evison, 2016; Davies et al., 2017).

From the six i-Tree Eco case studies, there was evidence of the commissioning local authorities as well as external organisations making use of the data to demonstrate the value of trees and their importance in a particular area. City of Edinburgh Council used its i-Tree Eco findings to comment on Scottish National Policy and argue for greater consideration of implications for ES (CEC, 2013). Within the Tawe catchment, one council has used the findings to help inform the discussion on the use of Tree Preservation Orders (CCS, 2016c). The results from i-Tree Eco projects have also been used by Industry Associations and Non-Government Organisations including the Landscape Institute, Town and Country Planning Association, the Woodland Trust and the Wildlife Trusts in position statements and in evidencing the benefits of urban trees to raise awareness and understanding for the importance of urban trees. In the US,

similar organisations have played an important role in pushing the urban forestry agenda and raising investment in the urban forest (Seamans, 2013).

Supporting urban forest research

Data from i-Tree Eco case studies has contributed to research into the state (UFWACN, 2017b) and value (Sunderland et al., 2013) of GB urban forests. i-Tree Eco has also been used to inform urban tree biometrics (Monteiro et al. 2016), as well as to explore relationships between both tree management and urban planning with tree cover (Andrew & Slater, 2014; Shields & Slater, 2017). This research helps improve our understanding of the benefits of urban trees, conduct risk assessments, and improve future estimations of the quantities of benefits delivered.

Securing funding for urban forests

i-Tree Eco projects demonstrate the benefits provided by urban forests. It has been reported that evidence provided by international i-Tree Eco projects has led to greater investment for urban forests (Escobedo, n.d.; Bieneman, n.d.; Wells, 2012), including increased planting and investment in management, thereby helping to support the continuation of these benefits of urban trees into the future. From the i-Tree Eco case studies there were, however, only limited examples of this occurring. In Torbay, there was some evidence of increased support for urban forestry, with plans to improve tree surveys and tree inventory databases (Torbay Council, 2013). In Wrexham, the i-Tree Eco project helped to justify retaining a tree officer position (Jaluzot & Evison, 2016).

Connectivity

Improving engagement between council departments

Urban trees can contribute towards meeting local authority targets beyond those directly associated with tree management; including in planning, health, transport, housing, climate change and sustainability. For example, trees can contribute to climate change targets by sequestering carbon, or contribute to health targets by encouraging people to be active outdoors. i-Tree Eco projects have facilitated connectivity between departments by demonstrating the diverse range of services that trees provide. The review of i-Tree Eco case studies revealed a number of instances where report findings had been used in policies by multiple departments (GCC, 2014; CCS, 2016d; BCBC, 2015).

Instrumental

Informing policies

i-Tree Eco projects can help inform tree and woodland strategies by providing evidence on the state and health of the forest. This information can be used to identify priorities and targets, set specific objectives to achieve these and select indicators for use in monitoring progress. From the i-Tree Eco case studies, the City of Edinburgh Council utilises findings to demonstrate the benefits of urban trees and inform an action plan with specific targets for future planting priorities to support particular ES

and proactive tree management (CEC, 2014). In Glasgow, Sidmouth, Tawe catchment and Bridgend, the i-Tree Eco projects have not yet fed into a new tree and woodland strategy, though in some cases they have helped to inform local development plans (GCC, 2014; BCBC, 2015; CCS, 2016d).

In North America there has been a much greater use of i-Tree Eco survey results to inform new tree and woodland policies. From one example, i-Tree Eco helped to inform new planting strategies, devise action plans to mitigate impact from pest and disease outbreaks and set by-laws to prevent loss of trees (Town of Oakville, 2008; 2016a,b).

Monitoring trends in urban forests

i-Tree Eco is a tool that can be used to monitor change. In GB, despite i-Tree Eco reports recommending update surveys, no second surveys have yet taken place as the recommended 5-year time lapse is only just nearing completion for the earlier studies. Internationally, repeated i-Tree Eco surveys have been used to track progress, for example towards canopy cover targets, and to evaluate the effectiveness of policies within their tree strategy (Town of Oakville, 20016a; City of Sydney, 2013; City of Toronto, 2013).

6.2. Challenges to achieving impact

From the literature of valuation studies and i-Tree Eco projects a number of challenges have been identified which can impede the delivery of impacts from i-Tree Eco projects. Little information was available for challenges encountered for the six i-Tree Eco case studies, which are instead reviewed within the Impact Evaluation report (Hall et al., 2018)

Findings not seen as relevant or useful by some council departments

From the review of impact from valuation studies generally, a challenge was identified where i-Tree Eco studies may not provide information at the scale which local authorities find useful to inform their concerns (Billé et al., 2012; Selmi et al., 2016). While i-Tree Eco can be used at the park or similarly locally scale, it is designed to inform on a whole urban forest, and therefore reports cover large spatial areas – such as a whole town, city, or region. An evaluation of the Wrexham i-Tree Eco project found that a GIS output of the results would have been useful to inform future development planning (Jaluzot & Evison, 2016). A lack of interpretation at the sub-city scale, such as local action plans, can limit a report's relevance to senior management.

Poor communication of results

The communication of results from some i-Tree Eco projects has been criticised for not adequately presenting information in a form and style to engage with a broad range of potential readers (Moffat, 2016). Reports have been described as being too technical, detailed and not relevant to many audiences (Moffat, 2016; Jaluzot &

Evison, 2016). From the six case studies, it was clear that public communication had become more challenging: the first projects achieved media attention due to being 'firsts', but such interest subsequently waned.

Lack of high-level support

The lack of high-level support within councils for i-Tree Eco projects could prevent the project having meaningful impact for informing changes in management and policy for urban forests. The literature review of ES valuation studies identified this as a challenge which led to symbolic use of report findings only within policies (Dunlop, 2014; Turnpenny et al., 2014). Details about the benefits of trees are often stated and positive but vague statements made regarding urban tree protection without specific targets or action statements. For example, wider policies mention the value of urban trees and results of i-Tree Eco projects which, while positive, do not articulate specific change in how the urban forest is managed.

High-level support may also play an important role in driving forward i-Tree Eco projects and pushing the agenda relating to the urban tree resource. Wrexham's i-Tree Eco evaluation found that having a high-level champion helped generate awareness for their report and deliver policy outcomes (Jaluzot & Evison, 2016). In the US, loss of a champion for tree strategies have led to them not being adopted (Young, 2011).

ES valuation not accepted as robust

One of the challenges to early projects in GB was the concern that i-Tree Eco would not be applicable to GB environments as it was developed in the US. Further, as a relatively new field, the financial valuation of ES may not be seen as robust (Billé et al., 2012; Baró et al., 2014). As the first project in GB, Torbay faced this challenge the most and addressed these concerns in its report (Rogers et al., 2011), helping i-Tree Eco to be accepted as a valuation tool in GB (Natural England, 2013). This has paved the way for all subsequent i-Tree Eco projects. However, although i-Tree Eco projects have been adopted across GB, some people may still not accept the values as being robust enough on which to base policy changes (Billé et al., 2012). Such attitudes may change in the future as environmental valuation is integrated more into national and local decision-making, a move advocated for by UK government (HM Government, 2018).

Staff changes interrupting project continuity

Wrexham's i-Tree Eco evaluation noted difficulties including staff changes. Such difficulties could make projects lose continuity, existing connections between departments and momentum to implementing practise and policy changes (Jaluzot & Evison, 2016).

6.3. Recommendations

Integrate with development or revision of a Tree and Woodland Strategy

i-Tree Eco projects which were aligned to the revision of a Tree and Woodland Strategy have had their report's findings quickly adopted to inform policy and urban tree management. In some projects, no Tree and Woodland Strategy has been developed since the i-Tree Eco report, limiting opportunity to achieve instrumental impact. In one project, Tawe catchment, the opportunity to inform a new strategy seems to have been missed despite close timing between the two. This timing of i-Tree Eco project with policy development was the main take-away message from the evaluation of Wrexham's i-Tree Eco project where this approach helped findings to be quickly made use of and also helped drive forward the publication of the new strategy (Jaluzot & Evison, 2016).

Align with multiple council interests

Urban trees relate to many departments within councils, which can both affect urban trees (e.g. planning, housing) and/or can benefit from urban trees (e.g. health, climate change). i-Tree Eco findings help to demonstrate the relevance of trees to these departments (Jaluzot & Evison, 2016), but enhanced collaboration with i-Tree project teams and wider council departments could help to adapt i-Tree Eco projects so they align with main council interests at this time. Such collaboration could inform the scale of data collection to ensure it is relevant to key areas of interest by different departments and thus support the use of i-Tree Eco findings in these departments' future plans and policies.

Make report and data widely available

The use of the six case study i-Tree Eco projects reports by groups external to the project team, such as citizen groups, non-government organisations and other public bodies, has helped to raise awareness of urban forests and their role in supporting healthy and sustainable urban environments. These studies have provided evidence for these groups to back-up claims with quantitative and financial figures for the benefits of trees. The secondary use of i-Tree Eco findings such as reports addressing pest and disease threats and green infrastructure help to place i-Tree Eco results into a wider context of the urban forestry topics as well as diversifying audiences. In the US, third sector groups have played an important role in supporting urban forestry change and implementation of planting and management strategies (Seamans, 2013). For local citizen groups, such as tree wardens, this information provides material for advocacy for trees which they can take to councils (e.g. Wandsworth Tree Wardens, 2017).

Making the report and its data more available and engaging with local groups during the i-Tree Eco projects affords greater opportunity for wider use of findings (Moffat, 2016). One simple step is making the reports and findings available on council websites. During the period of this review, only Sidmouth Arboretum and City of

Edinburgh Council out of the six case studies described their i-Tree Eco project on their websites.

Improve public awareness and engagement with projects

i-Tree Eco projects can help to engage the public with their urban forest by providing financial estimates of the ES they provide, raising awareness of the threats that face them and offering opportunities to improve skills through participating in tree surveys (O'Brien, 2015; Moffat, 2016). A more engaged local population can lead to greater community input and support for urban forest management and overcome the negative perception of trees (Britt & Johnson, 2008; Moffat, 2016). Engaged local populations can be important in supporting urban forestry planning, maintenance and investment. Sidmouth Arboretum provides an example for what such groups can do; after leading their own i-Tree Eco report, they plan to develop a community tree strategy (Sidmouth Arboretum, 2014).

Repeat surveys to allow trends to be identified

Previous and future projects should consider and plan for the use of i-Tree Eco as a long-term monitoring tool to track changes in urban forest and evaluate the effectiveness of management strategies. Repeated i-Tree Eco surveys help to set definitive targets such as for urban tree canopy cover, and key urban forest health indicators such as tree size, condition and species diversity which can help build a more accurate picture of trends in the urban forest (City of Toronto, 2013; City of Sydney, 2013). Subsequent policies can then take a more proactive role in tackling identified local trends.

Improve communication of report findings

The communication of i-Tree Eco findings can be improved by tailoring reports to the interests of key audiences and ensuring the length, language and design is appropriate to that group. Methods of dissemination have changed from the first project, Torbay, where a single technical report was produced, to later projects which added shorter summary reports and one-page infographics (e.g. Bridgend and Tawe catchment) with the aim to increase readership and make findings more digestible. Additionally, moving from simply reporting findings to integrating how ES can relate to local issues is recommended (Moffat, 2016). Future projects should undertake a review of their key stakeholders and develop a communications plan to ensure that each is appropriately engaged.

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