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Delivering Green Streets: an Exploration of Changing Perceptions and Behaviours Over Time Around Bioswales in Portland, Oregon

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Delivering Green Streets: an exploration of changing perceptions and behaviours over time around bioswales in Portland, Oregon

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Abstract

Green Infrastructure (GI) is an increasingly popular means of dealing with flooding and water quality issues worldwide. This study examines public perceptions of, and behaviour around, bioswales, which are a popular GI facility in the United States. Bioswales are highly visible interventions requiring support from residents and policy-makers to be implemented and maintained appropriately. To understand how the residents' perceptions and attitudes might develop over time, we interviewed residents of Portland, Oregon, living near bioswales installed 1–2, 4–5 and 8–9 years ago, to determine awareness, understanding, and opinions about the devices. We found no consistent patterns across time periods, but did find common issues affecting residents' appreciation and acceptance: environmental attitudes, awareness and understanding of purpose and function, plant choice and maintenance, and mess and littering. It was apparent that increased public engagement, localised maintenance strategies, and possibly even customising facilities to meet residents' needs where feasible, might improve acceptance.

Introduction

Sustainable urban planning and management in the United States seeks to meet the requirements of flood and stormwater management regulations requiring improvements in water quality and consideration of surface water flows (Gunderson *et al.*, 2011; Layzer, 2012). Municipalities are incorporating Blue-Green Infrastructure (BGI) and Sustainable Drainage Systems (SuDS) into urban development as a cost-effective measure to reduce stormwater runoff and improve water quality (Kloss, 2008), while generating multiple other benefits within the urban environment (EPA, 2013; Tzoulas *et al.*, 2007; Benedict and McMahon, 2006). BGI is in many respects similar to 'Green Infrastructure' (GI) (Benedict and McMahon, 2006; Tzoulas *et al.*, 2007), but with a stronger focus upon adapting urban water cycles to function more similarly to natural water cycles (see Voskamp and Van de Ven, 2015; EPA, 2008a). BGI can take many forms, including green spaces with a specific water function (e.g. green roofs, rain gardens and bioswales), rain-barrels and permeable pavements.

Of particular interest for this study are bioswales, highly engineered and modular stormwater management (SWM) facilities often built into or extending from pavements, used extensively in many cities in the United States (see Figure 1). Bioswales, and SuDS more generally, are increasingly accepted by professional stakeholders (EPA, 2013, Bloomberg and Strickland, 2012, Lamond *et al.* 2014, Woods-Ballard *et al.*, 2007) as a SWM tool (Parrot, 2007), a cost-effective combined sewer overflow control technique (EPA, 2004), and a Total Maximum Daily Load management tool (EPA, 2008b). Portland, Oregon, has a history of 'nuisance flooding' (events with a 10-year return period) causing road blockages, basement and house flooding, and poor water quality (BES, 2001). Bioswales are therefore part of a broader BGI strategy for dealing with these problems as well as working to mitigate other effects of climate change.

Portland is considered a leading city in its pursuit of BGI, and its efforts to improve liveability, promote sustainable development practices, and prepare for climate change (Saha and Paterson, 2008; Slavin and Snyder, 2011). For example it sits alongside Seattle, Boulder and several others in its high

Figure 1 Incomplete bioswale showing water inlets.

scoring for sustainability efforts in Portney's (2013) review of US cities (see also Mayer and Provo, 2004).

Little is known about the residents' perceptions of BGI. A small number of UK studies have found general preferences for blue-green approaches to flood-risk management over grey infrastructure, with regard to aesthetics (Apostolaki and Jefferies, 2005; Kenyon, 2007; Bastien *et al.*, 2012), although with varying degrees of awareness as to BGI's functionality. Understanding community perceptions is especially important because, in contrast to much hidden grey infrastructure, BGI often changes the visible urban environment, involving shifts in what flood risk management and water treatment involves and looks like (Shandas *et al.*, 2010). Furthermore, agendas and funds for their installation and maintenance are often subject to residential scrutiny. For example. in Portland, Oregon, the residents' sewer and water fees are used to install and maintain bioswales, opening up debate regarding the effectiveness of BGI to ratepayers.

From a community perspective, there are a number of possible advantages and disadvantages to BGI. As well as water quality and flood benefits, vegetated BGI space may also improve air-quality (Benedict and McMahon, 2006; Wise *et al.*, 2010), biodiversity (Hostetler *et al.*, 2011; McPhearson *et al.*, 2013), and aesthetics, which in turn have been argued to improve mental well-being (Ulrich, 1979; Tzoulas *et al.*, 2007; Dean *et al.*, 2011). Conversely, BGI, including bioswales, could be perceived negatively if residents were expected to fund or be involved with maintenance, if they felt uncomfortable with particular flora and fauna, or if they feared or experienced negative aesthetics and reduced functionality, possibly stemming from mismanagement. Poor maintenance (e.g. insufficient watering in dry-spells leading to plants dying) or neglect (e.g. litter blocking water inlets) could reduce both functionality and aesthetic appeal (Bastien *et al.*, 2012), whereas well-maintained facilities may become more aesthetically pleasing over time. Therefore, the study of attitudes toward and perceptions of bioswales over time may reveal negative or positive shifts regarding these structures.

Very few studies have evaluated perceptions of bioswales and similar facilities used for SWM, such as 'curb-side trees' and 'rain gardens' (although, see for example Seymour *et al.*, 2010, Barnhill and Smardon, 2012). In Portland, Shandas et al. (2010; Shandas 2015) studied the Tabor to the River Program (T2R) (BES 2015), comparing residents' attitudes in areas that had extensive bioswale development to neighbourhoods without. In the bioswale areas, residents judged neighbourhoods more highly on multiple characteristics (attractiveness, greenery, safety and walkability), indicating a possible relationship between BGI and resident satisfaction. In the same study, residents were also asked what they knew about BGI stormwater management and the likelihood they would employ such techniques themselves. Awareness of bioswale purpose scored the same across areas, although respondents in areas with bioswales were more likely to consider adopting such approaches (Shandas, 2015). Church (2015) also studied the T2R Programme, finding good awareness and strong overall support for the devices.

Shandas *et al.* (2010) found residents reported that direct mailings from the city's Bureau of Environmental Services (BES) were their primary source of information regarding BGI function; Church (2015) noted these were supplemented by meetings, conversations, tours and workshops. Everett *et al.* (2015) observed some dissatisfaction with levels of citizen engagement and voice within the development process. For Shandas *et al.* (2010), respondents' willingness to engage in maintenance of publicly owned bioswales was associated with their general engagement with other environmental behaviours.

A recent pricing study revealed a positive turning point in the impact of Green Streets (the city of Portland's term for public bioswales) on adjacent property sale prices following about four years of negative effects (Netusil *et al.*, 2014). Netusil *et al.* (ibid.) also observed how planting characteristics impacted upon property values; for example, a positive impact of trees in bioswales and complex planting being preferred to simpler facilities. The study identified that there may be a *temporal dimension* affecting installation, maintenance and acceptance of bioswales. However, no study has yet explored in more depth whether such an attitude change over time actually exists.

To address this knowledge gap, this study evaluated residents' perceptions of, and behaviours around, bioswales in Portland at a series of time increments since installation. The working hypothesis was that bioswales would be perceived differently based on their 'newness', and that changes in perceptions might have developed over time. If properly managed, perceptions may have grown increasingly positive as structures and appropriate behaviours around them came

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to be viewed as more normal within the urban landscape. The rationale behind this work stems from the concern that failure to appreciate this temporal evolution in perceptions could lead to unrealistic short-term expectations and therefore negative feedbacks and short-sightedness about public acceptance by municipalities.

Methods

Study sites

Installation of bioswales has been part of Portland, Oregon, USA's sustainable SWM strategy since the early 1990s. In 1999, the city adopted a Stormwater Management Manual (SWMM) (BES 2014), and then initiated a Green Streets Policy in 2007 (BES, 2007). The objectives of both programmes focus upon reducing street flooding and filtering rainfall before it reaches the Willamette and Columbia Rivers, which run through the city centre and along the northern boundary respectively. The Green Streets programme requires many street improvements to accommodate Green Infrastructure within SWM techniques. Bioswales have therefore been part of the landscape for around 10 years and represent an opportunity to evaluate citizens' perceptions and attitudes.

This study focused on six sites in Portland with a small amount of supplemental work at two further sites, avoiding the area covered by the T2R Programme already studied by Shandas *et al.* (2010) and Church (2015). Sites were identified using BES installation databases held at Portland State University, then ground-truthed to ascertain suitability. The sites chosen were principally in residential neighbourhoods containing single-family homes and duplexes, and included bioswales constructed during 2005–2006, 2009–2010 and 2012–2013. All sites were within the Johnson Creek watershed, a sub-basin that drains to the Willamette River and comprises a portion of Portland.

Data collection

The researchers adopted a *Point of Opportunity Interaction* (POI) method to gather a straw poll of 41 interactions with 45 respondents. POI involved approaching people directly outside their houses, to overcome 'self-selection bias' (see Whitehead, 1991, Hudson *et al.*, 2004) whereby residents might only choose to respond if they were aware of the bioswales and had strong opinions for, or perhaps against, them. The key advantage of adopting POI was therefore in inclusion of individuals who might not otherwise volunteer to be interviewed. The POI averaged a mean of 26 min and proved very fruitful in the quality and range of responses; even the shorter interactions produced rich data. A small number of pre-arranged full interviews (45–50 min) were also undertaken where participants were happy to talk but unable to do so when first approached. A semi-structured interview approach (Wengraf, 2001) was adopted for all interactions, allowing respondents to talk freely around 12 key questions, with follow-on prompts in case certain issues were not addressed (Table 1). This approach allowed the interviewer to pursue points of interest in a relaxed, conversational environment. Interview questions were structured around four general topics. In the presentation of findings below, respondents are identified by installation date, Site No., and Respondent No. for each site (for example, 2005.S1.R2).

Demographically, respondents were spread evenly across genders and age groups. A majority were White American,

Table 1 A priori theme development categories and corresponding interview questions chosen to explore each topic of interest

Focal topic area	Corresponding interview questions
Awareness and knowledge of bioswales and their functions	• Are you aware of the different water drainage systems around where you work/live? What do you see their main function as being? • What you know about their role in flood management? Have they made any difference?
Perceived advantages and disadvantages of bioswales	• Are there any advantages or disadvantages? • Do you make any 'use' of the bioswales? Do you appreciate them being there? Would you prefer more, less, none? Why?
Changes in behaviour, or changes in perceptions of, and relationships with, water	• What did you think of the bioswales when they were first installed? Has your opinion changed over time? • Have they changed the way you do things? • Does having bioswales make you think any more about your relationship with water? • Do you know about behaviour needed for them to continue to function well? Do you practice such behaviour? Have you always done so? • Do you know about the maintenance needed? Would you be happy to contribute (time or money) to such maintenance?
Perceived wider impact of bioswales on neighbourhoods and communities	• Do you think the bioswales have had any effect upon community relations? • Do you think other communities could benefit from having something similar? • Have they had any impact upon property values?

with nine Asian and three African–American participants. Because of the qualitative data collection methods and geographically targeted sampling scheme, detailed demographic analysis was beyond the scope of this study, and is withheld to preserve respondent anonymity. However, the range of responses received was spread across all demographics, with no exclusive areas of concern or benefit, and so demographics are not considered further in this paper.

Analysis

Responses were transcribed and analysed using Dedoose software. Fourteen core themes were derived *a priori* to capture responses addressing each topic. Following this, the researchers adopted a Grounded Theory approach (Glaser and Strauss, 1967), abandoning preconceptions to allow important issues to emerge directly from the data. Forty-nine specific sub-themes emerged during coding (Table 2) that drew out greater nuance and captured additional or unexpected issues and concerns. The use of structured themes and emergent sub-themes allowed qualitative gathering and placement of related data segments. These were then read multiple times to explore, evaluate and compare residents' attitudes, behaviours and feelings in depth.

A supplementary quantitative analysis of excerpt-counts for themes and sub-themes per minute of interview was also conducted on the coded transcripts. These were compared across installation date ranges (2005–2006, 2009–2010, and 2012–2013) to investigate opinions and attitudes over time. In this way, the core qualitative analysis was paired with a simple quantitative analysis. It is important to recognise that the quantitative coding measured topics' frequency of mention, representing respondents' interest in talking about issues rather than positions held towards them.

Results

Awareness and understanding

Mention of awareness and understanding of bioswales' intended functions and ancillary benefits did not appear to change much when comparing installations. Mentions of awareness of facility functions were most abundant for bioswales installed in 2009–2010 [Figure 2(a)]. Awareness mention frequency was roughly the same for residents living around the oldest and newest devices (2005–2006 and 2012–2013). Across the three age-ranges, a lot of low awareness was observed:

> 'Are you aware of the different ways that stormwater is managed where you live?'
>
> 'Sort of. I'm aware that they put new stuff in five, six years ago – I'm not exactly sure what does what.' [2005.S1.R7]
>
> 'You educated me – I didn't know it's for the water. I just thought it's pretty, and it looks nice for the neighbourhood.' [2005.S1.R2]
>
> 'I'm glad that you told me what the hell it is. I had no idea, I didn't know *what* that was.' [2009.S8.R2]
>
> 'I just figured it goes down the storm drain into the water treatment plant.' [2012.S7.R1]

Whilst respondents did not appear to display any general changes in patterns of awareness and opinion between installation dates, results indicate certain sub-themes were of greater interest or concern. For example, people spoke much more about awareness of flood risk mitigation and water-cleaning than other less visible co-benefits, such as their potential to assist with climate change adaptation [Figure 2(a)].

Figure 2(b) provides further indication of partial connection with possible benefits. Residents mentioned flood risk mitigation, water quality, aesthetics and green space as advantages of bioswales, with less discussion of air quality and biodiversity (other than the 2012–2013 cohort):

> 'Couple of nice things about them: one, it's keeping the water clean; two, it's keeping everything in the ground; three, it's filtering our water and four, it provides shade.' [2005.S2.R2]
>
> 'I haven't given it a whole lot of thought, other than just the obvious reasons, the drainage and preventing flooding.' [2009.S3.R4]
>
> 'It manages stormwater and it's extra green, extra green space.' [2005.S5.R1]

Respondents did not always appear to understand the potential citywide benefits of avoiding flooding; for instance, reduced flooding reducing disruption, infrastructure damage and recovery costs may allow for lower taxes over the medium- to longer-term. City engagement could help raise awareness of these connections; at present, some respondents felt bioswales were unnecessary because they themselves were not at flood risk:

> 'We're in the heights here, we've never had any problem with flooding.' [2005.S1.R7]
>
> 'I would not do that to my house. I wouldn't waste my money on something like that because we're so far up.' [2012.S6.R5]

Perhaps because of this apparent weakness in engagement, and so, development of understanding, a number of residents felt the city was being economical with the truth regarding the water-cleansing functions of bioswales:

> 'It's all going into one little spot – so it's just like a septic tank . . . they're concentrating it in one spot over

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Table 2 Core Themes and Sub-Themes developed from coding interview transcripts

Theme	Sub-themes	Description
Awareness	1. reducing flood risk 2. cleaning water 3. improving green spaces 4. climate change adaptation 5. others – awareness 6. general – aware exist 7. water and nature cycles	Awareness of the existence of bioswales as a distinct facility type; or awareness of the function provided by bioswales
Advantages	1. flood risk 2. water quality 3. air quality 4. aesthetics 5. nature – biodiversity 6. green space 7. other	Valuable, useful, helpful, or generally advantageous features of bioswales
Disadvantages	1. mess-littering 2. safety 3. access 4. parking 5. function (do they work?) 6. other 7. none	Potential or currently experienced problems, issues, or inconveniences due to bioswales
Behaviour	1. understand good/bad 2. behave themselves 3. others behaviour 4. proactive	Actions that residents do/don't do around bioswales; actions that residents should/shouldn't do around bioswales
Design	1. inlets 2. trees 3. plants	Characteristics of bioswale design including engineered and horticultural elements
City engagement	1. explain how work 2. explaining dos & don'ts 3. consulting re what's wanted 4. punitive (fines etc.) 5. encouraging (stewardship, etc.)	Municipal outreach activities
Costs	1. water bills 2. un/happy to pay for more	Any and all costs incurred by residents due to bioswale construction or maintenance
Opinion change	1. general 2. advantages 3. disadvantages 4. awareness 5. behaviour 6. community relations 7. sustainability 8. maintenance 9. city engagement	Explicit or implicit changes in resident opinions regarding aspects of bioswale structure and/or function since first exposure to a facility or from beginning to end of interview session
Maintenance	1. city do enough? 2. would you help?	Any trimming, cleaning, watering, or other sustaining activities needed to keep bioswales fully functional
Relationship with water	1. flood 2. drought 3. filling & emptying	Awareness of importance of managing water quality and quantity, whether presence of bioswales encourages reflection upon this.

years and years. You might as well have a pipe going into the ground and pour chemicals in it . . . It's real easy to think it's a good thing – but you gotta look, you gotta have some common sense.' [2005.S1.R4]

'I don't see how it could clean the water . . . They reckon the plants can take some of the pollutants and make the water clean. I'm not buying that, I don't buy that one at all.' [2012.S6.R5]

'It's got a long way to go before it gets to the river – be a thousand years before it gets there, probably.' [2005.S1.R1]

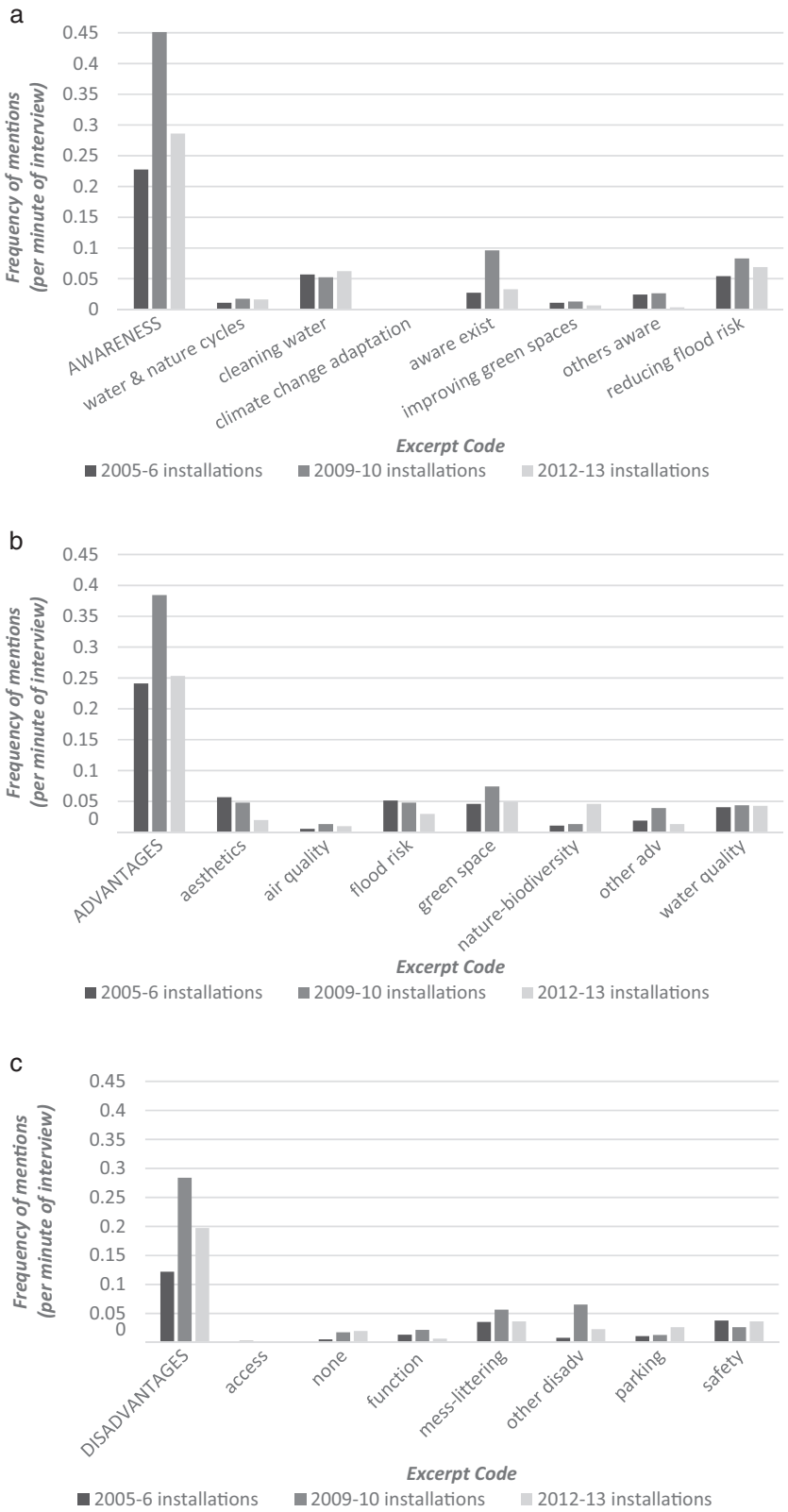

Figure 2 (a) Frequency of Interview Excerpts Coded with 'Awareness' sub-themes per minute of interview (b) Frequency of Interview Excerpts Coded with 'Advantages' sub-themes per minute of interview (c) Frequency of Interview Excerpts Coded with 'Disadvantages' sub-themes per minute of interview.

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Figure 3 Bioswale extending into the road.

Figure 4 Bioswale not extending into the road.

This is significant, since positive shifts in opinion seemed possible when the purpose and function of the devices was explained, face-to-face, in lay terms:

> 'I honestly thought they were a waste of time 'cos I didn't understand what they were trying to accomplish . . . But I love 'em now, I understand how they work and I see the benefits.' [2005.S2.R2]

The opportunity still remains to improve the information exchange that could help raise awareness and belief in functionality. More work around raising awareness might improve public perceptions, and so, approval of city funds being spent on BGI, simply by improving understanding of the devices' functionality and purpose. As the above respondent said at the end of our conversation: 'I didn't know about it before. I bet you, a lot of us don't know it's for the water' [2005.S2.R2].

Comparing Figures 2(b) and 2(c), it is illuminating that residents talked slightly more about advantages than disadvantages. This pattern is similar across all ages of installation, supporting observations from the qualitative analysis that residents were generally positive about the Green Streets programme as a whole.

Parking

From conversations with those who manage and study bioswales in Portland, it had been expected that the impact on parking and traffic from installations widening pavements and narrowing traffic lanes would be a primary concern (see Figures 3 and 4). However, this came up with only a couple of respondents [see Figure 2(c)], although these two saw it as an important issue and were very vocal:

> 'It occupies a traffic lane which is also a parking lane. So it's taking away *traffic* when it's designated to drive and *parking* in the evening. These are residential-commercial areas, so people who live there don't have a place to park anymore, people with businesses don't have places for their customers.' [2012.S6.R3]

> 'It is gonna take away parking for people that live closer to town . . .that detracts a little bit . . . you'd have to pick and choose the areas that you could have them . . . parking is a thing here, it's an issue.' [2012.S5.R3]

One respondent mentioned that she had heard a few people make such complaints, but roundly dismissed this as an insignificant cost compared with the benefits of reduced flooding:

> 'What would they rather have – more parking, or more flooding? . . . would they rather their house was flooded, all their things flooded, or more parking? Me, I'd rather my house wasn't flooded!' [2005.S1.R3]

This relates to the issue of raising awareness of citywide benefits, especially when devices are installed in areas on higher ground less directly at flood risk. This would also relate to wider social issues around recognising the social benefits of cost sharing.

Mess and littering

This study found that residents talked more often about perceived cleanliness and tidiness ('mess-littering') as a disadvantage than parking [Figure 2(c)], although only as often as they spoke of aesthetic benefits [Figure 2(b)]. Littering referred to waste being deposited in bioswales whilst mess indicated the perceived negative aesthetics of plants being too large, weed-like or unkempt. References to 'littering' occurred much more at one 2005–2006 site sitting to the side of a junction with a garage and two convenience stores:

> 'It is a problem when they turn into a standing garbage can, that is a problem.' [2005.S1.R6]

> 'It becomes a big trash catch, right next to my store, because it catches almost everything . . . it's full of trash.' [2005.S1.R8]

> 'There's always a problem with people throwing garbage around. Even my elderly neighbour, a gardener, would throw garbage into his swale; he didn't understand its purpose and he never saw its beauty unfold.' [2005.S1.R6]

'Mess' appeared to be the product of plant-choice and perceived regularity and efficacy of maintenance, occurring significantly more in the 2009–2010 installations (and some in 2005–2006) when the city was using taller *Juncus* rushes that many perceived as overgrown grasses:

> 'They're so ugly, they look like an unkempt yard.' [2009.S3.R2]

> 'I don't like that they look like overgrown weeds . . . they're quite overgrown.' [2009.S3.R3]

Plant choice – safety

The choice of plants also caused two further distinct varieties of concern, safety and fauna [Figure 2(c)]. There were two concerns over safety; firstly, that people might injure themselves falling into them because the plants obscured the sunken holes:

> 'It's a hole, and if you didn't know and you was just going to walk through that, you could fall right through. It's pretty deep, too!' [2005.S1.R2]

> 'I think that there should be a little more attention to barriers, or signs, or something to say 'this is different, watch your step.' . . . it is something I've always wondered about . . . it's like, let's get a little human interaction.' [2005.S1.R9]

Secondly, some respondents felt the tall rushes caused visual obstructions when driving:

> 'The bioswale there – if you look around that corner, when the grass is tall, you can't see as you're trying to pull out.' [2005.S2.R2]

> 'Some of the plantings grow too tall and make it difficult if you're trying to turn a corner and don't have good visibility.' [2005.S1.R6]

Plant choice – fauna

The second principal concern around plant choice was with invertebrate fauna. This may have been a matter of respondent cultural norms as much as city plant-choice, but on one street, insects observed in the devices caused some concern:

> 'It will have lots of insects . . . it will have insects.' [2009.S3.R2]

> 'Some plants got purple flowers, small, and they got some bugs, very, very tiny. My neighbour's having trouble with those bugs with their kid.' [2009.S3.R8]

In addition, one respondent blamed the flies that they had seen on poor social behaviour and maintenance:

> 'Flies will come to the rubbish which is thrown by people. In fact, it's very smelly.' [2009.S3.R45]

There was also some concern that bioswales might prove a breeding ground for mosquitoes:

> 'When it gets the mosquitoes! . . . when it rains and the water's down there, you see a lot of mosquitoes right here.' [2009.S8.R2]

> 'If the grasses are so high, I am worried it will induce mosquitoes. I don't know, will it have more mosquitoes in summertime?' [2009.S3.R3]

Trees

Trees in the bioswales were for the most part viewed very positively, pointing to a confirmation of the findings of Netusil *et al*. (2014). As one interested respondent explained:

> 'Trees in the bioswales, it's very important to keep the trees in, it makes people have a warmer feeling about their home . . . That is a good swale because it's low, it's green, it's well maintained – in about five years' time, those trees will make that house look tremendous . . . trees are an important part, especially when you don't have much yard.' [2005.S2.R2]

Trees were generally appreciated for their contribution to bioswale and streetscape aesthetics:

> 'I think they're nice. Because they've got the little trees coming out of them . . . I like the trees. They're really pretty.' [2005.S1.R3]

> 'I think they're good – and the trees too, they look nice.' [2005.S1.R2]

However, such appreciation was not universal. A small minority of respondents disliked the trees for various reasons, from shading of doorways or their own trees, to not wanting what they perceived as extra maintenance duties:

> 'If they can plant the tree which is not higher than the door, that'll be better. I'm not very satisfied with that high tree . . . Such a big tree isn't good to be put in front of the door.' [2009.S3.R6]

> 'These trees . . . I told them I was going to put battery acid on them, because they're blocking my trees. That tree is blocking the light for my trees, so my trees are going to die for their tree.' [2005.S1.R4]

'I really can't maintain another tree, I can't take care of it . . . I don't want a tree, man! I love trees, but not in my yard!' [2005.S1.R10]

Citizen voice

This relates to a more general issue with resident involvement with facility design. Portland's BES have undertaken engagement around installations coordinated under their Green Streets Plan and T2R, and are developing a 'welcome package' to be provided to new residents near Green Streets. However, the SWMM (BES 2014) stipulates that all developments with over 500 sq. ft. of impervious surface must incorporate green infrastructure, and private developers are not required to do outreach.

Many residents displayed strong satisfaction with the trees in their bioswales whilst a minority expressed significant dissatisfaction. Given that trees were not placed in every bioswale, this emphasises the importance of consultation and tailoring where administratively, aesthetically and financially feasible, to improve overall levels of satisfaction:

'I think it is good thing to have that, yeah, have tree. But sometimes people don't want it.' [2009.S8.R3]

Consultation may not satisfy all people's desires, such as those who wished for shorter grasses, more flowers and edible produce:

'The only thing that's negative is I wish we had plants that I like in there . . . A couple of blueberry bushes wouldn't hurt, something that I could eat.' [2012.S6.R6]

'If they can plant some nice flowers, I will support. If wild grass, it's ugly. It looks very dull with only grass.' [2009.S3.R4]

However, dialogue could improve awareness and understanding of the reasons behind plant choices, and so conceivably, help increase acceptance:

'It's pretty sad that we didn't have any input. You look across the street, they look great . . . I had no idea these were going to be a bunch of ugly vegetation we weren't going to be able to look at. Or change.' [2009.S3.R7]

Dialogue might also open up space for negotiation over plant and tree choices, subject to costs to the city regarding installation and maintenance, as well as the demands of relatively consistent street and neighbourhood-wide aesthetics.

Maintenance and clearing

Maintenance was quite a significant concern for residents across all installation dates; those who thought the bioswales were not well maintained found them overgrown, messy and ugly, as noted earlier:

'I think that the *concept* is good, however they are not maintained well enough – they get out of hand often . . . that one over there looks like hell.' [2005.S1.R4]

'What I don't like is they don't maintain – look how sloppy it is over there, right next door, the grass needs mowing and the tree at the bottom needs to be trimmed off.' [2009.S4.R1]

'That looks horrible, they need to mow the grass and take the weeds out.' [2012.S6.R2]

Some residents expressed a will to maintain the spaces, so they could keep them looking neater and tidier rather than to maintain optimal functionality:

'We can't touch it. We can't even come out here and trim it. . .' [2009.S3.R7]

'I wish they would come and just trim. If I could get a weed-cutter and just trim that, it would be great.' [2009.S8.R2]

'I don't know if I'd want it on my property. I can't touch it – to me, I'd want to cut the . . . I would change the plants for sure.' [2012.S6.R2]

A few had, or referred to others who had, undertaken maintenance work. One respondent referred to her husband treating the plants to improve aesthetics. The plants are chosen to help remove pollutants before water returns to the main watercourse; such uncoordinated efforts at improvements may not be consistent with city goals:

'He's tried to make it look better, to look good with that [their garden] too. Him and his brother brought home stuff to make the grass look better.' [2005.S1.R3]

Others had been, or felt they had been, actively discouraged from getting involved by the city, and so had stood back from any involvement:

'Down the street from us there is a swale and . . . they dug it out and a sign appeared almost immediately saying 'this is a protected space, do not clip, dig, remove any of these plantings', blah, blah, blah. So, we're not encouraged to do something unique with our swale.' [2005.S1.R6]

'I, personally, haven't paid much attention to them. Once we were told 'hey, leave 'em and they'll do their thing'. I was like, 'alright, they'll do their thing' and that was it.' [2009.S3.R4]

'I think it's a volunteer basis, what I've read – I think they do plenty. They say not to mess with it because they are planting specific things to manage the water, so it seems like they want you to be a bit hands-off.' [2012.S5.R1]

Figure 5 Incomplete bioswale with Bureau of Environmental Services sign warning against interference.

The city does have a volunteer Green Streets Stewards (GSS) programme, training people to know which plants should be in the bioswales and to trim and weed them (BES, 2012, 2013). Whilst they do not want untrained residents weeding (see Figure 5), they encourage people to clear out trash and debris to improve functionality (BES, 2012).

A small number of respondents across installation dates expressed a willingness to get involved with the GSS, although from such small interactions, we cannot know at this time the extent to which this was true intent or respondent bias (Furnham, 1986; Whitehead, 1991; Hudson *et al*., 2004):

> Interviewer: 'The City's trying to encourage the Green Streets Stewards Scheme to get volunteers to keep it all working.'
>
> Respondent: 'That would be a good idea.'
>
> Interviewer: 'Would you ever want to be part of that?'
>
> Respondent: 'Oh yeah. Yeah, sure we could do that . . . People like to do that kind of stuff around here.' [2009.S3.R5.R6]
>
> Interviewer: 'Would you be happy to be involved with maintenance?'
>
> Respondent: 'If it was the one in front of my house, yeah! I'd probably go out every day.' [2005.S1.R3]

With regard to clearing, mention of willingness to contribute did not change by installation date; rather, it was apparently motivated by environmental attitude, sense of self, civic duty and appreciation of bioswale functions and aesthetics:

> Environmental attitude: 'I come out and pick up every cigarette butt . . . we're talking millions I've picked up already – I know that those are heading right to that water source.' [2005.S1.R7]
>
> Sense of self: 'I always pick things up, 'cos I was raised up like that . . . I pick things up and put it in the garbage. People look at me, 'what are you doing?'. 'Well, I'm trying to keep it clean." [2012.S5.R4]
>
> Civic duty: 'People throw garbage and stuff in it . . . I clean mine. . . stuff that I see, I just clean it.' [2009.S3.R8]
>
> Appreciation of aesthetics: 'People treat them like a built-in garbage can. I'm one of the few that will walk through my swale and clean it up. I pull weeds out and stuff – I like to keep mine clean 'cos I really like it!' [2005.S1.R6]
>
> Appreciation of function: 'I'd probably get involved with it, just for the simple fact that I think they do serve a purpose.' [2005.S2.R2]

Some respondents said they did not get involved because it was the city's job and, as they had already paid taxes, they would be compensating for others' bad behaviour – or because of a lack of any faith in 'community' endeavours:

> 'I used to clean it out occasionally, but you see your efforts not amounting to much, you're just gonna give up . . . I'm not gonna do it if I'm the only one on the street doing it . . . I'm sort of a negative person, I don't like picking up slack for others.' [2005.S1.R8]
>
> 'We pay taxes, so let them do their work.' [2009.S8.R1]
>
> 'I'm having a very good time trying to maintain my own yard, but I really don't want to bother with something that is touted as 'community based.' [2012.S6.R3]

Acceptance

From our sample, acceptance of the existence of bioswales was generally widespread: a minority strongly did not want them, principally for reasons of cost and maintenance, and a further number were, in principle, happy with the devices but not the aesthetics, particularly the plant choices. It is interesting to note two trends to this acceptance. Firstly were those who were more environmentally engaged and so *positively* accepting:

> 'I like it because they're green. I like it because it's purifying the water. There's nothing I don't like about 'em.' [2009.S3.R6]
>
> Interviewer: 'Do you think there are any disadvantages to the swales?'
>
> Respondent: 'Nope, it's all 100% advantage. There are absolutely no disadvantages to come out of conservation.' [2012.S6.R6]

Secondly were those who more *fatalistically* accepted this was part of a city programme and there was nothing they could do about it:

> 'There's no point in opposing it, is there?' [2009.S3.R3]

> 'I don't really think too much about it . . . Well, they don't irritate me like they used to!' [2005.S1.R7]

However, a proportion of this more fatalistic acceptance seemed to stem from a lack of understanding, or belief, in bioswale functionality, prompting further questions around the potential benefits of increased city engagement and dialogue around purpose and design:

> 'I don't really care. I *think* they're doing a good thing, I guess . . . It's for dirty drain-water, right?' [2009.S3.R8]

> 'I don't think it freaking matters . . . I don't think they hurt, but I don't think they are necessarily good.' [2005.S1.R4]

Discussion and conclusion

This study examined changes in attitudes toward, and perceptions of, bioswales of residents near installations of different ages and evaluated whether perceptions differed across varying intervals of time since installation. Key findings are as follows:

1. Residents were generally positive about the Green Streets Programme expanding bioswale construction citywide, but the facility nearest to them was felt to be a separate issue about which they were more confident in expressing negative or positive views.
2. At street level, attitudes toward and perceptions of bioswales were most affected by site-specific physical and aesthetic characteristics (plant height, plant type, regularity of maintenance, taking parking spaces, etc.).
3. Maintenance of facilities was a primary concern. Many respondents felt maintenance was not regular enough, and that facilities looked unkempt. As a result, a number of residents wanted some control over maintenance because they felt the city was not keeping them aesthetically pleasing.
4. Although anticipated by anecdotal evidence, parking was generally not a major issue. This was likely due to our interviewees being in locations where parking is often of less concern than closer to the city centre.
5. Some general knowledge of the bioswales' basic functions is reaching residents, but wider understanding of their many potential co-benefits is lacking. Of those aware of bioswale function, water cleaning and flood risk reduction were most frequently mentioned, whereas other ecosystem services (climate change mitigation, providing wildlife corridors, etc.) were not much discussed.
6. Respondents generally reported trees to be a positive feature, whereas tall 'grasses' (*Juncus* rushes) were perceived more negatively as weeds. However, appreciation of trees was resident-specific and apparently related to the existing concentration of other trees. This suggests that opportunities for consultation by developers and city planners with residents, and flexibility in vegetation selection prior to installation, could be beneficial.
7. Our data suggest few trends in responses related directly to age of installations. This challenges the assumption that opinions will improve over time following the construction phase, as flora develop and bioswales become more accepted. However, whether this was due to lower levels of maintenance, plant-choices, or other neighbourhood factors is beyond the scope of our data.
8. Resident acceptance of bioswales is multi-faceted. Some acceptance was reluctant and fatalistic (*we don't want them, but what can we do?*), whereas some was more positive (appreciation of water functions and green space). Acceptance was hindered by lack of knowledge about the structures, yet encouraged by pro-environmental attitudes. Byrne *et al.* (2015) found similarly in Hangzhou, China, that acceptance of GI can be greatly influenced by public understanding of the multiple potential benefits.
9. Our findings of low awareness and understanding stand counter to those of Shandas *et al.* (2010) and Church (2015). This could be for two possible reasons. Firstly, we were researching a different area of Portland, where a number of installations were prompted by the Stormwater Management Manual (BES 2014) rather than a city development decision. These were not part of a targeted city programme and so residents would not have received the same level of, or perhaps any, outreach work. Secondly, the use of a POI methodology allowed us to gain feedback from respondents who may not have responded to surveys or other interviews, simply because they did not understand the purpose or function of the bioswales. This expansion beyond the established survey base has allowed us to broaden and deepen understanding of the population's engagement with stormwater management, and is easily transferrable to other cities and locations.

An implication of our research is the potential long-term benefit for urban planners to explore ways of raising awareness around water issues and involving citizens in the design, development and installation of bioswales and other BGI. Such collaborative efforts could develop the potential for local maintenance (and so facilitate cost reductions), as well as for adjustment and tailoring of facilities to accommodate the needs of residents where costs and technical considerations allow. This in turn could help with meeting residents'

expectations as far as possible, to produce uplift in approval ratings and encourage appropriate behaviour around devices. Because stormwater management is a critical global issue, the paper's findings about the value of increasing interactions between the public and governing bodies in the development of flood risk management strategies may be useful for, and transferrable to, similar work in the UK, and around the globe.

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