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Ecological Landscape Design and Public Perception

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Being 'green' has gained considerable importance in the development agenda of governments around the world, with the threats and impacts of climate change escalating. Recent urban planning and design concepts such as Biophilic Cities (Beatley, 2010), Regenerative Cities (Girardet, 2009) and Green Urbanism (Lehmann, 2010) emphasize the need for cities to consume less resources – reduce their ecological footprints, and help to generate within themselves some of the services that natural ecosystems provide for our survival and well-being. Consistent with these concepts is "ecological landscape design", a field within landscape architecture that has developed over time (Rottle & Yocom, 2010). Ecological landscape design emphasizes the deliberate consideration and application of ecological knowledge and principles for the creation of high-functioning landscapes that serve their intended purposes while consuming fewer resources and supplementing valuable ecosystem services; it is not ecological restoration per se, but the establishment of living systems modelled after nature through careful, informed design (Beck, 2013). By working with nature, the landscapes created would not require high maintenance, and should have better chance to persist through periods of environmental stress or disturbance. The scope of ecological landscape design covers the provision of green infrastructure in cities across spatial scales, but when referred to more loosely as "ecological landscaping" the focus tends to be on the smallest scale of the site, and this will be the primary context of this Research Technical Note.

Some Basic of Ecological Landscape Design

Ecological landscape design broadly encompasses the various biophysical processes operating within landscapes at different scales, including the abiotic hydrological and climatic processes. However, here we will go over some basics of botany and ecology applicable to the landscape design of a site.

Choose plants that are adapted to the local environment and specific microclimate

We think we know how – choosing plants suited for the site we are planting up based on lighting conditions, plant water needs, drought tolerance, size, flowers and other considerations. It seems simple, yet Beck, in his book *Principles of Ecological Landscape Design* (2013), shows us that we can be a lot more scientific in our approach, applying further the growing wealth of existing ecological knowledge.

Beck first established the fundamental importance of microclimates resulting from small-scale spatial variations in environmental conditions, and highlighted how constructed elements like buildings and impermeable pavements can significantly alter conditions for plants. He noted that such microclimatic differences provide horticultural and design opportunities rather than problems. He highlighted the work of Hansen and Stahl (1993), which defined distinct microclimatic zones (corresponding to different sets of microsite variables) within parks and

gardens of their temperate region, and identified perennial species most adapted to thrive in each zone. They reminded that conditions can vary considerably within a garden, and more detailed investigations in selecting the right plants for the right spots can lead to lower maintenance requirements. Indeed, air temperatures at different locations within a local regional park on a hot day can vary up to 4˚C (Hwang et al., 2015), and such known variances in microclimate could potentially inform our selection of plants for landscaping.

Where information for a more precise plant selection (like a tropical garden equivalent of Hansen and Stahl's book on selecting perennials) is not available, landscape designers can still try to use (propagate) existing native or introduced plants that have thrived under conditions close to the planting zone under consideration, or work with local nurseries to provide the selected species with greater genetic variability (e.g., by supplying several related cultivars instead of one). There is evidence that the more diverse we can make a plant population, not just genetically but also in terms of size and age, the more likely it will be able to persist over the years. Genetic diversity may enable a population to adapt to shifting environmental conditions over time, while a varied size or age structure can increase resilience against pests and disturbances. For urban tree populations, a more well-spread distribution of ages (sizes) also affords a more regular replacement of individuals over time instead of an undesirable spike in tree mortality from a disproportionately large aged cohort.

During the record dry spell here in 2014, some plants in our managed landscape perished, yet others survived without human intervention – they represent the inherent resilience of ecosystems based on genetic diversity. Carefully selecting some of these plants for propagation in our green spaces could be a pre-emptive measure for the next drought.

Assemble tight plant communites that are functionally diverse

Identifying individual species apparently suited for each location is just a start. To create high-functioning and resilient plantings, a common approach is to bring together species with different *niches* to form a *community*. By looking at natural communities like the tropical rainforest, landscape designers have commonly been able to apply *niche differentiation* along the gradient of light availability in creating layered plantings that model the different forest layers, typically the canopy, understorey and undergrowth layers. An example of this is our Nature Ways planting scheme.

A similar approach for the creation of successful communities is to go for functional diversity in the assembled community, which means selecting plants with different functional traits such as seed size and leaf area, or which belong to different functional groups, e.g., in a grassland community, the groups include cool and warm season grasses, nitrogen-fixing plants, forbs and shrubs (Beck, 2013). Functional diversity is a good predictor of ecosystem function, meaning less human inputs to thrive.

Going deeper, tight communities are formed when all available niche space is almost completely filled, and for this to occur, usually more than one species would be present in each resource partition to compete for the available resources. A guild of species in a community compete for the same pool (partition) of resources, and are better able to maximize primary productivity than a single species, thereby leaving no 'room' for invasive species to grow. This was demonstrated by Mark Simmons of the Lady Bird Johnson Wildflower Centre; he found that lawns planted with a high diversity mix of native grass species had higher density than the monoculture of the introduced Bermudagrass and suppressed weeds better. In our local context, Cowgrass lawns when left uncut for longer than usual will invariably lead to the spontaneous emergence of various weeds; these are ruderal species which are able to exploit resources not used by the

Cowgrass and increase productivity of the lawn, making it more able to maintain the looks of a lush green mat with much less intensive maintenance, e.g., mowing every few months instead of every few weeks (Hwang, 2015).

We have only scratched the surface here in describing the application of ecological principles to landscaping. An important principle we should mention is to allow for change in the planted communities over time in response to environmental variations and other dynamic factors, just like in natural ecosystems where dynamic equilibria operate. Limited human interventions, where required, may be made to alter natural trajectories so that the original intended functions of the designed landscape are maintained or to influence aesthetics for better public appeal.

Ecological Landscape Design Growing in Local Practice

If we take a step back from biological communities and look at self-sustaining ecosystems, which can be the ultimate aim of ecological landscape design, our constructed ecosystems should have the different trophic levels (Lindeman, 1942) present in their appropriate proportions, integrating *producers, consumers and decomposers* for a closed-loop. This means that in seeking to create landscapes ecologically we also need to consider the consumers (including humans), and, importantly, the decomposers which are required to cycle the nutrients in the system. Practically, this could involve the establishment of a phytoremediation system as part of the landscape design, the setting up of an on-site green waste composting facility, or even the creation of an 'edible' community garden. Given this broad perspective, the following could be considered as examples of recent ecological landscape design for local parks and green spaces:

- Naturalising of Kallang River and integration of a cleansing biotope (phytoremediation system) with the pond system in Bishan-Ang Mo Kio Park
- Jurong Eco-Garden's integration of a stormwater management system and various wildlife habitats to enhance biodiversity (including a freshwater swamp forest area)
- On-site composting of horticultural waste in Clementi Woods Park and Fort Canning Park
- Trial plots of spontaneous vegetation at Sungei Serangoon Park Connector and Marina Promenade Park

Public Perception Matters

In applying ecological landscape design, we need to remember that what is ecologically valuable may not look pleasing to people. Gobster et al. (2007) explored this issue and the possibility of bringing landscape aesthetics into closer alignment with ecological function through design and knowledge (or education) interventions, which could help move us towards a shared "ecological aesthetic" that would bode well for the sustainability of cities. For design interventions, a key category is *cues to care* (Nassauer, 1992), which essentially are vernacular landscape elements put in place by landscape managers, which communicate human intention for good environmental stewardship, and could be read as gestures of neighbourly consideration; for example, we may perceive a mown turf strip around a patch of wild vegetation as an indication of deliberate and sensible green space management.

A wide mown strip along the pavement (**at left**) denotes care despite longer grass of vacant open field (**at right**)
Photo by Ling Seow Kang

A road divider bursting with spontaneous wild flowers
Photo by Goh Gan Khing

From an ecological perspective, weeds are not "bad". If people can be persuaded, with appropriate cues to care or otherwise, to accept such spontaneous vegetation for certain green spaces, what we gain is more natural and resilient greenery that requires lower maintenance. The increased diversity of spontaneous vegetation also supports higher faunal diversity, and could provide higher levels of certain ecosystem services (like carbon sequestration and stormwater filtration) than a regularly mowed Cowgrass lawn. Certain urban green space contexts do seem to lend themselves more readily for the incorporation of spontaneous vegetation, as they received higher public preference (liking) than other contexts for the same spontaneous growth. This could be related to the public's opinion on compatibility as well as their perceptions of attractiveness and orderliness.

Survey on Public Perception of Naturalistic Landscapes

To assess the public's perception of spontaneous and naturalistic vegetation, the Centre for Urban Greenery and Ecology (CUGE) collaborated with the National University of Singapore (NUS), School of Design and Environment to conduct a photo elicitation survey of the general population to find out their preferences for different levels of spontaneous vegetation as well as the Nature Ways planting scheme. The survey draws upon NUS professor Hwang Yun Hye's findings from her research conducted on actual spontaneous vegetation trial plots, to generate realistic photo simulations for assessment by survey respondents. The following charts are a few of the key results from the survey.

Notes on the survey:

The growth percentages in the charts refer to the approximate vegetation volume with reference to the predicted growth at the end of 18 months (100%), based on the actual growth of spontaneous vegetation observed by NUS Asst Prof Hwang YH at her trial plots. The various growth conditions in the different contexts were simulated by NUS using digital photo manipulation technqiues, and the generated scenes shown to survey respondents in a randomised order for their evaluation. The Nature Ways planting scheme was also simulated for the Streetscape context.

The public likes 40% and NW most for Streetscape, while they like 0% and 40% about the same for the other contexts. Only for Park, 90% is liked as much as 40% and 0% by the public.

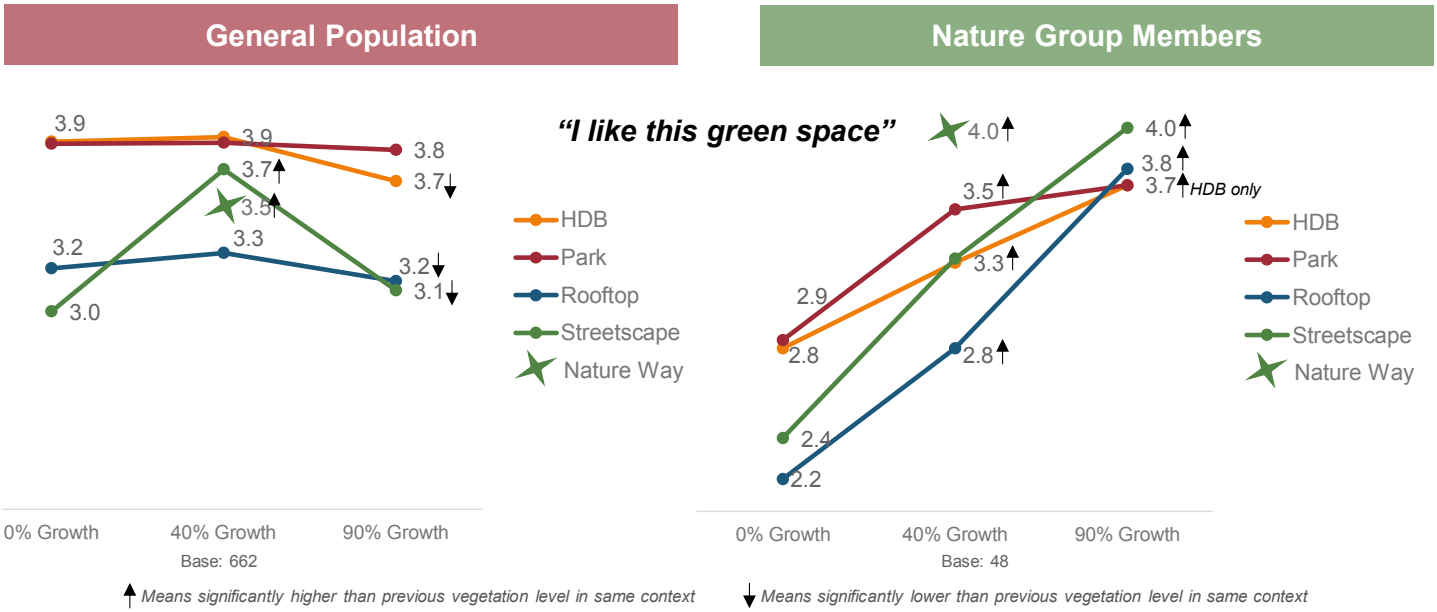


Fig. 1 Liking for various green spaces at different vegetation growth levels

'40%' spontaneous vegetation growth simulated along a road
Photo by Yue Zi En Jonathan

From the graph in **Fig. 1**, we see that preference (liking) for the green space by the general population is most sensitive to changes in the spontaneous vegetation growth level in the Streetscape context, with 40% Growth and Nature Ways (NW) both receiving significantly higher preference than 0% and 90%. For the other contexts, namely HDB, Rooftop and Park, changes to vegetation level did not affect public preference much, although there is slightly lower liking for 90% in general. Also, we see that the Park and HDB contexts received generally higher preference (liking) than the Streetscape and Rooftop contexts. Broadly, the appeal of the green spaces to the public in the various contexts appears to be optimal at 40% Growth. Whereas for nature group members, the higher the growth level, the more well-liked is the green space; and Nature Ways is liked as much as 90% Growth.

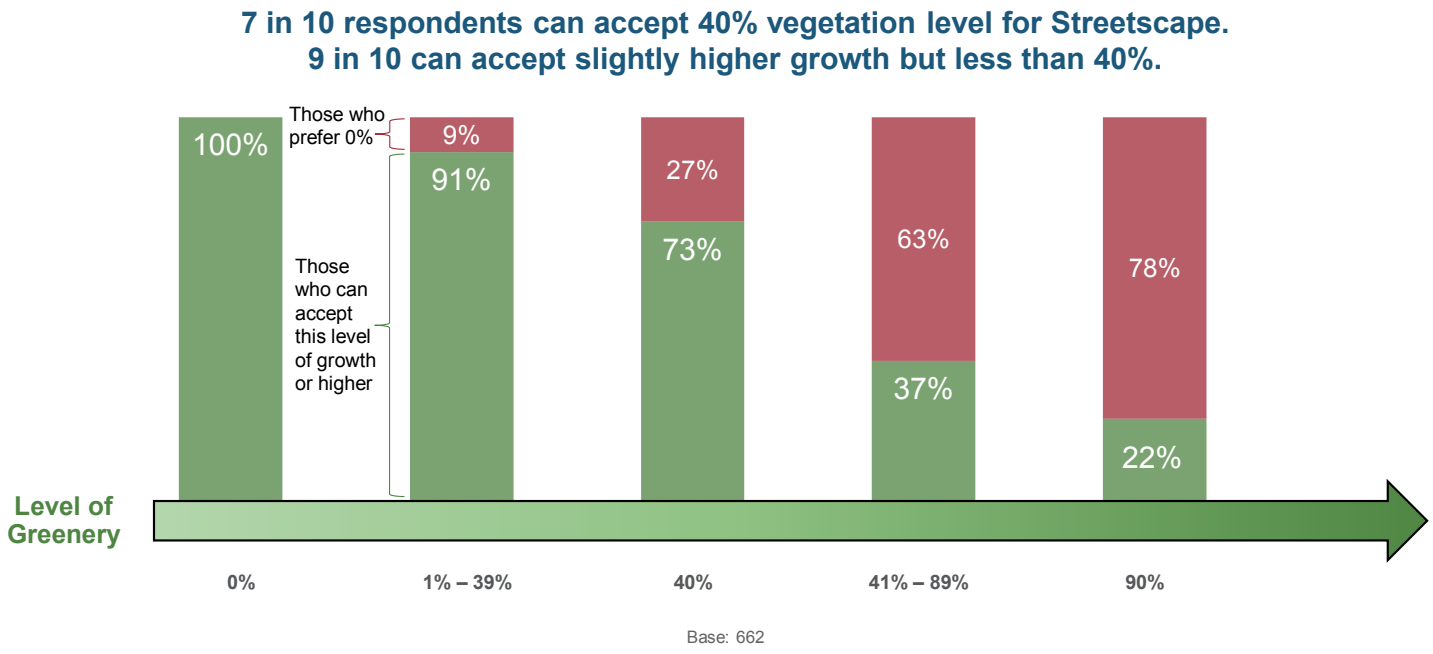
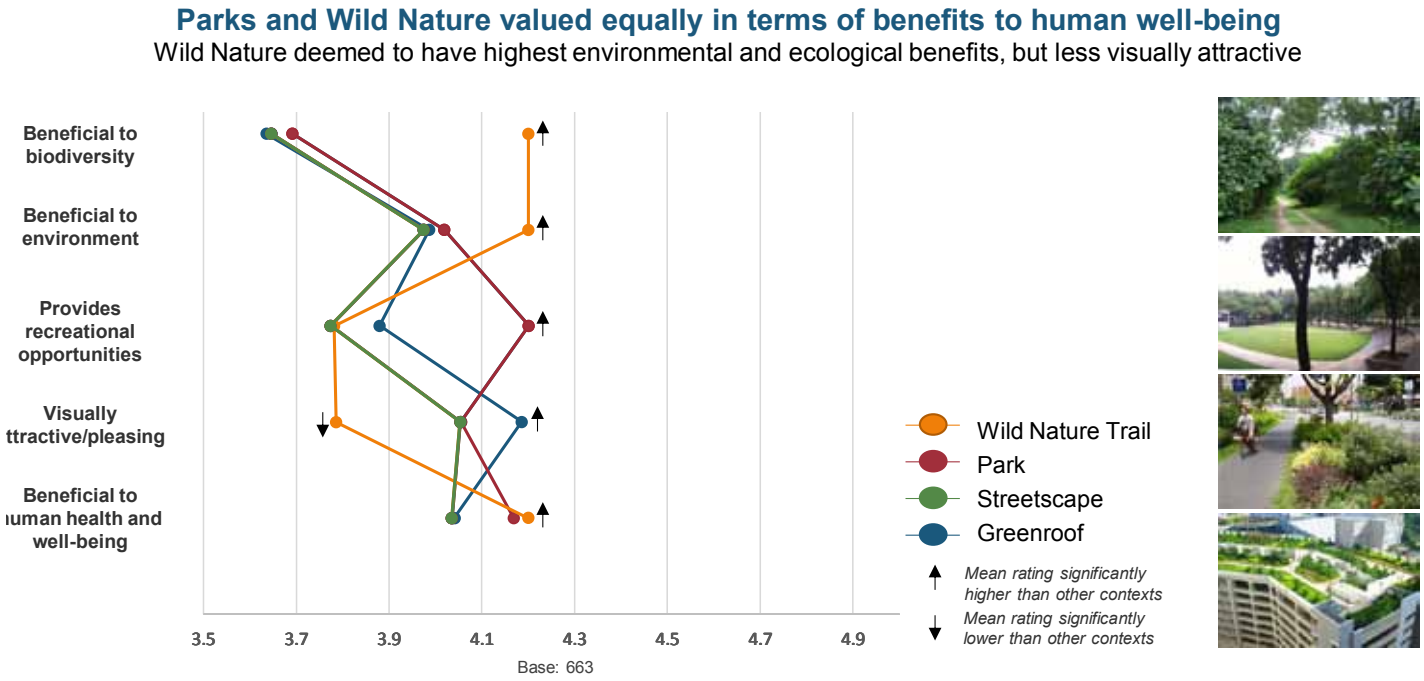


Fig. 2 Highest level of spontaneous vegetation growth acceptable for Streetscape

From the graph in **Fig. 2**, we can see that 73% of respondents could accept 40% vegetation for Streetscape while a high 9 out of 10 respondents could accept slightly higher growth but less than 40%. These are the highest figures among the 4 contexts tested, and suggest that the public is more willing to accept higher growth and lower frequency of mowing for Streetscape greenery compared to the other contexts.

In the same survey, we also asked for the respondents' general opinion regarding the benefits of various green space types, namely Wild Nature Trail, Park, Streetscape (with enhanced plantings) and Greenroof, depicted using photos, the results are presented in **Fig. 3**. It is interesting that Wild Nature Trail and Park received significantly higher ratings for being 'Beneficial to human health and well-being'. Wild Nature Trail was rated most highly for benefits to biodiversity and environment, although it was deemed less visually attractive than the other, manicured greenery types. These results give us an idea of how people value naturalistic landscapes – as places that are good for us as well as the other creatures living amongst us. Indeed, there has been recent research suggesting that vegetation which is more natural may offer greater benefits for human well-being, for example, Van den Berg et al. (2014), and Twedt et al. (2016).

Fig. 3 Perceived benefits of various green space types



Q: Looking at the photo below, please rate the landscape depicted for each of the aspects listed on a scale of 1 to 5, 1 being "Strongly Disagree" and 5 being "Strongly Agree".

Conclusion

There is significant potential to enhance the value and sustainability of greenery in our City in a Garden through ecological landscape design. By applying ecological principles to the creation and maintenance of our landscapes, we can work with nature to realise attractive and functional green spaces that are also easy to maintain, while providing important ecosystem services. In some cases, it is crucial to consider the public perception of the ecological planting or landscaping initiative, as is the case for spontaneous vegetation, which is traditionally deemed to be weedy and messy. Public education and cues to care could help to change the perspective of such vegetation – to consider them rather to be natural and ecological.

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