

Greening urban road verges highlights diverse views of multiple stakeholders on ecosystem service provision, challenges and preferred form

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Abstract

Globally, there is growing recognition of the potential of road verges to contribute to urban greening and ecosystem service provision, beyond their original functions of utility provision and public access. Numerous, diverse stakeholders are involved in their management, yet their shared and diverging perspectives on verge greening are poorly understood. This research examined the perspectives on road verge greening by 30 respondents from eight stakeholder groups from the Perth Metropolitan Area, Australia. Stakeholders spanned local and state governments, developers, peak bodies, utility providers, environmental consultants, verge treatment providers and urban greening advocates. Semi-directed interviews and Likert scales were used to assess respondents' perspectives and perceived importance of urban verge functions and ecosystem services, risks and challenges associated with verge greening, and preferred verge vegetation composition. The most important ecosystem services for all stakeholders were temperature regulation (through the provision of street trees), those associated with water management and aesthetically interesting streetscapes. Perceived challenges included limited knowledge for the management of native species verges and streetscapes, organisational costs for verge managers and utility providers, and the need to engage with multiple local government authorities with widely varying management and financial valuation of verge vegetation. Stakeholders' preferred verge reflected diverse uses, local characteristics, and was climate and water resilient (particularly 'waterwise'). A majority of stakeholder groups felt greater attention to the 'understorey' of the 'urban forest' was warranted. An emerging perspective across four stakeholder groups identified the potential for verges to grow a local 'sense of place', through plantings emphasising local native species and

highlighting local Whadjuk Noongar seasons. These findings support policies and programmes associated with urban greening, and assist in navigating the contestation often associated with new or transformative uses of land at the public-private interface.

Keywords

Nature strip

Urban greening

Urban landscape

Verge gardening

Perth Western Australia

Water sensitive urban design

1. Introduction

Roadside vegetation is an often-overlooked contributor to urban greening, even though streets are ubiquitous and central to people's experience of cities, as well as being a place where public and private spaces intersect (Vich et al., 2019, Weber et al., 2014). Urban road verges, variously termed roadside or street verges, roadside gardens, road easements or nature strips, have the potential to make a significant contribution to urban greening. For instance, in Melbourne, Australia, verges represent approximately one-third of the city's public greenspace (Marshall et al., 2019). Urban verge greening generates direct and indirect environmental co-benefits (Säumel et al., 2016, Vich et al., 2019), including promoting biodiversity and providing wildlife habitats (Aronson et al., 2017, Rudd et al., 2002). Verge greening also supports active transport and access to local parks, through shaded and more attractive streets (e.g. De Vries et al., 2013). It also contributes to broader neighbourhood greenness, which has been linked to positive health outcomes (e.g. Pereira et al., 2013).

Urban road verges are often contested greenspaces that are characterised by 'uncertainty regarding land tenure and maintenance regimes, use, regulation and legitimacy' (Rupprecht and Byrne, 2014, Mclain et al., 2014). In a relatively narrow strip of land, verges need to balance urban services with ecosystem services and diverse aesthetic preferences. Urban services are those public services and facilities historically provided in cities, usually without the direct use of ecosystems (see Antognelli and Vizzari, 2016), including for example utility provision, walking access, public transport access, and public safety requirements. The urban realm requires reconciling multiple uses with continual trade-offs between the public and private built environment, service provision, and public and private open space (e.g. Grose, 2009). Consequently, the capacity for cities to support urban greening is both constrained and facilitated by diverse and often competing stakeholder interests.

Understanding stakeholder perspectives, therefore, has a critical role to play in accommodating and supporting nature-based solutions, such as urban greening (Dorst et al., 2019), in our cities.

Analysis of stakeholder perspectives is an integral part of natural resource management (e.g. Reed et al., 2009) and urban planning (e.g. Lienert et al., 2013, Cousins, 2017), given stakeholders' influence over decision-making processes, the success of various management actions, and the potential inequities arising from stakeholder exclusion. Recently, attention has turned to stakeholder perspectives in urban greening, for example, in examining multifunctionality in peri-urban agriculture (Rolf et al., 2019), assessing the role of multi-stakeholder involvement in urban greenspace performance (Azadi et al., 2011), and stakeholder perspectives of urban environmental challenges in a developing country context (Ameen and Mourshed, 2017). Cousins (2017) examined agreement and disagreement among stakeholders in stormwater governance, while Suškevičs et al. (2013) performed stakeholder analysis to understand the roles of stakeholders in the governance of Estonia's national ecological network, highlighting stakeholder experiences and tracing cooperation and conflict trajectories.

While the ecosystem services framework has been in use for over two decades (Costanza et al., 2017), including to highlight the benefits of roadside vegetation (Säumel et al., 2016), it has only recently been applied to examine stakeholder perspectives. For example, Antognelli and Vizzari (2016) designed a classification system and model to evaluate urban services and ecosystem services for complex urban planning decisions. Garrido et al. (2017) used qualitative approaches to understand the perspectives of civil, private and public sector stakeholders on the socio-cultural ecosystem services provided by oak-wood pastures in Sweden. Miller and Montalto (2019) surveyed resident and practitioner stakeholders to elicit the ecosystem services attributed to various forms of green infrastructure. They found stakeholders valued a more diverse array of ecosystem services than expected. Lampinen and Anttila (2021) examined the attributes driving Finnish road verge stakeholders' attitudes towards management practices in support of threatened grassland species and perceived barriers to their implementation. These studies illustrate how stakeholder groups can have shared and diverging opinions regarding the value of ecosystem services, and the need to understand these perspectives in order to support management and planning.

In response to Rupprecht and Byrne (2014), who called for more studies on informal urban greenspace drawn from the southern hemisphere, this study aims to bring together stakeholder perspectives on verge greening in the Perth Metropolitan Area, Australia. To date, documentation of the diverse stakeholder perspectives on the use and management of this complex, yet under examined urban verge space is still limited. Previous research has focused on the perspectives of residents (Rupprecht et al., 2015, Church, 2015, Marshall et al., 2020), the general public (Weber et al., 2014), the local municipal authority (Hoyle et al., 2017), and those tasked with road and environment administration and management (Lampinen and Anttila, 2021). In common with many cities, urban verges in Perth are managed by both public and private actors, which bears many opportunities but also challenges. Understanding stakeholder views of the vegetated verge can assist in navigating transformative management of land at the intersection of public and private space. To gain greater insight into urban verge greening from the perspective of a diverse range of stakeholders, we explored perspectives on

both ecosystem services (Millennium Ecosystem Assessment, 2005, Costanza et al., 1997) and urban services, together with stakeholders' perceived challenges and preferred verge composition.

Specifically, we sought to answer:

- 1) What importance do different stakeholder groups attach to the urban and ecosystem services provided by urban road verges?
- 2) What are the main perceived risks and challenges stakeholders associate with the greening of urban road verges?
- 3) What do stakeholders envisage for their preferred verge composition?

We highlight evidence of common ground and diverse perspectives, and discuss how identifying these shared and divergent perspectives can assist in navigating contested views on urban verge management and greening policies.

2. Methods

2.1. Study area

The Perth Metropolitan Area (city centre: 31°57'18.64"S, 115°51'30.37"E) has a population of 2.1 million (Australian Bureau of Statistics, 2021) and sprawls more than 100 km along the Indian Ocean coastline, making the city's footprint (1564 km²) the 72nd largest in the world (DEMOGRAPHIA, 2020). Similar to many Australian cities, Perth has a low population density, with over three-quarters of the population living in detached suburban housing (Australian Bureau of Statistics, 2021). Continued population growth and urban sprawl have driven policies to increase urban housing density within both new and established suburban areas (DPLH, 2018b). This has negative impacts on roadside vegetation, with verge widths being reduced in greenfield developments, and street trees often removed for driveways and utilities in new infill developments.

The region has a Mediterranean-type climate of hot and dry summers and moderate winter rainfall (Bureau of Meteorology, 2021). The First Nations People of the Perth Area, the Whadjuk Noongar People, define six seasons and many native plant species act as seasonal indicators (Meagher and Ride, 1980). Perth has seen a steady decline in rainfall since the 1970s, with further drying projected under climate change (Bates et al., 2008) prompting strong public messaging on water conservation measures (being 'waterwise') from the Water Corporation. Recognition of the impacts of climate change and tree canopy loss on urban heat have prompted Local Government Authorities (LGAs) to increase their tree canopy cover on public land, along road verges and parks (DPLH, 2018a).

Perth is located in the South West Australian Floristic Region, a global biodiversity hotspot with exceptionally high plant diversity and endemism (Gioia and Hopper, 2017). Urbanisation has reduced the dominant vegetation type, the Banksia woodlands, to a Threatened Ecological Community under Australia's Environmental Protection and Biodiversity Conservation Act

1999 (Threatened Species Scientific Committee, 2016). Increased public recognition of this loss, appreciation of the values of local native plants, the desire to encourage wildlife into gardens, and the greater availability of native species in mainstream nurseries, along with public messaging on ‘waterwise’ gardening practices, have arguably all contributed to fostering community interest in gardening using Western Australian native plants.

Road verges in Perth are Crown land (owned by the State) but the management is fragmented across different entities. The State Government manages verges alongside major road and rail transport routes. Residential road verges are vested in one of 31 LGAs in the Perth Metropolitan Area, with management responsibilities for vegetation divided between the LGA (street trees, surfacing regulations, enforcement) and the resident (all other vegetation). Utility authorities are responsible for installing and maintaining water, gas, electricity, telecommunications and sewerage within prescribed utility corridors (Utility Providers Services Committee, 2018), activities which often affect verge vegetation. Until relatively recently, verge vegetation on most residential streets was fairly uniform, typically consisting of grass and, in the older suburbs, a street tree. In recent years, a growing number of residents have opted to install low-growing plants on the road verge adjacent to their dwelling. There is now a broad spectrum of attitudes towards what constitutes best use of verge space and a complex array of stakeholders with interests in the management of these greenspaces.

2.2. Data collection

2.2.1. Stakeholder identification

Stakeholders were defined as those individuals, groups or organisations with an interest in, or influence over, road verge land and associated vegetation. To identify stakeholders, we first undertook a review of online local policy and planning documents, particularly of all regulators. This included a comprehensive review of all Perth’s 31 Local Government Authority verge policies and verge gardening incentive programmes, as well as the State Government relevant urban planning policies, and the Utility providers code of practice (Ligtermoet et al., 2021). It also included reviewing the organisational roles or position statements of potential advocacy, peak body, environmental and planning consulting or industry organisations.

Based on this policy review and on the authors’ professional networks, eight stakeholder groups were identified through an iterative process. These were: Utility companies, State Government, Local Government Authorities, urban greening advocates, peak bodies, developers, allied industries (horticulture, turf and irrigation), and environmental consultants. Stakeholder analysis (after Reed et al., 2009) was conducted and validated this classification, with no changes other than minor name changes to the groupings. From an initial participant list of 62 entities (organisations, departments, companies or individuals), we selected and invited a subset of 42 leading or knowledgeable practitioners, policy makers, change-makers or well-known industry or commercial entities, of which 24 were interviewed (13 were unresponsive and five declined). Interviews provided an opportunity for snowball sampling

(after Noy, 2008), with a further 25 potential snowball-referred contacts spanning all stakeholder groups (except Utility), of which six were interviewed. During this process of identifying participants, no new stakeholder groups emerged, providing confidence we had adequately captured the range of stakeholder groups. Stakeholder groups and the descriptive roles of participating individuals, groups or organisations are provided in Table 1.

Table 1 Stakeholder groups, descriptive role in urban streetscapes and participating organisations

Stakeholders (abbreviation)	Description of role in urban streetscapes	Participating organisations
State Government Departments (n=3)	<ul style="list-style-type: none"> Prescribes verge land size requirements for urban developments (DPLH) 	<ul style="list-style-type: none"> Department of Planning, Lands and Heritage (DPLH)
	<ul style="list-style-type: none"> Management of major arterial road reserve verges (Main Roads) Promote Water Wise councils, including waterwise verge policies (WC) 	<ul style="list-style-type: none"> Main Roads WA Water Corporation (WC) - Water Efficiency Partnerships
Local Government Authorities (LGA) (n=5)	<ul style="list-style-type: none"> Management of crown land vested in LGAs. Prescribe verge use/management regulations and responsible for management of street trees and local streetscapes. 	<ul style="list-style-type: none"> Multiple LGAs, diverse verge policies prescribing surfacing requirements and engaged to various degrees in facilitating verge gardening practices.
Utility providers (Utility) (n=2)	<ul style="list-style-type: none"> Responsible for delivery and maintenance of water/gas/power/communications services. Operate under: <i>Utility Provider's Code of Practice for Western Australia</i> (2018) 	<ul style="list-style-type: none"> Western Power¹ Water Corporation – utility provision¹
Peak Bodies (n=4)	<ul style="list-style-type: none"> Umbrella organisations advocating for the interests of their member constituents. Raise latest professional/industry issues or developments. 	<ul style="list-style-type: none"> Urban Development Institute of Australia (UDIA) Turf Growers Association (TGA) Irrigation Australia (IAWA) Western Australian Local Government Association (WALGA) - Infrastructure
Horticulture, turf & irrigation industry (HT&I) (n=4)	<ul style="list-style-type: none"> Turf and irrigation consultants or suppliers - supplying residents and LGAs with verge related materials and/or education 	<ul style="list-style-type: none"> Turf consultant Irrigation supplier
	<ul style="list-style-type: none"> Horticulturalists/nurseries - native plant suppliers, involved in propagation, commercialisation, sales, education 	<ul style="list-style-type: none"> Native plant nursery (Not for profit) Planrite Wholesale Native Nursery
Urban Developers (Developer) (n=2)	<ul style="list-style-type: none"> Property development, suburb and community hub development and land sales, which incorporate and define the character of verges 	<ul style="list-style-type: none"> Satterley (Private developer) DevelopmentWA¹
Environmental consultancies (EC) (n=5)	<ul style="list-style-type: none"> Arborists engaged in management and maintenance of LGA network of street trees. 	<ul style="list-style-type: none"> Arbor Centre
	<ul style="list-style-type: none"> Native verge garden designers, installers and landscapers, and providers of community education. Larger firms combine environmental and urban planning services. Diverse spectrum of clients. 	<ul style="list-style-type: none"> Western Wildflower Gardens Sustainable Outdoors Josh Byrne & Associates Ecoscape
Champions of Change (CoC) (n=5)	<ul style="list-style-type: none"> Advocates (individuals or collectives) for resident-led verge gardening and urban greening more broadly. May also be educators, workshop providers. 	<ul style="list-style-type: none"> Individuals working in volunteer, consultancy or public office who have been influential in advocating verge gardening. Beyond Gardens Green Space Alliance

Notes:

1. Government Trading Enterprise

The study aimed to interview a maximum of five respondents per stakeholder group, to balance representativeness and resourcing. Potential participants were invited to participate until five were reached within each group or research time elapsed. In the case of three stakeholder groups, some invitations were declined or went unanswered, which resulted in less than five respondents per group. In particular, of the seven ‘Utility’ organisations active in Perth, only two responded, and of the eight ‘Urban Developers’ contacted only two responded. Of six Peak Body organisations on our contact list, four participated (Table 1). It should be noted this study was not intended to be comprehensively representative, but rather to provide a preliminary window into viewpoints from the range of stakeholders engaging with verge management issues and the emerging practice of urban verge greening.

Within stakeholder groups, respondents reflecting a diverse range of roles, expertise and interests were deliberately sought. Among LGAs, for example, an online survey across all 31 LGAs (reported elsewhere) helped in selecting the subset of LGAs to contact for interviews, depending on their level of engagement in verge greening. Among Environmental Consultants, respondents who worked across a range of interests and operated at different scales of influence were invited (e.g. consultants installing residential verge gardens, consultants working at an urban planning scale and an arborist for a street tree and canopy scale focus). Among the Champions of Change, there were two advocacy groups with discernibly different interests and three individual actors operating in very different roles within the community and verge gardening movement (guerrilla gardening, within local public office, and the facilitator of a Facebook verge gardening community group with national reach).

State Government participants were drawn from different government departments reflecting diverse priorities (Table 1). Moreover, the unique role of the Water Corporation (a State Government trading enterprise) in representing two stakeholder groups has to be noted. In its primary role as a water utility provider (and interviewed as such), the Water Corporation has an extensive outreach and engagement role promoting water conservation, or ‘waterwise’ behaviour, among the community, LGAs and industry (and largely state wide). As part of their ‘Water efficiency partnerships’ they have extensively influenced residential and LGA verge gardening practices to promote ‘waterwise verges’ and ‘waterwise councils’. Hence the separation of this arm of the Water Corporation from Utility to remain within State Government and our interviewing of them separately. In addition, the WA State Government Main Roads Department warrants further explanation, as both regulator and manager for arterial verges, having in recent years initiated the ‘Wildflower Capital Initiative’. This aims to promote Perth as a ‘Wildflower Capital’ and support tourism, waterwise and native planting practices and Noongar culture, for both residents and visitors alike, by showcasing local flora in the landscaping of major transit routes and public open spaces around the city centre. The authors are confident then, that the selection of interviewees capture potential for diverse perspectives within their stakeholder group in this illustrative study.

2.2.2. Stakeholder categorisation

Stakeholder differentiation and categorisation was largely analytical (top-down), where we explored the interest (role) and influence (power dynamics) in verge land and management (after Reed et al., 2009 and Raum, 2018). Stakeholder-led categorisation occurred in so far as respondents had the opportunity to define their organisational role and responsibilities, which also informed our categorisation. Analysis of stakeholder groups' primary interest in verge space (urban or ecosystem services, or both), their influencer role, and the scale at which their influence operated at highlights some clear differences between groups (Table 2). Participants' influencer roles were defined as: 'regulator', setting verge defining policy or regulations (State Government and LGAs, with Utilities defining space and access requirements), 'manager', directly involved in the maintenance and management of verge land (LGAs, State Government-Main Roads), and 'advocate', active in representing perspectives in the public sphere, including perspectives of its members (Peak Bodies), or verge social-ecological values of Environmental Consultants and Champions of Change (Table 2). Further, an 'enabler' refers to a facilitator of verge greening activities, through providing information and education, while a 'provider' offers some form of material influence, usually with a commercial imperative (e.g. sells irrigation, plants, designs or installs verge gardens) (Table 2).

Residents, while recognised as an important stakeholder group (subjects of influence and also acknowledged as potential influencers), are outside the scope of this study as the research focused on those entities shaping the conditions and norms to which residents respond. In addition, the group of urban greening advocates we classified as 'Champions of Change' effectively promote the interests of residents who are interested in verge gardening.

2.2.3. Semi-directed interviews and survey

A face-to-face, semi-directed interview process (Reed et al., 2009) was chosen for its conversational tone and capacity to permit set questions to be asked, while providing flexibility to probe for further information or follow up particular responses. An interview guide was used for set questions, to maintain consistent lines of inquiry across all respondents and stakeholder groups, and to maintain consistency between two interviewers (Appendix I). A flexible structure allowed for dialogue during the interview (Kallio et al., 2016), and for including additional questions that were specific to particular stakeholder groups. We contacted potential participants individually (by email or phone) and invited them to participate in an interview of between 1 and 2 h. Thirty interviews, ranging from 45 min to 2.5 h in length (an average of 1.5 h) were carried out during June-October 2019, and all were audio recorded, with one exception for a respondent who preferred not to be recorded for which extensive interview notes were made. Following the related interview question, respondents were asked to complete a short questionnaire rating the relative importance of the verge in providing urban services and ecosystem services using a five-point Likert scale (i.e., not important to slightly, moderately, very and extremely important) (Table 3).

Table 2. Classification of stakeholder interests in urban services (US) and ecosystem services (ES), their 'roles' influencing the urban verge space and urban greening and the scale of this influence.

Respondent	Primary Interest	Influencer roles					Scale
	US/ES (or both)	Regulator	Manager	Enabler	Provider	Advocate	small= household to street scale, med= LGA scale, large= city/state)
State Gov- DPLH	US, ES	√					large
State Gov- Main Roads WA	US	√	√				large
State Gov- WC (partnerships)	ES, US			√	√	√	large & med *
LGA1	US, ES	√	√	√			med
LGA2	US, ES	√	√	√	√		med
LGA3	US, ES	√	√	√	√		med
LGA4	US, ES	√	√	√	√		med
LGA5	US, ES	√	√	√			med
Utility- Western Power (GTE)	US	~			√		large*
Utility- Water Corporation (GTE)	US	~			√		large*
Peak Body- UDIA	US, ES					√	med-large
Peak Body- Turf Growers Assoc (TGAWA)	ES					√	large
Peak Body- Irrigation Aust (IAWA)	ES					√	large
Peak Body- WALGA	US, ES					√	large*
H, T & I Industries- Turf consult	ES				√	√	med
H, T & I Industries- Irrigation supplier	ES				√	√	small-med
H, T & I Industries- Native plant nursery (NFP)	ES			√	√	√	small-med
H, T & I Industries- Native plant nursery	ES				√	√	small-med
Developer 1	US, ES				√		med
Developer 2 (GTE)	US, ES				√		med-large
Env Consult- Arbor Centre	ES			√	√	√	small-med
Env Consult- Western Wildflower Gardens	ES			√	√	√	small
Env Consult- Sustainable Outdoors	ES			√	√	√	small
Env Consult- Josh Byrne & Associates	ES, US			√	√	√	small-med
Env Consult- Ecoscape	ES, US			√	√	√	small-med
Champ of Change- Councillor	ES			√		√	med
Champ of Change- Guerilla gardener	ES			√		√	small
Champ of Change-Verge Gardens Aust	ES			√		√	large
Champ of Change-Beyond Gardens	ES			√		√	small-large
Champ of Change-Green Space Alliance	ES			√		√	med-large

GTE= Government Trading Enterprise. NFP= Not For Profit organisation

~ Regulate in so far as defining minimum verge space and access for utility requirements

*works with individual LGAs

Table 3. Urban and ecosystem services listed in questionnaire and categorisation for analysis.

Urban services
<ul style="list-style-type: none"> • Provision and maintenance of utilities • Footpaths/pedestrian access • Public transport access • Provision of bicycle paths • Future road widening • Car parking • Space for street tree
Ecosystem services
Regulating
<ul style="list-style-type: none"> • Stormwater management • Water quality improvement • Air quality improvement • Temperature regulation (shading) • Carbon sequestration • Soil nutrient cycling
Supporting
<ul style="list-style-type: none"> • Rainwater infiltration • Soil formation and soil biodiversity • Plant diversity • Animal diversity • Food for urban wildlife
Cultural
<ul style="list-style-type: none"> • Recreation and mobility • Aesthetic amenity • Social interaction • Improving residential property value
Provisioning
<ul style="list-style-type: none"> • Food for people[^]

Note:[^] 'Food for people' in the urban residential verge gardening context could also arguably fall within cultural ecosystem service category, given the emphasis on social practices of neighbourly sharing and the broader urban social sustainability movement (e.g. 'food is free' and the urban permaculture farm network)

2.3. Data analysis

Qualitative interview data were transcribed and imported into NVivo 12 Plus (Qsr International Pty Ltd, 2018) for analysis. Data was thematically coded (Guest et al., 2011) by identifying repeating themes and by progressively refining the coding structure until all data could be incorporated within themes (Williams and Moser, 2019). Coding was carried out in two rounds. The first round of coding aligned with the major pre-defined interview guide topics and

questions (e.g. relevant policies, organisational role relating to the verge, urban and ecosystem services provided by verges, opportunities and barriers for verge gardening, risks and challenges in transforming verges, what constitutes an ‘ideal’ or preferred verge; Appendix I). The second round of coding captured emergent patterns within the responses, from the issues, factors or outcomes that were spontaneously raised in response to open ended questions. For example, in relation to respondents' preferred verges, responses were coded for factors comprising general form and vegetation composition principles.

Median scores of the Likert scales were calculated for each urban and ecosystem service and plotted using heat maps for visualization of ratings by different stakeholder groups. Potential risks or challenges raised in relation to transforming verges with predominantly native gardens were represented in a heat map reflecting the proportion of respondents in each stakeholder group raising the particular concern. A heat map was also used to represent the relative weighting of the factors comprising stakeholders' preferred verge composition. These results were reported when raised by a minimum of two respondents. Graphics were produced in Microsoft Excel.

3. Results

Overall, all stakeholders perceived the urban road verge as a highly important space in the provision of urban services and ecosystem services. Street trees were the most highly valued urban service, along with utility provision, public access and mobility. Temperature regulation, water management, and aesthetic amenity were the ecosystem services considered most important by all stakeholder groups. Other ecosystem services were differently valued by different stakeholder groups. Perceived risks and challenges included potential public health and safety considerations, limited knowledge and experience associated with the new and emerging management of native verges, and organisational costs for verge managers and utility providers. Finally, stakeholders' preferred verges were those designed to be aesthetically interesting, fit with the built and environmental context, follow water sensitive urban design (WSUD) principles. and be resilient to a warming and drying climate (i.e., water conserving). Critically, stakeholders indicated that verges should retain options for diverse cover, but be ‘living’ (i.e., no artificial turf) and contain greater structural complexity than is the current norm (beyond just turf, or turf and tree).

3.1. Stakeholder views on urban and ecosystem services provided by road verges

The questionnaire survey revealed that all urban services were valued to some degree of importance but street trees were the only urban service recognised across all stakeholder groups as ‘very to extremely’ important. All stakeholder groups, except Utility Providers, rated ‘very to extremely important’ the following urban services provided by verges: street trees, pedestrian access/footpaths, bicycle paths, and public transport (Fig. 1). Utility provision was considered ‘very to extremely’ important by all stakeholder groups except Horticulture, Turf & Irrigation Industries and Environmental Planning Consultants (moderately important). Car parking and future road widening were the least valued urban services, although the

Horticulture, Turf & Irrigation Industries and Utilities considered space for car parking to be very important. In contrast with all other stakeholder groups, Utility Providers only placed slight to moderate importance in the contribution of verges to public transport and walking/cycling mobility (Fig. 1).

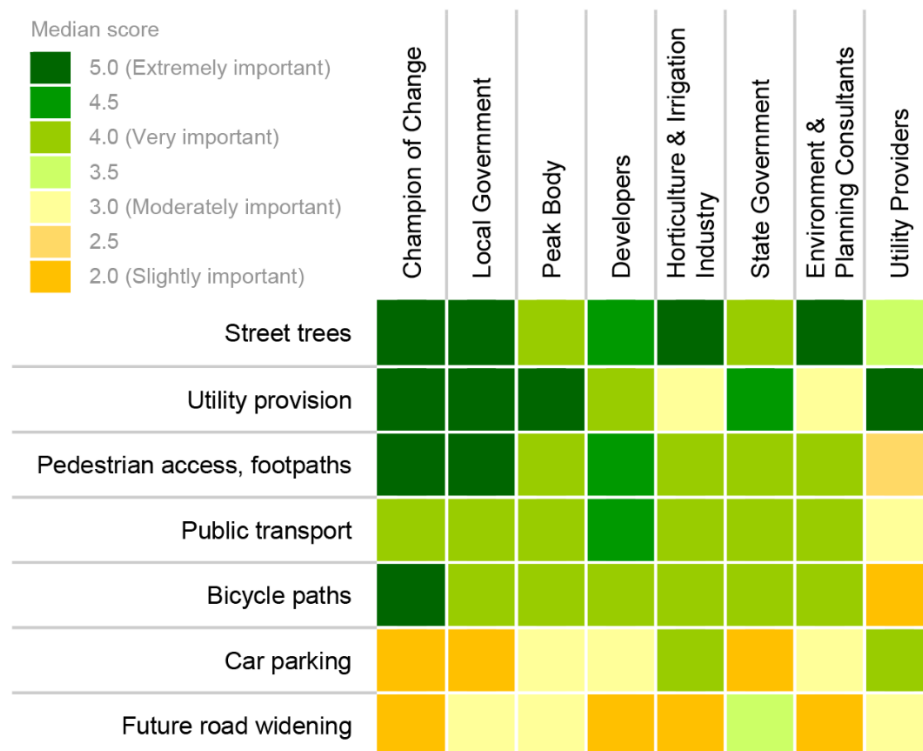


Fig. 1. Heatmap visualisation of stakeholder perceptions of the relative importance of urban services provided by road verges. Coloured squares represent the median score attached to different urban services (rows) by each stakeholder group (columns). Note that there were no median scores below 2.

Among the ecosystem services, temperature regulation was rated very to extremely important by all stakeholder groups (Fig. 2). As one respondent summarised: ‘I think first and foremost it does help reduce the urban heat island effects’ (PB-4). The following most valued ecosystem services included water management (rainwater infiltration, stormwater regulation and water quality improvement), plant diversity and aesthetics. These ecosystem services were considered very to extremely important by all stakeholder groups except Utility Providers (also, Developers rated stormwater management and water quality as ‘important’). The ecosystem services that elicited a wider range of values included air quality, soil nutrient cycling, carbon sequestration, food for wildlife, residential property value, and food provision. These ecosystem services were variously valued by respondents, with some stakeholder groups rating them as very to extremely important, while others only as slightly to moderately important (Fig. 2). Utility Providers stood as the stakeholder group with most different perspectives about the role of verges, placing only slight to moderate importance across a range of ecosystem services. Developers aligned most closely with verge greening advocates like Champions of Change and Environmental Consultants, in the valuing of most cultural ecosystem services as very important (aesthetics, recreation and mobility, property value) (Fig. 2).

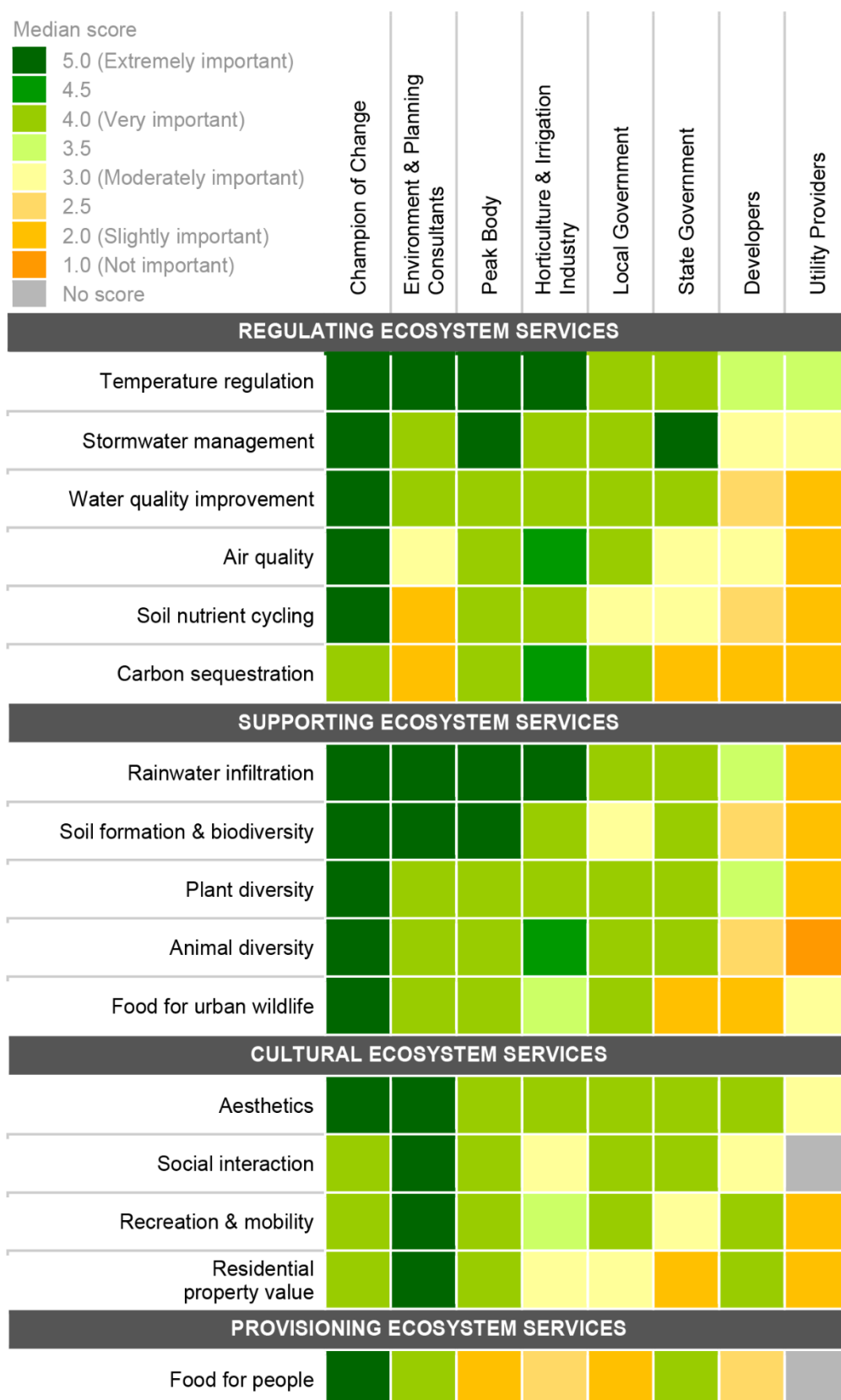


Fig. 2. Heatmap visualisation of stakeholder perceptions of the relative importance of ecosystem services provided by vegetated road verges. Coloured squares represent the median score attached to different ecosystem services (rows) by each stakeholder group (columns). 'No score' was recorded where the ecosystem service was outside the respondent organisations' core business.

During interviews, stakeholders prompted additional insights into their views on the importance of verges, with a range of aspects raised about cultural ecosystem services. Indeed, the social and individual wellbeing benefits generated from aesthetically interesting or pleasing streetscapes and verge gardens were repeatedly mentioned, particularly among Environmental Consultant, Champions of Change and LGA stakeholder groups. For example, an LGA respondent described how a well-tended streetscape or verge garden provided a sense of care and security:

'When you've got people that actually have quite vibrant, interesting verges, it creates a little bit more of an amenity to an area... it creates an atmosphere of somebody actually looking after it...I certainly think that it changes the mood of area... When you go to a place where all the verges are maintained and there's different textures and colours, it's a lot more welcoming. You do feel more secure. It does feel better.' (LGA-5).

A significant cultural ecosystem service not covered by the questionnaire but mentioned by all stakeholder groups (except Utility Providers) was the contribution of native verge greening to generating a 'sense of place'. For example, an Environmental Consultant described their organisation's motivation to design and install verge gardens using native species to foster a unique sense of local identity:

'If we can demonstrate our sense of place, of who we are, down each street... that would be exciting... but again it's the deeper aspect of who we are in this country... because our plants are so unique, we can begin to represent this in our gardens.' (EC-2).

Respondents across Environmental Consultants, Champions of Change, Horticulture, Turf and Irrigation Industries, and State Government groups described this 'sense of place' emerging through local plant use. For several of these respondents, this included planting verges to have flowering patterns highlight the six seasons recognised by Perth's First Nations Whadjuk Noongar people. Verge greening with native plants was also used to enhance sense of place along major arterial roads, including through the State Government Main Roads-led 'Wildflower Capital' Initiative. This initiative has installed displays of local native vegetation in the gardens and road verges alongside public centrepieces and transport hubs of Perth city. Despite Western Australian flora being recognised internationally as a unique biodiversity hotspot, many respondents acknowledged the lack of local appreciation among residents and the need to grow this through greater education:

'Our bush is what it is. And it's the most beautiful... at certain times of the year, and people travel from all over the world to come and look at it... we just need to change [local mindsets].' (HT&I-3).

The verge space was highly valued for recreation, mobility (promoting neighbourhood walkability) and social interaction opportunities. Respondents who viewed verges as very important for recreation cited space for contemplation, gardening, and children's play. Conversely, stakeholder groups who did not view verges as having a strong recreational role (State Government, Utilities) felt that private gardens or designated public open space were better placed for more active recreation opportunities. Social interaction generated through verge gardening was also highly valued by five stakeholder groups (Fig. 2), and particularly raised by Champions of Change, Environmental Consultants and LGA stakeholder groups, as the primary groups involved with enabling and encouraging verge greening. These respondents frequently cited incidental interactions during verge gardening as contributing to growing a sense of community. For example:

'It's just that physical act of being out the front of your house, undertaking an activity – gardening [...] and you get to talk to people. And they stop and they chat, because I find that inherently, people want to communicate but there are limited opportunities within the streetscape, within a local community, so it's this fantastic act of community building as well, that I think is something that's probably really under-recognised in that space.' (LGA-1).

The economic contribution of a vegetated verge to residential property values was identified as very important among half the stakeholder groups (Fig. 2). Additionally, where economic value was attributed it was frequently linked to public 'commons', rather than the private property sphere. Importantly, several stakeholder groups (Utility Providers, Developers, LGAs, State Government, and Champions of Change) noted the efforts by LGAs to attach a financial value to street trees in order to minimise their loss resulting either from residents wanting unimpeded views, or the actions of contractors engaged by developers or utility providers. Champions of Change and LGA respondents described economic valuation of street trees as an important step to protect these 'green assets', and also where street tree removal was indeed necessary, a mean for the LGAs to recoup 'public' costs associated with the tree loss. Utility Providers and Developers, on the other hand, while cognisant of this evolution in green asset valuation, often worked with multiple LGAs, and found the variability in the approvals and compensation processes across the Perth's 31 metropolitan LGAs challenging to navigate. Stakeholders did not relate financial valuation to verge vegetation other than trees.

3.2. Co-benefits of verges

Stakeholders noted the positive interaction between various ecosystem services provided by verges. For example:

'Our goal is to maintain the multifunctional values of verges. [In the past] It's just been stripped down to utilities. We want to reverse this trend and emphasise multiple values.' (SG-3).

The close association between stormwater management and water quality improvement was recognised by Environmental Consultants, State Government and Champion of Change stakeholder groups:

'And we have to put more [water] into these verges, they can be very effective drainage easements...instead of running at high speed to the nearest river, which is the old dynamic, now we want to slow it down. [Because] the faster water moves, the more it carries, so you get erosion and also you get transportation of hydrocarbons from cars, all the usual rubbish, goes straight into the river... Now we're creating these 'living streams'... it's turning them into living places that slow the water down and you've got reeds to catch the nutrients and basically turn that into clean water.' (CoC-3).

'We often do sumps and then it filters through the groundwater. Very occasionally, we do linear wetlands, so the water goes through the reeds, stripping the nutrients out' (SG-2).

Environmental Consultants, who are frequently required to employ water sensitive urban design, also noted the interactive effects of *in-situ* water management with temperature regulation and biodiversity conservation:

'So water sensitive urban design, where we keep the first 15 mm of a rainfall event at source or on a verge, that not only assists with treatment of that water before it goes in the groundwater, but it also assists in urban cooling, keeping moisture at the surface. Certainly urban cooling is a priority from a human liveability perspective. From an environmental perspective, we look for opportunities for roadside swales, which enhance biodiversity on that front.' (EC-4).

Temperature regulation was highlighted as critical for human health and mobility by Environmental Consultants, Developers, and Champions of Change. Indeed, providing shaded corridors was recognised as fundamental to the walkability of neighbourhoods (e.g., *'That is absolutely front and centre for us. Again... people won't go there if it's not shaded. You know, heat is becoming a real health issue. So street tree policy, which links into verge policy as well, is really important'*; EC-4). Finally, also mentioned were the co-benefits derived from biodiversity conservation and provision of sociocultural benefits associated with birdlife observation in the verge, as part of the front garden extension, and along streetscapes.

3.3. Perceived risks and challenges associated with verge greening

The perceived risks and challenges associated with verge greening nominated by stakeholders crossed multiple domains, including physical hazards, species selection, organisational, biotic losses, among others (Fig. 3). All stakeholder groups raised the potential for public safety concerns if LGA or Main Road regulations regarding vegetation requirements were not adhered

to. Public safety management concerns of additional verge vegetation included maintaining vehicle sightlines (pedestrian or traffic visible from driveway), maintaining open pathways (for safety, avoiding trip hazards, spiky or poisonous plants), and managing the potential for additional fire risk. Human health risks included the spread of disease or produce pests associated, among others, with unmaintained fruit trees, and the potential for edible produce contamination (e.g. vehicle exhaust) (Fig. 3). Respondents across half of the stakeholder groups (Environmental Consultants, Champion of Change, Horticulture, Turf and Irrigation, and LGAs) commented on the perceived over-emphasis by LGAs on public liability, to the detriment of ecosystem services delivery and more widespread adoption of innovative verge designs. Additionally, lack of enforcement of LGA verge vegetation policy (through limited resourcing or lack of political will) was also raised as a concern (LGA, Champions of Change).

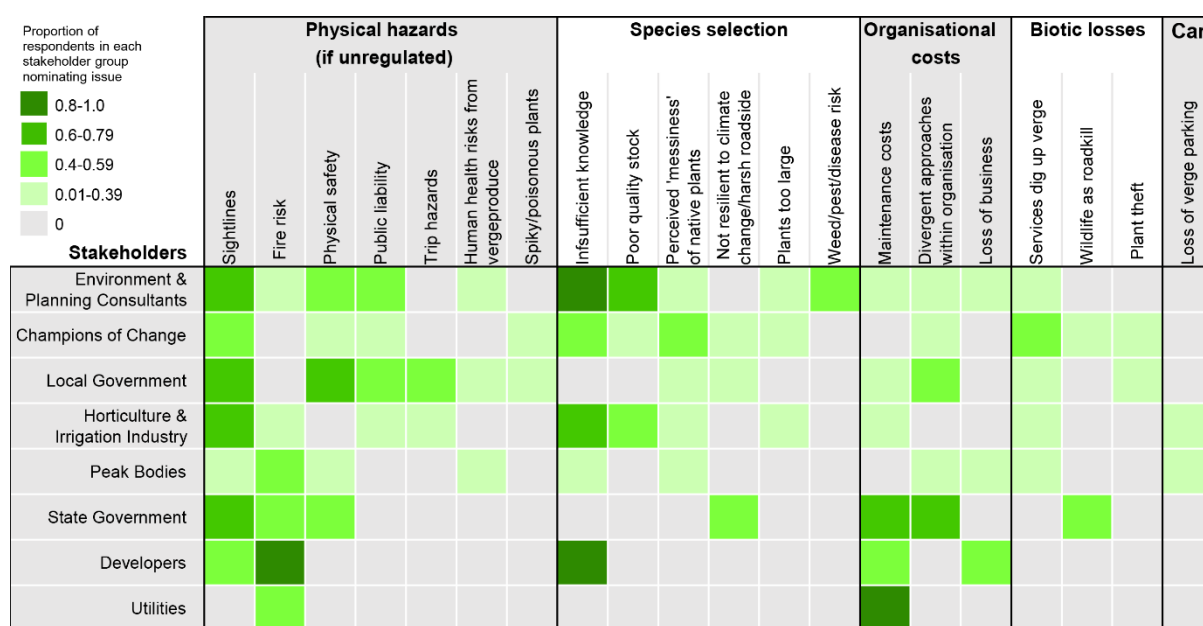


Fig. 3. Summary of stakeholders' concerns associated with the installation or management of vegetated verges. The concerns shown in this table were raised spontaneously by respondents during interviews, rather than in response to targeted questions. Categorisation by the authors. Note: organisational costs nominated by Environmental Consultants (EC) and the Horticulture, Turf and Irrigation Industries (HT&I) stakeholder groups refer to maintenance costs for other organisations (e.g. LGAs, nurseries).

All stakeholder groups identified organisational costs associated with innovative verge designs, if not for themselves then for others (i.e. Environmental Consultants and Champions of Change also identified costs incurred by other stakeholders) (Fig. 3.). These costs related to the additional, new or different requirements in access, management or maintenance, which acted as a constraint for LGAs adopting innovative verge greening. For example:

'It's a bit of an issue for us because often we will try to put in a water sensitive design, the best results are usually when you do have vegetative swales but then the local authority will go, "No, we're not going to manage that." Because if they can't drive a mower over it, they're not really interested.' (Developer-2).

Organisational costs for Utility Provider and State Government respondents included additional costs associated with asset maintenance (e.g. costs of closing roads to work around trees) and navigating the wide variety of urban forestry policies, approvals and compensation processes across Perth's multiple LGAs. For instance:

'A lot of that will be differences in the calculation of either the number of [replacement] trees or the cost that the LGA's trying to enforce via their local government policy. Some of them, for what could be considered rather minor works from our point of view, have some significant costs... [in our view] it goes beyond what's reasonable. And in those instances, particularly where it's not a statutory obligation on us, then there is quite often negotiation...' (Utility-2).

Impacts to profit margins were a concern for some stakeholders, while the businesses of others were directly dependent on verge greening. Developers were concerned about the loss of saleable lot yield to the area of verge land. Respondents associated with the turf industry raised the direct loss of business with conversion of verge lawn to gardens and were also concerned about the potential loss of verge car parking function. This is in contrast to the native plant industry and native garden verge designers and installers, who stand to gain from the growing trend in verge gardening.

Internal organisational challenges for managing the verge space were raised by State Government, LGA and Utility stakeholder groups. For instance, policy implementation, communication and operation can become more challenging where verge policy and management are split across different sections of the organisation:

'Even within LGAs, often different parts of the City have responsibility for maintaining verges... Often there's no single department in charge of it. There's no one entity that's in charge of it or wants to take charge of it, I suppose.' (LGA-5).

Organisations like LGAs (and the Peak Body representing them) frequently have to navigate internally competing or potentially opposing objectives. For instance:

'We even have competing objectives with our own organisation, because within the councils, there's road engineers and there's environmental proponents and they would have conflicts within an organisation...the engineering functions versus the priorities of environmental conservation.' (PB-2).

Internally competing objectives were particularly challenging in organisations where verge greening may not be perceived as 'core business' (e.g., operating verge greening programmes within primarily engineering organisations, like the Water Corporation or Main Roads Department). Within these organisations, respondents emphasised the critical importance of clear and ongoing internal communications to manage these potential challenges.

Challenges associated with vegetation establishment and maintenance were also noted. Most stakeholder groups raised the impact of lack of knowledge on the success of verge greening efforts (Fig. 3), namely within the general public, residential gardeners and LGA maintenance staff. This lack of knowledge extends to the initial and ongoing requirements of native plants, the variety of suitable species available and the planting environment (e.g. the harshness of the roadside environment, soil often fill from building, how to manage weeds). For example, a horticulture respondent described:

'I think, you've got to overcome this overwhelming failure in Australia about the lack of knowledge and interest in native plants, because I think you've just have this huge [non-native] nursery industry promoting other things. So I think, one of the biggest barriers is lack of education... For example, a lack of understanding of how to remove couch grass,.that a native garden isn't "set and forget", it does take some maintenance early on.' (HT&I-4).

Multiple respondents raised the challenges of inappropriate species choice (e.g. for space, resilience to roadside environment or a warming climate, aesthetics), poor quality stock (plants or soil), and inadequate consideration of landscape design (drainage, pest/disease susceptibility), for cost and success of verge transformation (Fig. 3). All stakeholder groups, except for Utility Providers and Developers, noted a risk of biotic loss caused by utilities digging up plants to access essential services and plant theft, as well as the potential for roadside animal deaths (Fig. 3). Other challenges noted included a dislike for the aesthetics of native vegetation among part of the community, and the desire to retain space for vehicle parking on the verge.

3.4. Stakeholder preferred verge responds to local conditions, is resilient and includes understorey vegetation

In response to asking what constitutes an 'ideal' verge, patterns in the elements comprising stakeholders' preferred verge emerged. Vegetation cover would ideally be beautiful or interesting, attract birds, and have some degree of structural layering or complexity. Verge design and vegetation were recognised as context dependent, but should follow principles of Water Sensitive Urban Design and be resilient (waterwise) (Fig. 4).

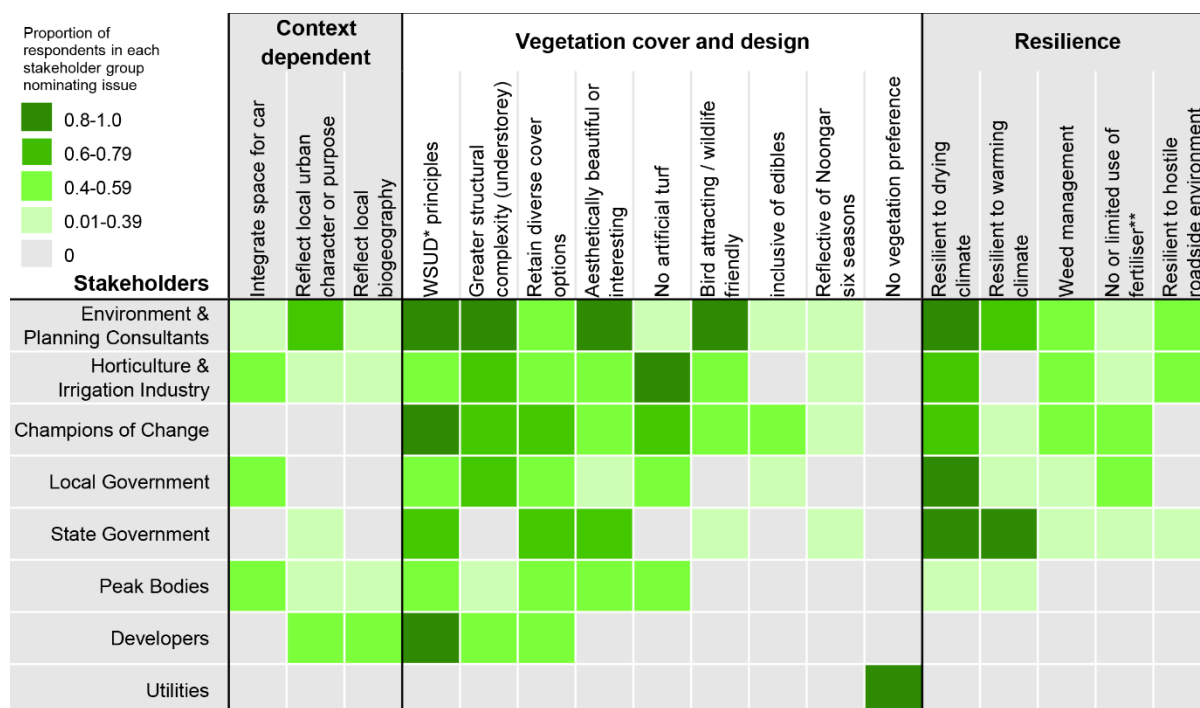


Fig. 4. Summary of stakeholders' preferred features of vegetated road verges. The preferences shown in this table were raised spontaneously by respondents during interviews, rather than in response to targeted questions. Categorisation by the authors. Notes: * WSUD refers to Water Sensitive Urban Design. ** limiting the use of fertilisers was associated with notions around being 'estuary-wise' to reduce nutrient run-off and subsequent eutrophication within the Swan-Canning Estuary.

Respondents conceded that appropriate verge designs are highly context dependent, reflecting community needs, local edaphic conditions, the surrounding built form, and, for several stakeholder groups, retain the option for a car parking space (Fig. 4). For example, a Peak Body respondent (PB-4) described verges around activity hubs with higher population densities requiring off-street parking as being better suited to trees and turf, while suburban areas with connections to remnant bushland could focus on supporting biodiversity.

In terms of verge vegetation preferences, Utility Providers were the only stakeholder group who did not express any (Fig. 4), instead prioritising factors related to infrastructure, such as fully documented and accessible assets to facilitate maintenance or repairs. Many Perth suburbs are undergoing conversion to underground power which aligns with the Utilities' preference 'to remove [risks associated with] environmental factors and third-party impacts' (Utility-2), and general community preferences for underground power (e.g. 'I would love for an opt-out street tree programme and I would love for underground power, and for where every power pole was there to be a tree'; LGA-3). All other respondents wanted, at a minimum, something 'healthy and living' (HT&I-2) or simply 'Green. Just green. Green with a tree in the middle. You can park your car there or you can sit in the shade' (PB-3), and emphasised walkability and shade, for which turf and a tree sufficed (Fig. 5).

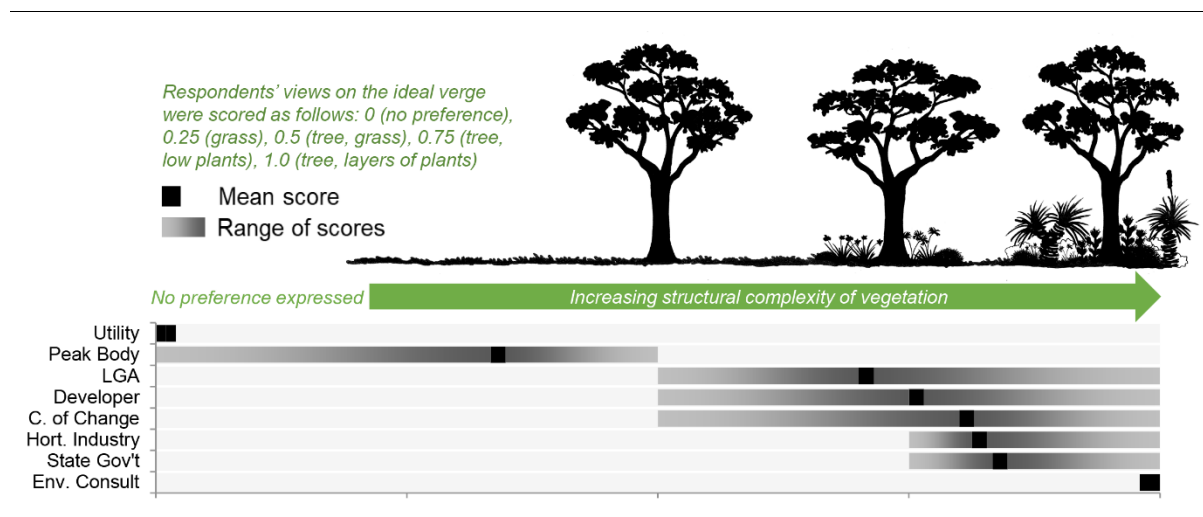


Fig. 5. Visualisation of the variation in stakeholders' preferences for structural complexity and diversity of an idealised urban road verge. This was in response to the general question 'What would an ideal verge and streetscape verge look like to you?'

Yet, the majority of stakeholders valued vegetation structural complexity, particularly Environmental Consultants (Fig. 4) and preferred inclusion of low plants or understorey in addition to a street tree (Fig. 5). Discussions of structural complexity included an emphasis on bird attracting mid-storey shrubs and a diverse understorey including flowering native plants to reflect local seasonality, as well as the use of ground covers. Several respondents (Champions of Change, Horticulture, Turf and Irrigation, and Environmental Consultants) felt that attention to mid- and understorey vegetation was long overdue, pointing at the current predominant emphasis on canopy cover only by LGAs' Urban Forest Strategies. For example: 'A lot of urban forest strategies talk about trees and nothing else. I think it's about time they had shrubs [...] and an ideal [verge] is something flowering all year round' (CoC-4). These respondents felt that comprehensive Urban Forest strategies would also need to promote a structural complexity more reflective of that found in local natural ecosystems.

The need for retaining choice and a 'balance' of vegetation cover layers along a spectrum from grass only through to understorey, midstorey and canopy was emphasised by several respondents. For example:

'I would like to see half of it native plants and half of it turf, so people can park there if they need... There's certainly a combination needed' (HT&I-3).

'It's about trying to promote more effective landscapes, where it's appropriate. Because there are some areas where it's appropriate to have a lawn, especially if you live in the hills and the like, because it actually acts as a firebreak. So, it's about fit for purpose, it's about balance... It's about having a choice, still giving

people the choice, it's about promoting green and real, over fake and hot, essentially.' (State Gov-1).

The contrasting option of *'fake and hot'* here refers to artificial turf, a topic raised, unprompted, by respondents spanning all stakeholder groups (except Utilities), who noted its increasing use as a verge treatment (Fig. 4). Respondents felt an urgent need for artificial turf use to be regulated, raising multiple sustainability concerns, such as release of microplastics to the environment (given short lifespan and susceptibility to damage), contribution to urban heat, restricting water infiltration, causing poor soil health and compaction, and potentially becoming weed mats.

All stakeholder groups, except Developers and Utility Providers, made reference for a verge to be resilient (Fig. 4). This was recognised as critical in the current context of both a drying and warming climate. Responding to a drying climate through a *'waterwise'* verge was most widely cited among these stakeholder groups, and particularly for LGA and State Government groups. Species had to be climate resilient, through being adaptable to increasing average or extreme temperatures, as well as having to manage weeds, limit fertiliser use and cope with the harsh conditions of the roadside exposure (such as wind and reflected heat), particularly along larger arterial roads (Fig. 4).

Water sensitive design principles were raised by all stakeholder groups except Utilities. This factor also united verge greening advocates with Developers in the elements of a preferred verge. Environmental Consultants emphasised this factor, for example explaining preference for *'[a verge] that makes use of stormwater, like rain garden infiltration, and to have people understand its function and treat it as such would be quite good.'* (EC-5) and considering topography was an important part of this.

A native plant pallet synchronised with the six calendar seasons of Perth's First Nations Whadjuk Noongar people (i.e., containing species whose flowering signals different seasons) shaped the preferred verge of respondents across four stakeholder groups (Champion of Change, Environmental Consultants, Horticulture, Turf and Irrigation Industry, and State Government). For example: *'if we look at the six [Noongar] seasons, there are these six beautiful, magnificent displays of colour that you will see at one time throughout the six seasons.'* (EC-2). Edibles constituted part of the preferred verge for respondents across Champions of Change, Environmental Consultants, and LGAs (Fig. 4).

Illustrative photos of a spectrum of suburban verge greening treatments are provided (Fig. 6.A-D), as well as examples of native road verge greening along arterial roads as part of the State Government's Wildflower Capital Initiative (Fig. 6. E-F).



Fig. 6. Verges illustrating a spectrum of verge greening treatments that can be found throughout Perth, Australia. Photos (a) to (d) are suburban verges: (a) grass; (b) grass and tree, the commonly grown weeping peppermint *Agonis flexuosa*; (c) native tree and understorey plantings such as kangaroo paws, (d) multiple structural layered verge planting. Photos (e) and (f) illustrate the native vegetation greening along arterial roads and shared pathways within the centre of Perth, as part of the State Government's 'Wildflower Capital Initiative'.

4. Discussion

Here, we highlight the common ground, or shared stakeholder perspectives, as well as diverging ones in relation to urban and ecosystem services provided by the verge, verge greening challenges and preferred verge vegetation composition, respectively. There was much common ground identified, perhaps assisted by the observation that most stakeholder groups occupied two (or more) roles of influence, or interest in both urban and ecosystem services. This should give regulators and managers, in particular, further confidence in adopting verge policies or programmes supporting the delivery of these services. The most divergent perspectives were found among the group whose interest was solely on urban services (Utility Providers). This suggests communication and engagement between those and other stakeholder groups continues to be critical as verge services evolve and expand beyond the traditional urban services of access and utility provision alone.

4.1. Navigating stakeholder perspectives in perceived urban and ecosystem services

The ecosystem services of temperature regulation, those associated with water management, and the cultural services of aesthetically interesting streetscapes were the most highly valued across almost all stakeholder groups. These findings identify those services as a point of convergence, or common ground, from which to address those services that are differently valued. The recognition of temperature regulating effects of verge vegetation and the need for verge space to accommodate street trees as an urban service, among all stakeholder groups, demonstrates a paradigm shift in viewing the role of the verge from one of access and service provision, to one that recognises its potential to support urban greening as equally important. Street trees were clearly an accepted component of the verge. This is reflected in the strong growth in municipalities not only in Perth but around the world in implementing urban forest strategies (Ordóñez et al., 2019) and metrics for canopy cover. The challenge stakeholders identified now relate to retaining adequate verge land area to support shade-giving trees in new developments and subdivisions, as well the diverse compensation costs among LGAs.

The role of the verge in providing water-related ecosystem services was uncontentious. The high proportion of respondents referring to water sensitive urban design principles and ‘waterwise’ resilient vegetation in their preferred verge also suggests that incorporating such principles into verges and streetscapes should be well accepted. The majority of respondents recognised the challenges posed by reduced rainfall in a drying climate, and of climate change more broadly. The public messaging around water scarcity in Perth has been very effective. This has largely been led by the Water Corporation over several decades, through various public outreach programmes. For example, the Water Corporation’s Water Efficiencies Partnerships Programme, has assisted numerous LGAs in encouraging residential behaviour change in water efficiency, including through encouraging water sensitive verge gardening and promoting levels of ‘waterwise’ certification for LGAs. Furlong et al. (2018) similarly, found Melbourne’s water utility, who also adopted a concurrent urban greening programme, strongly influenced a cultural shift supporting water efficiencies and urban greening within local governments. Numerous cities globally are facing water shortages and drying climates (e.g. Koop and Van Leeuwen, 2017, Millington and Scheba, 2021), and similar partnerships between government water providers and LGAs could be effective vehicles for influencing public awareness and the necessary behaviour change.

The desire for aesthetically ‘cared for’ streetscapes was clearly a strongly shared, highly important verge service among all stakeholder groups but Utility Providers. Verge treatments can constitute visible landscape interventions that contribute to urban sustainability, as defined by Nassauer’s concept of ‘cues to care’, and have recently been linked to enhanced neighbourhood safety (Nassauer et al., 2021). Cultural ecosystem services proved the set of ecosystem services with greatest common ground between, for example, Developers and other groups. However, the remaining differences among other cultural services for at least half the stakeholder groups, suggests there remains scope to grow both stakeholder and broader public

understanding of the social-cultural benefits of vegetated verges. While existing public messaging has focused heavily on environmental outcomes (water saving, cooling effects), more could be done to strengthen recognition of the socio-cultural benefits associated with verge greening.

Just as ‘guerrilla gardening’ has underpinned the verge greening movement, verge greening can foster ongoing social activation. Half the stakeholder groups, those which shared ‘enabling’ characteristics through the provision of education and information, identified the importance of native verge vegetation, particularly the understory, in building a local sense of place and identity. While Seddon (1972) and others have articulated a local ‘sense of place’ for Perth many years prior, it remains a concept with different meanings among practitioners. With the growing public recognition of Perth’s unique position as a city within both the South West Australian Floristic Region and a global biodiversity hotspot (where endemic species are also threatened), many people want to support native biodiversity where they can exert some immediate influence (i.e. their own garden or verge). For a small proportion of respondents within each group, this included a clearly emerging preference for verge vegetation to reflect not only ecological values, but also Perth’s unique local biocultural heritage values, through plantings highlighting First Nations’ Wadjuk Noongar seasons. That these respondents were spread across half the stakeholder groups, demonstrates it was not an interpretation siloed to one group and thus likely has the potential for wider acceptance and implementation. The verge space offers a tangible means of supporting the urgently needed application of decolonising approaches in urban planning (Cocks et al., 2020, Porter et al., 2020). For example, seasonal signifier plantings could be used in combination with interpretative signage along primary pedestrian routes to contribute to place making through raising awareness of First Nations’ cultural heritage. Everyday mobility provides opportunities to experience native species phenologies at multiple scales, from the residential verge to city-scale transit corridors. In addition, verges along drainage networks and associated riparian zones (often historic human movement corridors), as well as other major transport routes such as train lines, could contribute to ecosystem services (Polyakov et al., 2017, Bolleter, 2017), including under recognised cultural heritage services. Future studies would benefit from engaging with culturally diverse stakeholder groups, including local First Nations perspectives, on the use and management of informal greenspaces.

4.2. Navigating stakeholder perspectives on major concerns and challenges in verge greening

Differences in the concerns raised among stakeholder groups in response to verge greening, largely reflected their influencer role. For those stakeholders who act as regulators, managers or utility providers, organisational challenges were perceived as the biggest challenges in navigating the increasing trend of verge greening, including in a drying climate context. There will always be tensions between State and Local government managers and utility providers, as with developers, due to their influencer role and primary interest. Adaptation or reorganisation of an organisation's internal structures and responsibilities may be required to

accommodate roles and functions moving beyond traditional ‘core business’, to meet the demand of societal sustainability challenges. The internal organisational challenges and costs highlighted for LGAs, State Government and Utility Providers concurred with those identified in Ordóñez et al. (2019), of limited resourcing, knowledge, policy alignment and coordination across an array of internal groups associated with urban forest governance. Existing LGA structures may not adequately serve urban and verge greening programmes that encompass staff working in policy, operations, enforcement and community engagement sectors. In addition, the point of contention that State Government, Utility Providers and Developers all articulated in their engagement with LGAs was their desire for a greater consistency among Perth’s 31 LGAs in terms of their ‘green asset’ valuation. This may become even more relevant as the financial value of green verge ‘assets’ or ‘infrastructure’, including street trees (e.g. Pandit et al., 2013) and other vegetation, becomes more widely recognised. Costs remain for Developers and LGAs in the implementation of Water Sensitive Urban Design. Such novel designs and vegetation form can also be challenging for LGAs to manage the ongoing maintenance of such landscaping. This may require LGAs to support, and suitably resource, further education and training in transformational verge management practices, as well as developers being willing to modify site-engineering techniques i.e. retaining natural topography (Kullmann, 2014, Grose, 2010).

There was a clear recognition among most stakeholder groups that a lack of education and knowledge contributed to failure in successful implementation of native verge gardens or streetscapes. There was a clear call, particularly from across enablers, providers and advocates (e.g. Environmental Consultants, Horticulture, Irrigation and Turf Industries, Champions of Change and LGAs), for greater education and training to benefit both residential verge gardeners and Local and State Government operations staff in maintaining innovative verge designs. Adopting native species gardening (particularly in small spaces) is a relatively recent, emerging practice without a long history of widely understood methods. In addition, providers and advocates spoke of the ‘risk-adverse’ nature of many LGAs in terms of their willingness to permit verge gardening, though ‘Champions of Change’ have effectively worked to reduce this and generated change in some LGAs’ verge policies. The lack of public knowledge regarding gardening using native species is gradually being addressed on multiple fronts. Through decades of pioneering work among local horticulturalists, nurseries, and Perth’s Botanic Gardens and Parks Authority (Kings Park Science), identifying, selecting, and propagating verge-suited native species (e.g. low growing, hardy) has become more viable and common, with a growing range of native and endemic plants commercially available. While information and advice on species suitability and growing requirements is becoming more accessible, all providers and enablers noted that widespread education remains necessary. Through cross-sectoral endeavours, such as the Wildflower Capital Initiative, for example, Perth’s Botanic Gardens is providing biological advice to the verge managers at Main Roads. With support from the Water Corporations ‘waterwise verge’ programme, multiple LGAs are now offering verge gardening information and education (consultations, workshops) and

incentives (e.g. free mulch, awards and rebates for installing verge gardens, verge garden awards) to transform bare verges into waterwise gardens.

Moreover, there was widespread stakeholder interest, also across those stakeholder groups acting as enablers, providers and advocates, in obtaining locally derived evidence on a variety of ecosystem services the verge may provide. Several respondents offered to provide in-kind support for such research programmes. Field experiments of locally relevant management scenarios and their effects on ecosystems service provision and modelling at various scales (e.g. Miller and Montalto, 2019, Phillips et al., 2019) would contribute to providing such an evidence-base. Research linking species composition and structural diversity in verge vegetation with particular ecosystem service outcomes, for example, could help convince stakeholders that the benefits of more innovative design outweigh possible costs of adapting to different vegetation management regimes. For example, in Perth, positive effects of urban greening have related quality of vegetation (e.g. Sugiyama et al., 2015) and accessibility (Dushkova et al., 2021) to physical and mental health (Pereira et al., 2013). This underscores the importance of well-designed, structurally diverse verges that are directly accessible from people's homes, yet there is little direct local evidence of the benefits of this form of urban greening. Ultimately, a larger local evidence base could help address perceived risks and concerns and establish common ground among stakeholder groups, particularly those for whom urban greening is not core business.

Limited understanding of the potential ecosystem services and co-benefits provided by verges can exacerbate disparate values and potentially conflicting management priorities. This could account for the greater difference in importance ascribed to those ecosystem services respondents were less familiar with, including those relating to soil, air and carbon sequestration. Addressing research gaps through stakeholder partnerships provides opportunities for experimenting with innovative, collective forms of governance by multiple actors (Voytenko et al., 2016). This may generate new urban living solutions or new types of relations between people and place (Frantzeskaki et al., 2018). Such innovative partnerships between Environmental Consultants, LGAs and Developers have emerged to produce award winning, innovative and sustainable community development projects (e.g. Byrne et al., 2020, Hancock et al., 2020). These projects provide evidence and insights through showcasing public garden and verge management that support sustainable social and environmental outcomes. Additionally, understanding how knowledge sharing networks among diverse stakeholder groups shape this transformational urban greening, for instance through social network analysis, as has been applied in other urban natural resource management contexts (e.g. Robins et al., 2011, Lienert et al., 2013), would also enhance stakeholder relationships and address potential conflicts.

4.3. Navigating stakeholder preferences for verge vegetation composition

Stakeholder preferences in verge design largely agreed upon the need to retain diverse design and vegetation cover options to reflect and suit local built and environmental contexts. This was shared across diverse groups including Environmental Consultants, Horticulture, Irrigation and Turf Industries, Peak Bodies, and Developers (advocate and provider roles), but was not noted by Champions of Change (enabler & advocate) or Utility Providers. Ecosystem services provider stakeholder groups (as those most involved with on ground material provision, design or installation) and Peak Body advocates also recognised the need to retain potential for car parking space in the verge design. Preferred vegetation elements reflected those highly valued ecosystem services, i.e. being aesthetically interesting, structurally complex, bird attracting and adopt Water Sensitive Urban Design principles.

Attention among most stakeholder groups has clearly shifted to enhancing the understorey vegetation in support of multiple ecosystem services. Stakeholders' discussion of both canopy (tree-related) and understorey management issues is partially a reflection of the inherent complexity of verge management. This relates to the different responsibilities (public residents managing understorey in residential areas, LGAs the street trees) and different policies across LGAs (for example policies on low growing plants, residents planting a street tree, edible plants may be permitted, subject to approval or not permitted (Ligtermoet et al., 2021)). Despite this, the clear preference among all stakeholders (apart from Utilities) to include recognition of an understorey in urban 'forests', should encourage otherwise reticent LGAs to engage with verge planting programmes, and encourage those LGAs already engaged with urban forest strategies to 'look below' the dominant layer of canopy cover. However, LGA respondents also variously referenced staff training, adequate resourcing, effective internal governance and local political leadership as integral to a LGA's capacity to provide greater attention on understorey vegetation. Successful vegetation outcomes are also more likely if vegetation experts (arborists, environmental consultants, horticulturalists) are involved from the earliest planning and design phases to support appropriate species selection (i.e. resilient to roadside and drying, warming climatic conditions) and to ensure sufficient space is retained at the design stage.

Stakeholders were adamant that this 'understorey' should not be of 'plastic green'. The united front across verge lawn traditionalists (turf industry) and verge gardening advocates (Environmental Consultants, Champions of Change), in their desire to prohibit artificial turf as an approved verge surface treatment was notable. Studies of artificial turf used in playing fields highlight various concerns around elevated temperatures (Jim, 2017) and infill leachate risk (Magnusson and Mácsik, 2017). Other social and environmental considerations include the likely loss of ecosystem services associated with living lawns (Francis, 2018). These issues are shown to be at least partly recognised already by Perth LGAs, where, for example, of the 24 LGAs who refer to artificial turf in their verge policy, 11 do not permit its use, and a further 12 restrict its use in area and/or require LGA approval (Ligtermoet et al., 2021). Further community education would likely support this shared preference among diverse stakeholders for living and green verges to support ecosystem service delivery.

5. Conclusion

In identifying shared and divergent perspectives among stakeholder groups on urban verge services, the potential risks or concerns and preferred composition of verge greening, much common ground has emerged. Verge greening is now clearly recognised as a core verge function among stakeholders, along with traditional functions of access and utility service provision. Our analysis identified that all stakeholders viewed the verge as a highly important space for providing the ecosystem services of temperature amelioration, water management (regulating stormwater run-off, supporting infiltration and water quality improvements), and aesthetic amenity. While stakeholders tended to agree on the importance for multiple verge functions to coexist, their management is still complicated in practice. Navigating the contestation often associated with new or transformative uses of land at the public-private interface requires ongoing education, among the public and land managing authorities, of the benefits and requirements of managing verge native gardens. Stakeholders sought locally derived evidence demonstrating the specific ecosystem service outcomes of verge greening, particularly those beyond the more widely understood temperature, water and aesthetic services. Stakeholders envisaging their preferred verge highlighted the need to reflect local context and retain diverse options but to incorporate water sensitive urban design, be visually interesting, and resilient to a warming and drying climate. A majority of stakeholder groups felt greater vegetation structural diversity would be beneficial, and there was an emerging recognition of the potential to enhance sense of place with the use of native plant species. These findings provide further evidence to support decision making in the contested and rapidly changing space of urban road verge management and policymaking.

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Appendix I.

Interview guide: themes and illustrative questions, some of which were specific to particular stakeholder groups. This example is for a respondent from the LGA stakeholder group.

Theme	Illustrative interview questions
Local policy	<ul style="list-style-type: none"> • Can you describe [your LGAs] current policy and/or programmes on urban greening [urban forestry]? • How does [the LGA] select plants for street-scaping of arterial roads and verge programmes [where applicable]? • Can you describe your current policy on verge gardens, and how this policy has been developed? [history] Who or what drove the policy? • What is/are the main reasons that [the LGA] has decided to develop (or not develop) a programme to encourage verge gardens? • Does [the LGA] offer any incentives or supports for verge transformations? (E.g. demonstration verges, guidelines, physical assistance, rebates or plant subsidies?). Can you tell me the current annual budget for this? Has this changed over time? • Is [the LGA] a Water Corporation certified waterwise LGA? If yes, are there any incentives or rebate programmes with matched funding from Water Corporation?
Governance structures	<ul style="list-style-type: none"> • Can you tell me which part of [the LGA] is responsible for verges?
Values of verges	<ul style="list-style-type: none"> • What do you consider to be the actual and potential value of verges for the environment? [biodiversity, water, heat, public/community goodwill, amenity...] • Are there differences in how [the LGA] understands these values for residential verges vs streetscapes? • How does [the LGA] understand the value of the verge to key stakeholders including residents, neighbours, and developers? • What do you consider to be the role or potential role of verges for community engagement/cohesion? (social capital) • How has the value (or perceptions) of street verges changed over the last few decades? • Do you consider the values of verges to differ for residential in-fill vs new developments?
Process of verge transformation through native gardening	<ul style="list-style-type: none"> • How do you understand the actual or potential process of transforming a verge area to a native garden • What in your experience inspires this process to begin? • What kinds of resources are required, and available for verge related activities and who coordinates these? • [Where appropriate] what is the annual budget for verge transformations? • What are the constraints and enabling factors encouraging the uptake of native verge gardening?
Impacts and outcomes	<ul style="list-style-type: none"> • What were the advantages and disadvantages of streetscape/verge garden transformation? • Where there any recognisable changes in ecosystem service provisioning? [Is there any monitoring/ evidence post verge transformation]? • Any observed financial, social or environmental outcomes for your organisation or community? • What are the compliance, maintenance and risk management issues associated with street verge transformations? [any monitoring of these?] • Does [the LGA] have in mind a desired proportion of 'transformed' verges throughout the LGA? [Or alternatively, preferred distribution of transformed verges].
Community feedback	<ul style="list-style-type: none"> • How many participants have taken up incentive or rebate programs for street verges / native plants this year [or latest year for which complete data available]? How has this changed over time? • What do you think are the main motivations for verge transformations by residents? • What do you think are the main barriers in the uptake of verge transformations for residents? • What are the challenges, conflicts or complaints that most often arise when it comes to verge gardening?
Future preferences	<ul style="list-style-type: none"> • Given adequate resources- what would an ideal verge and streetscape verge look like to you? (species composition, density, ground cover, other?) • Are there any changes you'd like to make to your street scaping/ street verge policies or programs for the future?