Environmental Research 156 (2017) 97–107

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Challenges for tree officers to enhance the provision of regulating ecosystem services from urban forests

Helen J. Davies[a,*], Kieron J. Doick[b], Malcolm D. Hudson[a], Kate Schreckenberg[a]

[a] Centre for Environmental Sciences, Faculty of Engineering and the Environment, University of Southampton, Highfield Campus, University Road, Southampton SO17 1BJ, United Kingdom

[b] Urban Forest Research Group, Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH, United Kingdom

ARTICLE INFO

Keywords:
Ecosystem services approach
Disservices
Climate change
Air pollution
Local authorities

ABSTRACT

Urbanisation and a changing climate are leading to more frequent and severe flood, heat and air pollution episodes in Britain's cities. Interest in nature-based solutions to these urban problems is growing, with urban forests potentially able to provide a range of regulating ecosystem services such as stormwater attenuation, heat amelioration and air purification. The extent to which these benefits are realized is largely dependent on urban forest management objectives, the availability of funding, and the understanding of ecosystem service concepts within local governments, the primary delivery agents of urban forests.

This study aims to establish the extent to which British local authorities actively manage their urban forests for regulating ecosystem services, and identify which resources local authorities most need in order to enhance provision of ecosystem services by Britain's urban forests.

Interviews were carried out with staff responsible for tree management decisions in fifteen major local authorities from across Britain, selected on the basis of their urban nature and high population density. Local authorities have a reactive approach to urban forest management, driven by human health and safety concerns and complaints about tree disservices. There is relatively little focus on ensuring provision of regulating ecosystem services, despite awareness by tree officers of the key role that urban forests can play in alleviating chronic air pollution, flood risk and urban heat anomalies. However, this is expected to become a greater focus in future provided that existing constraints – lack of understanding of ecosystem services amongst key stakeholders, limited political support, funding constraints – can be overcome.

Our findings suggest that the adoption of a proactive urban forest strategy, underpinned by quantified and valued urban forest-based ecosystem services provision data, and innovative private sector funding mechanisms, can facilitate a change to a proactive, ecosystem services approach to urban forest management.

1. Introduction

Urbanisation (particularly densification) is increasing the risk of flooding (Eigenbrod et al., 2011) and extreme heat episodes (Lemonsu et al., 2015) in Europe's cities due to the loss of urban greenspace (Davies et al., 2011). In Britain, the government's latest Climate Change Risk Assessment reveals the greatest climate change threats to the country to be flood and heat-related risks to communities and businesses (Committee on Climate Change, 2016). Air pollution is also a problem in many densely populated cities, particularly in more deprived areas (Netcen, 2006), and is forecast to be an increasing public health concern as the climate warms (De Sario et al., 2013).

Concern about the impacts of climate change on urban environments has led to a growing interest in regulating ecosystem services, which can pose an effective solution to some of the negative impacts of urbanisation (Andersson et al., 2014). Ecosystem services, or "the benefits people obtain from ecosystems" (MEA, 2005), are categorised into provisioning services (such as provision of food and timber), regulating services (such as air purification, heat amelioration and stormwater attenuation), cultural services (such as public amenity and opportunities for recreation) and supporting services (such as soil formation and habitats for wildlife) (MEA, 2005). This paper focuses on regulating services, which are of particular relevance to combating climate-related impacts on urban environments.

Within urban areas, regulating ecosystem services are provided predominantly by the urban forest (Davies et al., 2017), defined as "all

* Corresponding author.
E-mail addresses: hjd1g15@soton.ac.uk (H.J. Davies), Kieron.Doick@forestry.gsi.gov.uk (K.J. Doick), mdh@soton.ac.uk (M.D. Hudson), K.Schreckenberg@soton.ac.uk (K. Schreckenberg).

http://dx.doi.org/10.1016/j.envres.2017.03.020
Received 13 September 2016; Received in revised form 7 February 2017; Accepted 15 March 2017

forest and tree resources in (and close to) urban areas" (Konijnendijk, 2003: 177). This is because, in comparison with other forms of green infrastructure, trees and forests are particularly effective at alleviating summer heat through evaporation, photosynthesis and shading (Doick and Hutchings, 2013); reducing stormwater run-off by intercepting and absorbing water and improving infiltration (Armson et al., 2013); and enhancing air quality by intercepting and/or absorbing gaseous pollutants and particulate matter (Escobedo and Nowak, 2009). On this basis, urban forests could be posed as a 'nature-based solution' for sustainable urbanisation and climate change adaptation in European cities (European Commission, 2015).

The urban forest can also have adverse effects on society – these 'disservices' are defined as "functions of ecosystems that are perceived as negative for human well-being" (Lyytimäki and Sipilä, 2009: 311). Some of the most frequently reported disservices provided by urban forests are increased ground-level ozone through the emission of biogenic volatile organic compounds, the blocking of light and heat, tree root-induced damage to infrastructure, a risk of injury or damage from tree or branch fall, and pollen-associated allergic reactions (Roy et al., 2012). Trade-offs between the ecosystem services provided by urban forests can also occur, particularly between regulating and cultural services, leading to a reduction in expected benefits (Bennett et al., 2009; Davies et al., 2017). Handley and Gill (2009) suggest that for urban forests to better help British urban society, it is necessary to address the information gap on the nature and extent of each local authority's urban forest, and to conduct further research on decision support systems which improve understanding of ecosystem services and associated economic benefits.

Matthews et al. (2015) reveal that there has been a wealth of literature published on the biophysical capacity of green infrastructure to help cities adapt to climate change, but that socio-political factors (including governance, funding and public involvement) are poorly understood. 'Path dependence', whereby decision-makers favour fixed patterns of thinking and lack motivation to respond meaningfully to new problems and solutions, is identified as a significant constraint to embracing green infrastructure (Matthews et al., 2015). Surveys of urban forest professionals in England (Trees in Towns II) and Scotland (TWIST) suggest that urban forest management is reactive to human health and safety concerns (Britt and Johnston, 2008; Van der Jagt and Lawrence, 2015); these studies did not consider the extent to which local authorities also target ecosystem service delivery or climate change adaptation.

The purpose of this study is to identify constraints and drivers to British local authorities adopting an ecosystem services approach to urban forest management. To this end, four research questions are posed:

a) What are the main objectives for urban forest management in Britain*
b) Do tree officers in British local authorities manage their urban forests for regulating ecosystem services and, if so, why and how*
c) What are the opportunities and constraints for British local authorities to move from a risk/reaction approach to an ecosystem services approach*
d) How might tree officers in British local authorities promote an ecosystem services approach going forwards*

2. Materials and methods

2.1. Data collection

Telephone interviews were carried out with a staff member responsible for managing local authority-owned trees (hereafter referred to as 'tree officer', actual job title varied) in each of 15 urban local authorities from across Great Britain. This figure represents a response rate of 54%, with 28 local authorities having been contacted by email (generally via their 'parks departments'). These local authorities were selected on the basis of them meeting three criteria:

a) Unitary authorities or metropolitan districts, i.e. those responsible for all local government functions within their area under a single-tier administrative system.
b) Classed as being urban – in England this includes authorities in classes 4, 5 and 6 of Defra's Rural-Urban Classification system (Defra, 2014), whilst for Scotland and Wales 'urban' refers to settlements of at least 3000 and 10,000 people respectively (ONS, 2005; Scottish Government, 2014).
c) A high population density to reflect the densification of urban areas being associated with environmental problems (this was set at a minimum of 25 persons per hectare).

The interviews were semi-structured, with tree officers answering 32 open and closed questions that they were provided with in advance. The full list of questions is provided in Appendix A. Questions were grouped into five categories: urban forest resource; approach to urban forest management; ecosystem services provided by urban forests; governance; and urban forest funding. Prompts and follow-up questions were employed where the response was considered incomplete or unclear, or if a point of particular relevance to the study was raised (following: Foddy, 1993). Interviews were recorded and lasted for 54 min on average, ranging between 33 and 83 min. Where available, local authority policies relating to trees were analysed for specific mentions of ecosystem services.

2.2. Data analysis

The interview recordings were transcribed verbatim and edited to remove repetitions, stop words and habitual irrelevant phrases, whilst retaining accuracy. The transcripts were then analysed in the software package 'Nvivo v.10' (QSR International, 2012) using a thematic approach, following the process outlined by Braun and Clarke (2006). A full list of themes, codes and their descriptions is provided in Appendix B. Direct quotations were then selected to illustrate the key points being made within each theme, as suggested by Braun and Clarke (2006). Comments from participating tree officers have been anonymised; as such, they are identified as 'TO1' up to 'TO15' rather than ascribed to particular named local authorities.

Quantitative analysis was also performed where appropriate, and is presented in the form of frequencies and percentages. For example, in Tables 1–4, 'No. of refs' refers to the number of times the particular sub-theme (i.e. Nvivo code) appeared throughout the entire dataset, allowing comparison of code frequencies (Guest et al., 2012). In order to give an indication of the proportion of participants who addressed each sub-theme, the number and/or percentage of the 15 tree officers who commented on a particular topic at any point during the interviews is also provided in the tables, as well as elsewhere in the text (Toerien and Wilkinson, 2004). Whilst high frequencies or percentages are not necessarily a measure of significance (Toerien and Wilkinson, 2004), they offer an indication as to which concepts or situations experienced by tree officers are most commonly reported, and may therefore be expected to be shared amongst other tree officers.

Geographic, population and tree-related data (i.e. geographic location, geographic size, population size, population density, adoption of a tree strategy, tree canopy cover, and tree budget per head of population) were also collected for each of the interviewed local authorities. This was to enable identification of city characteristics that may have influenced the tree officers' responses with regards to particular themes. Local authorities were grouped into those strongly representing a theme, and those representing the opposite (some authorities fell outside of these extremes and so were removed from further analysis). Detail on the process of the (non-statistical) analysis is provided in Appendix C.

3. Results

Interviews were carried out with 15 local authority tree officers (identified below as TO1 to TO15) from densely populated cities across Great Britain. The interviews revealed many similarities but also some differences in their approaches to urban forest management and the constraints that act upon them. In general, responses seemed to be unrelated to the geographic, population and tree-related characteristics mentioned above, however some loose relationships were observed. The three cities identified as having proactive urban forest management were generally less (densely) populated and more likely to have tree strategies (either adopted or in development) than the reactive cities. The three cities considering regulating ecosystem services in their urban forest management were amongst the larger cities in the sample (in terms of area and population), with higher than average tree canopy cover and tree budgets. Interestingly, these three cities were also all in the group experiencing environmental issues. Finally, cities facing constraints to ecosystem service-focused management were less likely to have tree strategies and had lower budgets than those without such constraints. Additional results can be found in Appendix C.

3.1. Urban forest management focused on reducing risk and reacting to complaints

A high proportion (67%) of the tree officers interviewed indicated that they have a reactive approach to managing their urban forest (Table 1). Much of their time and financial resources are taken up by survey and maintenance activities to reduce the risk of trees causing injury to people or damage to property, and responding to complaints from the public about tree disservices. Addressing health and safety concerns was the dominant theme across the interviews – it was mentioned by all participants and a total of 65 times. All of the interviewed tree officers except TO9 indicated that they have received complaints about tree disservices (a total of 51 references). Undertaking management actions on a reactive basis was mentioned 35 times by all but TO9 and TO12.

When discussing the subject of 'complaints about disservices', tree officers generally did not mention specific disservices but referred to complaints and problems caused by trees, and reducing conflicts between people and trees. When specific disservices *were* mentioned, blocked sunlight came up as the most common disservice (13 references), followed by leaf fall (7), blocked TV signal (5), sap/honeydew falling onto cars (3), damage to buildings (3), creation of fear/anti-social behaviour (3), blocked views (2), blocked access to premises (2), damage to pavements (2), and bird droppings falling onto cars (2). Complaints about tree disservices are generally raised by citizens, with only a few tree officers reporting to have received complaints from businesses.

3.2. Managing urban forests for regulating ecosystem services

All interviewees were aware of the concept of ecosystem services, though to differing levels. When asked an open question about which ecosystem services they thought their urban forest was providing, 13 tree officers (87%) referred to specific regulating services; the other two (TO11 and TO12) only mentioned the aesthetic benefits that trees provide. Both TO11 and TO12 did however make a single reference to regulating ecosystem services at other points in the interviews: TO11 reported that both engineering work and trees should be used to address flooding; whilst TO12 recalled that a business had once contacted the council interested in planting trees to help offset their carbon emissions. Air purification and stormwater attenuation were quoted more often than heat amelioration. TO3, TO7 and TO13 in particular suggested that heat amelioration was more relevant to London or southern European cities.

When tree officers were asked to what extent their department takes an ecosystem services approach to urban forest management, seven (47%) stated that such an approach is not taken. Three (20%) said it is taken into account but is not a priority, whilst five (33%) said that is taken seriously within the tree team, but not across the wider council. However, when tree officers were asked how technical or scientific

Table 1
Comments from local authority tree officers relating to taking a reactive approach to urban forest management.

Sub-theme	No. of TOs	No. of refs	Example responses from local authority tree officers
Theme: Addressing health and safety concerns			
N/A	15	65	*"We survey for health and safety, so that's the overriding policy as we have a duty of care to discharge, that's our primary reason. Obviously we need to look after our trees so that they don't hurt or damage anyone." (TO1)* *"[For] street trees particularly, it's more about risk – physical risk to property or people, or subsidence risk. And a lot of our street trees are managed to counter that. [For] park trees and woodlands, there's nowhere near the same level of focus." (TO12)*
Theme: Complaints about tree disservices			
General complaints	12	36	*"Citizens, our valued customers, don't seem to value trees at all most of the time... it's 'get rid of the trees cos they're just a nuisance to us as residents'." (TO8)* *"A lot of the trees that are still standing shouldn't be... they're not desirable, they're in the wrong place, they're doing the wrong thing, but we haven't got the money to get rid and we haven't got the money to replace." (TO11)*
Specific disservices	10	16	*"Businesses on the whole aren't as tree friendly I find, always wanting frontages clearing, signs unblocked, so trees are often seen as a nuisance to their business." (TO14)* *"For things like leaf litter, loss of light, shading, people want trees removed and they don't see the benefits of them." (TO4)*
Influence on management	8	14	*"Local elected members and the perceptions that they have... can be negative if they get a lot of people complaining about trees in a particular area; we could be under quite a lot of pressure to manage them more severely than we would (like)." (TO1)* *"People start to object to having a woodland on their boundary cos... it's quite a barrier to natural light – but also because of this problem of antisocial behaviour in them. So we often have to manage woodlands to create a zone so that they're not in contact with properties." (TO3)*
Theme: Reactive approach to urban forest management			
N/A	13	35	*"We're regularly and routinely carrying out visual tree inspections, but that tends to be on a tree-by-tree and location-by-location basis and also depends on the enquiries that come in... we're very much enquiry-led." (TO10)* *"There is a reactive, 'oh god that tree's just dropped a branch and we need to do something about it' kind of management." (TO8)*

Table 2
Comments from local authority tree officers relating to drivers for considering regulating ecosystem services in urban forest management.

Sub-theme	No. of TOs	No. of refs	Example responses from local authority tree officers
Theme: Understanding of environmental issues			
Air pollution/purification	13	40	*"We're a major transit city for both international and national travel – so we've got attacks on all sides in terms of air quality. I do believe that local air quality can be significantly improved by local tree planting. All the scientific research seems to be pointing in that direction." (TO6)* *"We're most concerned about the absorption of pollution... If you can increase the volume of your tree cover you can increase the abatement of air pollution... It would be the size of the tree, the variety of tree. We know for example that London planes [Platanus×acerifolia] have a much better pollution abatement function than Pyrus chanticleer." (TO9)*
Flooding/stormwater attenuation	11	37	*"We've particularly got issues in [the city] about flooding, and we now work very closely with the flood team... regarding flood alleviation schemes in our parks and that comes along with associated planting." (TO14)* *"There is flooding in certain areas of [the city] but there is no doubt that tree cover, both street trees and woodland, is increasing the time it takes for the rainfall to reach the water courses... If there is a flooding issue, we can plant trees that are much more efficient at transpiration... [such as] alder [Alnus sp.] and willow [Salix sp.]." (TO7)*
Heat islands/amelioration	10	23	*"I would love to see more street trees go in to reduce the heat in the inner city... Trees casting shade and lowering the temperature would be fantastic." (TO8)* *"There's an industrial area along the [motorway] where there's a huge heat island... and that coincides with very few trees - so as new developments are going in there we're trying to encourage tree planting in those." (TO15)*
Theme: Political support for trees			
Advocates in high places	9	18	*"What we do every year is we will report what wasn't done, and on that basis we were actually told to spend more this year than last... We happened to have got a lot of political support and in a time of declining budgets that's quite unusual to be given additional money when other departments are losing resources." (TO3)* *"Our director of public health is an absolute fanatic about improving people's quality of life and [is] adamant about planting trees. So I've kind of got people in high places on my side." (TO8)*
Adoption of tree strategy	6	11	*"We make the case – the tree policy is there – we say this is what we're going to do, and the various departments need to put the money forward for that." (TO15)* *"Hopefully through pushing forward the strategy, (local air quality) will become a greater focus." (TO6)*
General political support	7	9	*"I know CABE Space were putting out information on trees, and the Landscape Institute has tried – some politicians have bought into that." (TO9)*
Supportive planning policy	5	6	*"I think probably the biggest advantage is that we do have some clout through planning... That's our biggest lever for making sure we do get trees in the city." (TO1)* *"We have some very strong policies to deal with protecting trees. So the default is that trees shouldn't be removed unless there's a good reason, and if we do conclude that it is right to remove trees then we have a standard which requires up to 8 trees to replace any 1." (TO5)*

information is used to support urban forest planning and management, only one tree officer mentioned ecosystem services:

> *"We are keeping an eye scanning in terms of what research is out there and what relevance it has to us as a city, and then there's that more progressive research which is game changer stuff in terms of the ecosystem service stuff. So rather than it being just a tree issue, I'm quite interested in how we as a city might benefit from an ecosystem service based approach." (TO5)*

The interviews revealed few examples of tree officers actively managing their urban forests for any of the regulating ecosystem services. For example, TO1 suggested that whilst specific objectives to enhance air quality and stormwater attenuation supported urban forest retention, on a day-to-day basis their influence on tree management and maintenance was very limited. In contrast, TO5 had specific objectives to enhance air quality and stormwater attenuation and, in this case, providing these ecosystem services dictated the choice of species and location (though this was a subjective decision as the benefits were not quantified):

> *"The first question we ask anybody when we're talking about trees is not 'what species do you want to plant and where do you want to plant it' but 'what outcomes do you wish to achieve from the tree that you wish to plant*' So you're looking to achieve, and from those benefits you can then play it back in terms of how the species and the orientation of the trees will then better provide those outcomes". (TO5)*

Two tree officers (TO5 and TO15) were using GIS data to highlight spatial correlation between tree canopy cover and environmental issues such as flooding, air pollution, and heat island effects. TO5 had made use of this data in an attempt to influence local plan decision making, whilst TO15 was using the data to support tree planting in certain locations. Finally, TO10 was using the results of an i-Tree Eco[1] study to justify the benefits of trees when dealing with complaints from members of the public.

Of the fifteen local authorities investigated through this study, only four (27%) have adopted overarching tree strategies (published between 2002 and 2012). The tree officers said that ecosystem services are referred to in these strategies, however they did not provide any examples of how this influences tree management or enhances provision of these services. In the case of two strategies, published in 2002 and 2004, this is not surprising given that these predate much of the ecosystem services literature. Indeed, the strategy adopted in 2002 refers to tree benefits (including improved air quality and noise mitigation) only in its introduction. The 2004 strategy improves on this, containing a whole chapter on the environmental and social benefits of trees, however only visual amenity and wildlife conservation make it into the long list of strategy objectives.

One of the strategies, published in 2010, puts particular emphasis on the heat and flood regulation benefits of urban trees. For example, the strategy recommends large canopy species for addressing these problems and seeks to plant the right trees in the right places to maximise their effect. Finally, the 2012 strategy emphasises the contribution the city's trees make to the Council's wider strategic priorities of quality of life and climate change adaptation and mitigation. It includes a chapter detailing all the benefits that urban trees

[1] i-Tree Eco is a software application developed in the USA that uses data collected in the field to quantify the structure and environmental effects of urban trees, and calculate their value to society (USDA Forest Service, 2016).

provide, linking these with evidence on recommended species and tree and canopy sizes as well as some economic values of ecosystem services. Despite this, the strategy's nine-page action plan makes only three indirect references to ecosystem services, with "actively communicate the benefits of the urban forest to communities, colleagues and businesses" being of particular note.

Evidence of active tree management to enhance regulating ecosystem services in the study cities was rare. However, the interviews revealed that these qualities are certainly on the radar, fuelled by two main drivers. The first is the presence of environmental issues, such as flooding, in their cities and an understanding by the tree officers that trees can help to alleviate such issues. This driver was mentioned 56 times in total and by all but one tree officer. The second driver was political support for trees and the benefits they provide (mentioned 43 times and by all but one tree officer). Evidence from the interviews for both of these drivers is provided in Table 2.

3.3. Constraints to proactive, ecosystem service-focused management

There was widespread dissatisfaction amongst those interviewed with their reactive approach to urban forest management. Tree officers expressed a desire to move towards more proactive management, planned to enhance ecosystem service provision and reduce complaints. For example, one tree officer commented:

> *"We want to be much more aspirational. Obviously change people's minds about the value of trees and the multiple values and the benefits they can have as long as they're in the right place… (B)ut the disadvantage at the moment is… we're just maintaining a status quo, fire-fighting if you want to call it." (TO7)*

The tree officers were hopeful that the future would offer a greater focus on managing urban forests for regulating ecosystem services, but recognised that such a change would not be easy. NVivo analysis showed that constraints to moving towards an ecosystem services approach fell into four categories:

a) Funding constraints: 67% of interviewed tree officers said that their budgets had decreased, typically by 33–50%, in recent years;
b) Unsupportive governance structures: coordination and information-sharing between departments was a particular issue;
c) People not taking trees seriously: this was apparent both within the council and amongst citizens and businesses; and
d) Limited understanding of ecosystem services amongst stakeholders: relating to poor communication and education.

Each of these categories was raised by a majority of those interviewed – example responses are provided in Table 3.

3.4. Promoting an ecosystem services approach

A number of suggestions were made by the interviewed tree officers about how they plan to address some of the constraints to taking an ecosystem services approach to urban forest planning and management going forwards (Table 4).

Most of the tree officers (54%) would like a comprehensive evidence base on local ecosystem service delivery and value to present to senior council staff; they felt that only an economic case for trees would increase political support and funding. Using such information to improve the perception of trees amongst citizens was also considered beneficial, though this was only mentioned by four tree officers (27%). A third of respondents were of the opinion that their department would take more of an ecosystem services approach in future if the benefits provided by their trees could be quantified in some way to improve understanding, while 33% also said that they would use information on ecosystem services directly to improve tree management:

> *"It was in the last few months that I read about that stuff (some species being 30% more efficient at removing water from the ground) and that has really improved my knowledge of the kind of things we need to do." (TO7)*

When asked specifically about whether (and how) a change to their urban forest could enhance provision of ecosystem services, all but one tree officer (TO12) thought it could. The most common suggestion of how to increase ecosystem service provision was to plant more trees in tree-deficient areas (60% of respondents), followed by ensuring the right type of tree is planted and managed in the right place (27%), increasing tree species diversity (also 27%), and improving the health and condition of the tree stock (20%). One respondent (TO2) suggested

Table 3
Constraints to undertaking an ecosystem services approach to urban forest management as perceived by tree officers.

Sub-theme	No. of TOs	No. of refs	Example responses from local authority tree officers
Theme: Constraints to undertaking an ecosystem services approach			
Funding constraints	10	36	*"There's a lot of politician speak about the benefits of trees… but quite often the money's only available for the actual capital and nothing's available for the revenue. So when these schemes come about they become a real drain to try and deliver." (TO11)* *"Well as a department we're very well aware [of ecosystem services] and we do and try and focus on it, but we're working against cuts in budgets and particularly our planting budget." (TO6)* *"I think we've unfortunately had to get more reactive because of the reduced budget." (TO14)*
Unsupportive governance structures	9	21	*"We're not working well enough with highways, with housing and planning to come up with a concerted joint effort on all of this… That probably goes from the fact that there's been a disjointed tree services department for the last 3 or 4 years and so no-one's been moving that agenda forward." (TO4)* *"There's a new (building) that's been built in the centre of town which has involved the removal of about 20 really nice healthy trees, but we weren't consulted on it at all." (TO13)*
People not taking trees seriously	11	20	*"We don't have a policy or a strategy at the moment… a cabinet member didn't like it – it was a bit too green for them unfortunately so it was never adopted… I think they think we're all a bunch of tree huggers here, and if we find out too much we're going to go around everywhere and put TPOs on all the trees." (TO13)* *"Some companies, I was trying to convince them to have tree planting around their development, and they were like 'we're going to have none of that because they'll encourage birds and birds will make a mess'. They wouldn't care about the other benefits." (TO15)*
Limited understanding of ecosystem services amongst stakeholders	11	17	*"I think [the council] probably would be interested in the air quality issues, but I don't think that link has been made strongly enough". (TO2)* *"I think we've got an education lack within the city; we don't sell the benefits of our trees to our citizens at all well at the moment." (TO4)*

Table 4
Suggestions made by tree officers for adopting an ecosystem services approach to urban forest management.

Sub-theme	No. of TOs	No. of refs	Example responses from local authority tree officers
Theme: Promoting an ecosystem services approach			
Awareness raising	13	31	*"Until you've actually got facts and figures and scientific information to present to people, you can't just say, 'well we'd like trees because they're nice'... So 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." (TO1)* *"By putting a capital value on the ecosystem services they provide... that puts them [back] in the black." (TO15)* *"I've seen ideas in the States where they put a label on trees... [saying] 'this tree is worth £2000', and then they itemise why it is worth £2000. It really brings the value of that tree to people, and that potentially would act as a driver for business and people to sponsor the tree realising the tree value." (TO7)*
Novel funding streams	11	23	*"I think that anyone who lives, works or visits the city should in some way – even if it not be financial – should contribute. Particularly big industry... I would like to see them paying proportionately more because the impact they have is huge." (TO1)* *"There may be some arguments we can make which is that we are providing a benefit that is free and maybe it shouldn't be free going forward, and we should be trying to provide a payment system for that... We are thinking about creating a brokering system called something like a Natural Capital Trust." (TO5)* *"A lot of money within the council is allocated around public health... the air cooling, air cleaning, de-stressing factors are reducing the need for medical intervention for people; ecosystem services are providing those benefits to people, so can we lever in some [of that] money*" (TO15)*
Strategic planning	9	22	*"I think the first thing we want is a really intelligent strategy about what we want to do for the next 50 years... The priority would perhaps be restocking the city centre with trees that deal with air pollution and perhaps focusing on reducing flooding because we're anticipating more intense rainfall events with climate change." (TO7)*

a need for larger trees.

A greater understanding of the ecosystem services provided by trees was considered an important factor to help fund urban forestry activities. With recent cuts to local authority tree budgets across Britain, tree officers are starting to look to the private sector for financial support: 67% of interviewed tree officers already receive small contributions to their budget from corporate sponsorship, sale of tree management services to property owners, and corporate social responsibility activities. As such, the majority of those interviewed (73%) were keen to investigate the possibility of adopting some sort of 'beneficiary (or polluter) pays' approach. Eleven tree officers (73%) were of the opinion that businesses should contribute (e.g. through mitigation funds, sponsorship, environmental taxes, or planting on their own land), whilst 67% thought that citizens should contribute (via sponsorship, environmental taxes, community grants, or voluntary work). However, several tree officers had concerns around asking private stakeholders to pay the council for benefits that they already receive, and already contribute towards via council tax and business rates. Four tree officers thought some form of collaborative partnership, involving for example businesses, citizens, tourists, schools, public health and even other government entities may work, based upon beneficiaries paying for the ecosystem service benefits that they receive.

4. Discussion

4.1. Urban forest management focused on reducing risk and reacting to complaints

The typical approach to urban forest management in Britain is currently reactive, risk averse and complaints-driven. Eight tree officers (53%) placed an emphasis on austerity, introduced by the British government in 2010. Austerity reduced the money local authorities had available to spend over the period to 2015 by 22.2% (Innes and Tetlow, 2015), and while spending on statutory services (for example, social care) was fairly well protected, spending on non-statutory environmental services fell by 48.6% in this period (National Audit Office, 2014). Two-thirds of interviewed tree officers had seen their budgets decrease in recent years. A duty of care of society to reduce health and safety incidents meant that maintaining a healthy tree stock would always be a key priority for tree officers (regardless of funding). However, the provision of ecosystem services is not a statutory duty, but a 'luxury' (Mell et al., 2013), even for 'aesthetic enhancement' unless the tree has been placed under a preservation order.

Austerity cannot shoulder the blame entirely, however. The Trees in Towns II survey revealed an average of 71% of tree maintenance work in England is carried out in response to health and safety risks or complaints from the public (a similar figure of 75% was reported by Scotland's TWIST study), but interestingly, the Trees in Towns II reporting period of 1999–2004 actually saw an overall *increase* in tree budgets (Britt and Johnston, 2008; Van der Jagt and Lawrence, 2015). One tree officer (TO8) said: *"To my knowledge it's always been this way – which is worrying"*, and suggested other factors are at play. Indeed, reactive management is fairly common in public administration. Boyne and Walker (2004) note that public sector managers tend not to make changes unless forced to do so by outside pressures, and Bevan and Hood (2006) suggest that the UK government and health care professionals actively seek improvements to health services only where targets have been set, often to the demise of performance elsewhere. Similarly, Low and Carney (2012) show that local authorities in New South Wales, Australia took a proactive approach to the most important environmental issues (water and waste management), whilst lower priority issues (air and noise pollution) received only reactive management. The authors also suggest a correlation between reactive management and smaller budgets (Low and Carney, 2012).

Prior to 2007, policy of the UK's Department for Environment, Food and Rural Affairs (Defra) was often "driven by influential lobby groups and short-sighted responses to public crises" (Rothstein and Downer, 2012: 785). Under the subsequent Labour (Blair) administration, decision-making across the UK Government (including Defra) became increasingly risk-based and focused on delivering strategic objectives (Rothstein and Downer, 2012). However, the authors report that such policy making didn't reduce 'surprises', it only created an illusion of consistency. Indeed, an investigation into the Government's treatment of floods in England found that "Parliament[ary] funding was initially cut and only increased due to the reactive funding injection following the winter 2013–2014 floods" (Environmental Audit Committee, 2016: 3). Despite further flooding, flood risk management reportedly remains reactive (Environmental Audit Committee, 2016).

A lack of strategic planning was apparent in the responses of the tree officers interviewed in this study. Only four of the 15 study cities currently have tree strategies in place, and two of these are well over a

decade old. Without a formal tree strategy – or other tree-related policies of a strategic nature – tree officers have little or no involvement in delivering their council's strategic policy. A key shift towards proactive management would come from the integration of trees and greenspaces into delivering the Council's wider strategic objectives. A number of tree officers shared this reasoning, for example:

> *"As there isn't a management plan, there aren't any objectives." (TO8)*

In overview, the non-statutory nature of a tree officer's duties (aside from risk management) has resulted in unprotected council tree budgets, low or non-prioritisation of strategic planning of the urban forest, and the continuation of a reactive approach to urban forest management. The interviews further suggested that urban trees are often seen and treated in a negative manner, with little focus being placed on finding solutions to specific disservices. This is concerning as a notable proportion (47%) of the tree officers interviewed revealed that complaints from citizens and businesses can have a strong influence on day-to-day management, even where it goes against their own better judgement. A counter to this would be a focus on positive and proactive urban forest management (planting and managing the right type of tree in the right place), so that ecosystem service benefits are enhanced and disservices (and thus complaints) are reduced (see for example Davies et al., 2017). How this may be achieved is discussed below.

4.2. Managing urban forests for regulating ecosystem services

The interviews revealed that the majority of tree officers do not currently manage their urban forests for regulating ecosystem services, though there is a desire and an understanding of the benefits that can be achieved from doing so. The Trees in Towns II (Britt and Johnston, 2008) and TWIST (Van der Jagt and Lawrence, 2015) surveys provided no evidence to suggest that an ecosystem services approach is being taken in England and Scotland respectively. Together with the current study, this suggests that (with exceptions such as TO5) regulating ecosystem services are not currently a priority in the day-to-day management of Britain's urban forests.

Political support from a local authority's councillors and senior management was revealed as a potential driver for a move towards proactive, ecosystem services-based urban forest management, although such support was not always forthcoming. Tree strategies had only been adopted in 27% of the study cities, suggesting little progress since the Trees in Towns II survey revealed that only a quarter of responding English local authorities had published tree strategies (Britt and Johnston, 2008). However, there is progress in the *content* of tree strategies, with those published most recently in Britain addressing ecosystem services (particularly those relating to climate change adaptation) in their visions, aims, objectives and policies (Bournemouth BC, 2014; Wrexham CBC, 2015; Cambridge CC, 2016; Walsall C, 2016). A key driver for this might be the UK Government's National Adaptation Plan which encourages city councils (particularly those with large and/or dense populations) to improve climate resilience through enhancements to green infrastructure (Defra, 2013). Cambridge and Wrexham councils have additionally used tree canopy and i-Tree Eco surveys to inform their policies (Wrexham CBC, 2015; Cambridge CC, 2016).

Examples from Europe suggest that progress is mixed: strategies in Barcelona and Dublin refer to ecosystem services only in passing (Barcelona CC, 2011; Dublin CC, 2016). Helsinki's puts 'securing ecosystem services' as its main objective, though delivering this only amounts to considering the effects of decision-making on the long-term vitality of ecosystem services provision (City of Helsinki, 2014). Sweden, Denmark and Switzerland all prioritise the provision of cultural services (e.g. recreation and education) in their objectives for urban woodland management (and to a lesser extent nature conservation), but regulating services receive very limited explicit attention (Nielsen et al., 2013; Wilkes-Allemann et al., 2015). However, Capotorti et al. (2016) suggest that the (regulating) ecosystem services provided by urban forests have been gaining increasing attention in Europe since publication of the EU green infrastructure strategy (EC, 2013). Using a case study of Rome, the authors report that scientific information on noise mitigation, temperature regulation and air purification has been incorporated into technical guidelines for tree planting in the city (Capotorti et al., 2016).

Urban forest strategies are more common in the USA, Canada and Australia, and (regulating) ecosystem services are addressed more convincingly. In Australia, tree strategies have placed emphasis on enhancing tree benefits, with Melbourne seeking to reduce the urban heat island effect through increasing canopy cover (City of Melbourne, 2012). In Canada, urban forest master plans have been adopted in 33 municipal authorities across nine provinces/territories, with almost half of those (45%) following publication of the Canadian Urban Forest Strategy 2013–2018 (Tree Canada, 2012). A review of plans published prior to the national strategy suggested that "ecological, social, and economic considerations lack specificity and operational clarity" (Ordóñez and Duinker, 2013: 36). However, since then, regulating ecosystem services have been incorporated into visions, strategic goals and operational principles, with Toronto in particular supporting theirs with an i-Tree Eco study (Toronto CC, 2013). In Ontario, an interview-based study with 18 urban foresters revealed that "the provision and maintenance of ecosystem services were, second to tree establishment, the most important consideration in urban forest management" (Fontaine and Larson, 2016: 10).

In the United States, a survey of 599 municipal arborists found that 73% are moderately to very engaged in managing trees and other green space assets to produce ecosystem services such as heat amelioration and stormwater attenuation, though no information was provided on how they do this (Young, 2013). Urban forest masterplans are common across the country and frequently draw on the results of i-Tree studies[2] to support regulating ecosystem service objectives (Hauer and Peterson, 2016). Many set short, medium and long-term actions for government departments and other organisations to enhance, quantify, value or communicate the benefits provided by the urban forest; in Portland these actions are updated on an annual basis (Portland Parks and Recreation, 2016). This is supported by urban forest guidelines recently published by the United Nations FAO, which state that "urban forest plans should provide a framework for actions" (Salbitano et al., 2016: 32).

The interviews revealed environmental issues (poor air quality, surface water flooding and/or heat islands) to be present in the cities involved in this study, a general understanding amongst tree officers of nature-based solutions, and at least some political support for urban forests. Given the variability in ecosystem services content amongst tree strategies adopted in Britain and worldwide so far, the publishing of an urban forest guidance document that facilitates production of strategies incorporating ecosystem service-specific actions is extremely welcome. However, even if regulating ecosystem services are considered to be important by the tree officers and their wider council colleagues, competing objectives and limited funds may mean that central government stimuli are required.

4.3. Constraints to proactive, ecosystem service-focused management

The interviews revealed that tree officers within British local authorities are trying to move from a risk/reactive approach to proactive and ecosystem service-focused management. Key constraints

[2] 25% of the 408 US towns and cities surveyed in 2014 use i-Tree Streets and 8% use i-Tree Eco to quantify and value urban forest-based ecosystem services (Hauer and Peterson, 2016).

to enacting this change were found to relate to funding, governance, apathy and poor understanding (each considered further below). These results agree with those of Britt and Johnston (2008) and Van der Jagt and Lawrence (2015) who previously revealed similar restrictions for proactive urban tree management: limited financial and staff resources; poor communication amongst local authority departments; poor public and political support for trees; and a lack of data on the local tree stock. Similarly, a lack of data on urban trees and a lack of investment were identified as major obstacles to improving approaches to urban tree management in towns and cities across Europe (Pauleit et al., 2002).

The four categories of constraints to adopting an ecosystem services approach in decision making identified in this study are also recognised in the wider literature. Turner and Daily (2008) identify a deficiency of detailed information linking ecosystem services with wellbeing benefits at scales useful for decision makers, and Guerry et al. (2015) suggest that government, business and civil society are not working together closely enough to ensure that ecosystem services are integrated into every day decision making. Ojea (2015) reports issues of poor governance structures, public participation and inappropriate financial mechanisms preventing ecosystem-based adaptation to climate change. Similarly, a study of the implementation of ecosystem services in urban planning in cities in Europe and the US identified the science-policy gap and, specifically, the limited connection of ecosystem services with policy problems as the key barrier (Kremer et al., 2016).

Britt and Johnston (2008) state that it is the responsibility of tree officers to ensure that the public and the council start to view urban trees as assets rather than as liabilities. As one interviewee commented, this is not always possible:

> *"We used to have a ranger service which was a perfect vehicle to deliver a lot of these [ecosystem service] concepts... These were the first lessons that we could get kids involved in, and that starts to bring the family members in and that's one of the ways I saw the message had been delivered in the past. But... now we've got two rangers left out of 40." (TO11)*

The current study suggests that communicating the benefits of trees to politicians and the public has not been possible due to the reduction in funds and staff, and related to this, the lack of data on local ecosystem service provision. However, Moffat (2016) suggests that it is the failure of urban forest professionals in Britain to adequately communicate with politicians and the public about the benefits of trees that has *caused* the reduction in support and funding for Britain's urban forests. The author suggests this is due in part to scientific reports overplaying the likely benefits that urban trees can bring and ignoring important aspects such as varying temporal and spatial scales, trade-offs between ecosystem services, and tree disservices (as people can lose faith when they can't see the promised benefits) (Moffat, 2016). Recent publications including Lafortezza and Chen (2016) and Davies et al. (2017) seek to help address this issue, though a publication itself cannot solve the problem – the information needs to reach and be taken on board by the politicians and public alike. Whether it is falling levels of support that is preventing tree officers in Britain from improving the image of trees, or vice versa, many are finding themselves caught in a downward spiral at a time of increasing threat from pests, diseases and climate change. Urban canopy cover and, therefore by inference, tree numbers are reported to be decreasing across Britain's towns and cities (Doick et al., 2016). Attention must now be turned towards methods for increasing urban forest support and funding if this trend is to be halted and reversed and if urban society is to continue to benefit from ecosystem services provided by trees.

4.4. Promoting an ecosystem services approach

The majority of suggestions made by the interviewed tree officers were about increasing levels of understanding and support for trees amongst the public and other council departments by quantifying and valuing the ecosystem services they provide. Previously, Vandermeulen et al. (2011) and Corona (2016) have also argued that placing economic values on green infrastructure is necessary to convince politicians, citizens and other stakeholders of their usefulness. In the United States "New York City, Boise, Minneapolis and many other cities found that monetizing the value of their municipal forest services led to increased appreciation of trees and tangible program enhancements" (Soares et al., 2011: 69). Similarly, the i-Tree Eco survey in Torbay, England resulted in an additional £25,000 being added to the council tree budget (Forest Research and Treeconomics, 2017).

The i-Tree software currently only partially addresses the heat amelioration service provided by urban trees, quantifying the energy saving effects of trees to buildings, and not their impact on surface, air and radiant temperatures and the importance of this to human comfort. Furthermore, the valuation is currently not valid in Britain as it is based on US housing stock. Accurate quantification of heat amelioration by Britain's trees could be a valuable communication tool, though many of the interviewed tree officers were unaware of the extent of this benefit and so they too require further information and support. Premature deaths from heat-related conditions in the UK are estimated at 2000 a year and this is expected to triple by the 2050s (Committee on Climate Change, 2016), affecting the East Midlands, South East, West Midlands and East of England in particular (Hajat et al., 2014). Trees can be a significant part of the solution (Gill et al., 2007), however neither the message on the severity of changing climate or the roles of trees in combatting it were found to be prevalent amongst the tree officers interviewed.

The FAO's urban forest guidance document recommends "that savings in healthcare costs generated by urban forest ecosystem services are taken into account in relevant policies and duly incorporated in the financial accounts of governments" (Salbitano et al., 2016: 49) and this is starting to be considered in Britain. For example, Sheffield City Council has created a natural capital account to incorporate costs and benefits associated with its parks (Vivid Economics, 2016). Meanwhile, a Dutch 'TEEB for Cities' study has developed a tool to incorporate the financial benefits of green spaces within municipal balance sheets (though only two of the eight study cities subsequently implemented the tool) (van Zoest and Hopman, 2014). It is likely that national government support will be needed to ensure natural capital accounting is carried out by local authorities and that this additional information leads to new policy and action in support of the urban forest.

In the absence of sufficient tree management budgets, novel funding approaches that draw in financial (or in-kind) support from citizens, businesses or other council departments are needed. 'Payments for Ecosystem Services' (PES)[3] was specifically referred to by one of the interviewed tree officers while also raising concerns about how it would work in practice:

> *"It's all very well having these payment for ecosystem service systems built in but who's going to broker the payment, and how... [do you ensure] it would be quality controlled, and how do you achieve landscape scale improvements from disparate and reductive payments coming in*" (TO5)*

PES schemes have rarely been used in urban settings due to perceived complexities around ecosystem service interactions, and the vast number of potential buyers and sellers potentially increasing transaction costs and the risk of free riding (Wunder, 2008; Wertz-Kanounnikoff et al., 2011). Nevertheless, urban PES schemes have

[3] PES is defined as "a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources" (Muradian et al., 2010).

been piloted in Britain, with some success. The Defra PES pilot schemes in Hull and Luton, for example, found buyers (the councils, local water companies, residents and some businesses) who were willing to pay for green infrastructure improvements due to stormwater attenuation benefits (MacGillivray and Wragg, 2013; Brewer et al., 2014). The research did not however investigate the potential role of trees for providing this service, and thus further research would be required to test this as a route for novel funds for the urban forest.

In terms of strategic planning, Kenney et al. (2011) propose a framework of 25 indicators that local authorities could use to shift the focus of urban forest management towards more easily quantifiable and sustainable results. These relate to the socio-political constraints to adopting an ecosystem services approach identified through the present study, for example the awareness of tree benefits by the public; the level of private and public funding; and the suitability of the maintenance regime and location of the tree for provision of benefits (Kenney et al., 2011). This latter point is key, as a number of the interviewed tree officers share the popular yet overly simplistic view that provision of (all) ecosystem services can be enhanced simply by increasing canopy cover. In reality, urban forest-based ecosystem service provision depends on the type and structure of the trees, their location, ownership and management, and the proximity of the tree/woodland to people (Davies et al., 2017). Furthermore, "the inclusion of all possible benefits that urban trees can bring presents too wide a picture and hinders focus on those goods and services which would really make a difference in the particular circumstances" (Moffat, 2016: 7).

Kenney et al. (2011) concede that assessing urban forest planning and management against such a large number of indicators may seem overwhelming, but reveal that such an approach has already been successfully adopted in three Canadian municipalities, and can save time and money going forwards. Similarly, Hansen et al. (2016) identify factors for successful implementation of green infrastructure in a number of European case study cities. Such factors include linking green infrastructure to pressing challenges (e.g. flooding and heat islands); identifying advocates amongst those with political clout; and increasing resource availability by involving different council departments and accessing private sector funds (Hansen et al., 2016).

The proactive approach advocated by these authors is similar to the action plans associated with urban forest strategies in the United States. Importantly they seek to itemise the opportunities and threats to 21st century urban forest management and seek solutions to these within specific timeframes. Five of the tree officers interviewed in this study were preparing tree strategies, though it was not clear to what extent ecosystem service provision would be prioritised, or if and how the strategies would be linked to other council departments. One exception was TO15 who intended to link the new strategy with the development of a natural capital planning tool, conducting an i-Tree Eco survey of the city's trees, and working more collaboratively with the public health department. Echoing the FAO's urban forest guidelines, this study recommends that all British cities should have an up-to-date tree strategy that takes an ecosystem services approach, is intentionally proactive, and is underpinned by an action plan, delivery indicators, and a commitment to regularly review and revise the strategy.

5. Conclusions

This study contributes to the literature by investigating explicitly and for the first time, whether and how regulating ecosystem services influence urban forest management in Britain; and what socio-political constraints local authority tree officers face in using urban trees as a nature-based solution to the heat, flood and air quality problems associated with densely populated cities. It highlights the necessary drivers for adopting an ecosystem services approach to urban forest management, and drawing on both the international literature and the tree officers themselves, sets out a number of recommendations to take this further.

Two-thirds of the tree officers interviewed indicated that they have a reactive approach to managing their urban forest, focused on reducing risk and complaints. This is largely due to declining tree budgets and a lack of local strategic policy, though it is also partly a consequence of central Government thinking. Only two of the tree officers gave examples of how they currently manage their urban forest to benefit from reductions in the urban heat island, air pollution and stormwater flooding.

Just 27% of the study cities had published tree strategies, and only one of these included specific recommendations for enhancing the provision of regulating ecosystem services. This situation appears to be fairly common throughout Europe, and redressing it is an important next step. Having political support for trees and the benefits they provide was seen as a key driver to adopting an ecosystem services approach to urban forest management. This however has to be underpinned by local data and the economic case for trees, and obtaining these are recommended to the study cities as important next steps; for example through the application of an i-Tree Eco study. Awareness-raising is also key, as evidenced in the United States and Canada. And while such measures can improve funding for the urban forests in Britain, a natural capital accounting approach may also be necessary to bring in funding from other council departments, and payments for ecosystem services (PES) could be used to encourage businesses and citizens to contribute.

This study was conducted with just 15 of the 28 most densely populated cities in Britain (excluding London), and as such may not be indicative of or relevant to all local authorities. Nevertheless, the findings are thought to be relevant to urban areas across Europe (and potentially elsewhere) where trees may offer a cost-effective solution to those common issues of urbanisation: surface water flooding, poor air quality and urban heat islands. It is recommended that British and European cities take heed of the FAO urban forest guidelines and attempt to replicate the proactive approach adopted in North America (i.e. action-based urban forest strategies supported by i-Tree studies). Going forwards it would be useful to conduct further research into the feasibility of PES schemes and natural capital accounting to increase funding for urban forests from the private and public sectors, respectively.

Funding sources

Funding for the research was provided by EPSRC (EP/M50662X/1), the University of Southampton, the Scottish Forestry Trust (P15-253B).

Ethical approval

Ethical approval for this research was granted by Ethics and Research Governance Online (ERGO 19753) at the University of Southampton.

Acknowledgements

We thank the local authority tree officers for their participation in this study. We thank two anonymous reviewers for their constructive comments on an earlier version of this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.envres.2017.03.020.

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