Urban Wild Initiative: Rewilding Urban Green Spaces to Enhance Biodiversity

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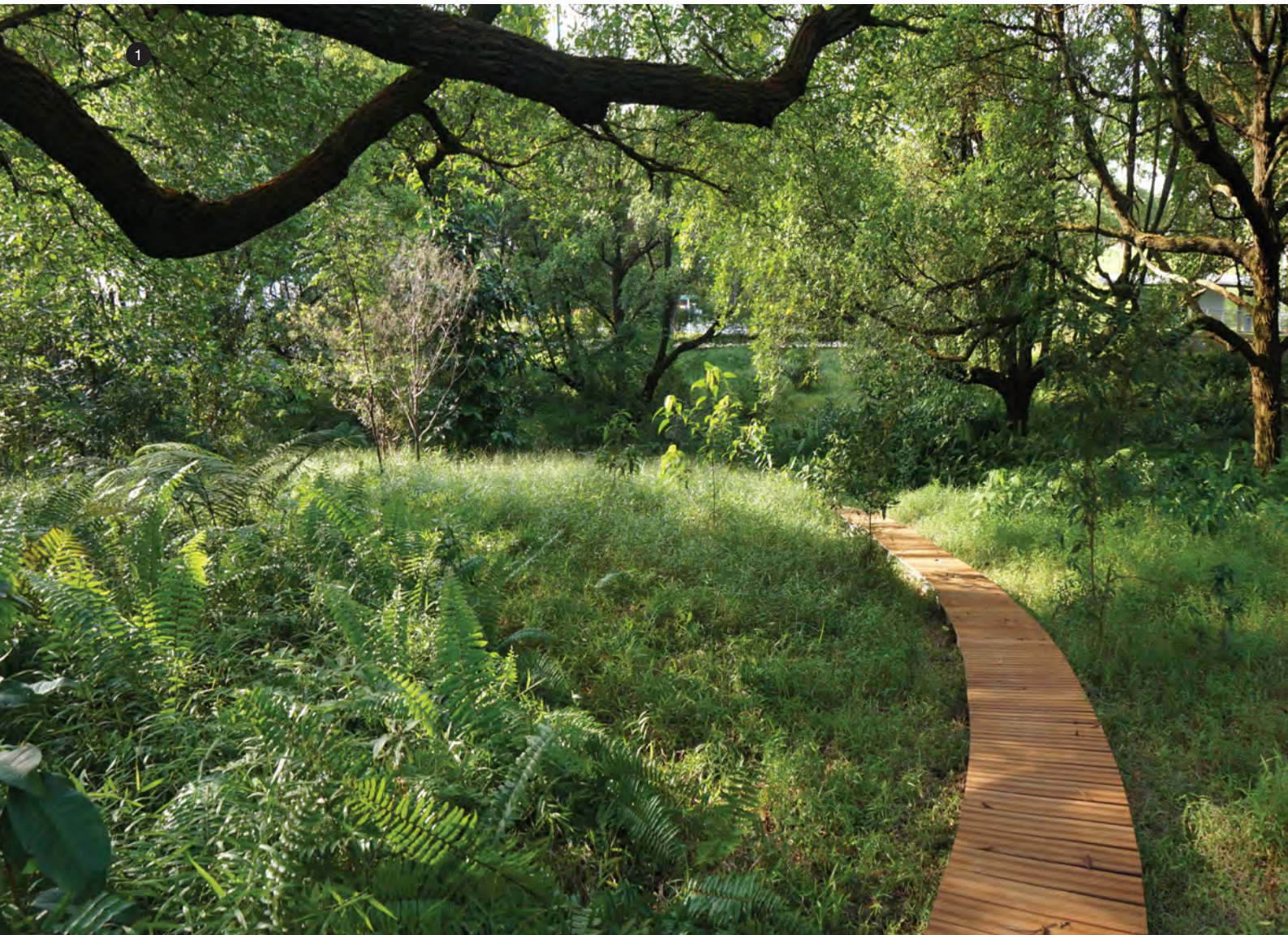

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Rewilding urban green spaces refers to transforming manicured landscapes to an intentional and managed state of wildness - one with a balance between planted and spontaneous plant growth, promoted to develop ecologically rich landscapes through selective human interference. As the first in a series on urban wild initiatives, this article highlights the ecological benefits of wilder urban green spaces focusing on habitat enhancement for biodiversity through an observation of landscape changes in three rewilded green spaces in Singapore.

Ecological Benefits of Wilder Urban Green Spaces in a Tropical City

As a result of colonialization and rapid urbanization, most of the land in Singapore has been transformed into a constructed environment with highly managed greenery, resulting in biodiversity loss and ecological degradation from the originally lush tropical rainforests. However, there is potential to upgrade the existing urban green spaces to compensate for the loss of a vital ecosystem, by allowing a degree of reversion to the original state through rewilding. Rewilding works well in a tropical setting, where the climatic conditions promote rapid natural growth of vegetation. Denser vegetation, increased structural complexity, habitat quality, and species heterogeneity are the intended results of rewilding, through the promotion of the dynamic and spontaneous growth of managed greenery.

Increased floral density and diversity are known to improve urban ecosystem services. For example, densely vegetated areas can improve soil nutrients and prevent soil erosion because of the complex root matrixes and soil biota, attenuate noise, air, and water pollution, mitigate flash flooding through rainwater interception, infiltration, and detention/retention of stormwater, enhance growth of other plants through the natural decomposition of organic matter from the areas, and mitigate urban heat by means of the shade created by multi-tiered vegetation because of its higher rate of evaporation and moisture level. Spontaneous vegetation is also naturally tolerant to stressful urban conditions, such as flash floods, dry spells, and the urban heat island effect. Even vegetation that is non-native and commonly considered weeds can contribute to various ecological niches and provide resources beneficial to an assortment of insects, birds, and other fauna. Increasing species diversity, allows more types of food for various fauna, including pollinators, who influence plant propagation, contributing further to urban biodiversity. In sum, rewilded green spaces are a novel typology - reducing urban barriers to wildlife, recreating local habitats as nature refuges otherwise critically endangered in the compact city, and enhancing landscape connectivity for flora and fauna movement by acting as stepping stones across isolated patches of green in the concrete jungle.

This article focuses on one key aspect of the ecological benefits of rewilding urban green spaces, namely the provision of a habitat for biodiversity. It draws on three case sudies of rewilding to explore low maintenance and high biodiversity in urban landscapes. The first two cases are National University of Singapore's (NUS) Ventus Garden and the Centre for Urban Greenery and Ecology's (CUGE) backyard, both rewilded lawns; the third is Bishan-Ang Mo Kio Park, where planted and spontaneous plants flourish simultaneously.

1. A scenic view inside of the NUS Ventus Garden to experience of dynamic landscapes. Photo credit: Yue Zi En Jonathan

Table 1. Species richness of three plots observed during 2017/2018

	Context	Flora	Fauna
NUS Ventus Garden **Location - 1°17'45.0"N 103°46'12.8"E**	A former lawn sized 2,500m², one dominant groundcover species (*Axonopus compressus*) with mature Tembusu trees, 25% sunny.	5 trees, 2 palms, 6 ferns, 8 tall shrubs and herbs, 10 short shrubs and herbs, 6 grasses and sedges, 4 creepers, 6 ground cover species (total 47 species)	9 mammals, 22 birds, 5 reptiles, 2 snails/worms, 13 bees/wasps, 7 ants, 22 butterflies/moths, 13 flies, 5 grasshoppers /crickets/ katydids, 4 spiders, 4 true bugs, 3 dragonflies, 3 misc. arthropods (total 112 species)
CUGE Backyard Garden **Location – 1°19'06.4"N 103°48'57.4"E**	A former lawn sized 100m², one dominant groundcover species (*Digitaria longiflora*) with no trees, 50% sunny, adjacent to three-story building and Singapore Botanic Garden.	11 trees, 1 palms, 3 ferns, 5 tall shrubs and herbs,11 short shrubs and herbs, 5 grasses and sedges, 4 creepers, 1 ground covers (total 41 species)	2 mammals, 9 birds, 5 reptiles/ amphibians, 30 butterflies/moths, 17 true bugs, 15 bees/wasps, 12 grasshoppers/crickets, 8 spiders, 6 dragonflies/damselflies (total 104 species)
Bishan-Ang Mo Kio Park A **Location – 1°22'02.5"N 103°49'48.8"E**	sized 6000m²: 12 tree species (including *Couroupita guianensis, Khaya grandifoliola*), 9 shrub species (including *Calathea lutea, Pandanus amaryllifolius*),2 dominant groundcover species (*Desmodium triflorum, Zoysia matrella*)	24 trees, 4 palms & ferns, 6 tall shrubs, 10 short shrubs, 3 grasses, sedges, 3 creepers, 1 aquatic flora, 11 groundcover species (total 62 species)	4 mammals, 42 birds, 5 reptiles/amphibians, 11 worms, 26 bees/wasps, 6 ants, 13 butterflies/moths, 54 flies, 3 grasshoppers /crickets/ katydids, 3 spiders, 14 true bugs, 2 dragonflies, 33 misc. arthropods, 6 aquatic fauna species (total 222 species)
Bishan-Ang Mo Kio Park B **Location – 1°21'38.7"N 103°49'48.8"E**	18000m²: over 30 tree species (including *Dalbergia oliveri, Eucalyptus delgupta*), 75% sunny, 12 shrub species (including *Phyla nodiflora, Crinum amabile*), 5 aquatic plants, 3 dominant groundcover species (*Desmodium triflorum, Zoysia matrella*)	**Site B**: 31 trees, 2 palms & ferns, 4 tall shrubs,9 short shrubs, 5 grasses, sedges, 7 creepers, 3 aquatic flora, 10 groundcover species (total 71 species)	1 mammal, 38 birds, 8 reptiles/amphibians, 3 worms, 18 bees/wasps, 5 ants, 21 butterflies/moths, 57 flies, 4 grasshoppers /crickets/ katydids, 2 spiders, 6 true bugs, 1 dragonflies, 24 misc. arthropods, 8 aquatic fauna species, (total 196 species)

NUS Ventus Garden

Supported by sustainable campus initiatives from the Office of Facilities and Management of NUS, a 2,500m² NUS campus lawn has been transformed into a vibrant naturalized garden. The exising condition of this site was a gently sloped and partially shaded lawn covered by predominantly exotic grass *Axonopus compressus* and a dozen mature Tembusu (*Cyrtophyllum fragrans*) trees with a large canopy. For the first two years, maintenance activities were halted within a fenced portion of the lawn (20x10m), allowing the area to develop spontaneously without human intervention. After two years, the fences were removed, and the garden area expanded to the current 2,500m² size.

With the goal of emphasising the natural characteristics of the site and increasing its biodiversity, several selective maintenance interventions were made to facilitate conversion into a more biodiverse garden. These interventions included: removal of aggressive species, such as creepers *Mikania micrantha*, and *Cissus hastata*, to prevent them from dominating other shrubs and tree saplings; thinning densely growing spontaneous plants, such as *Nephrolepis biserrata*, to make room for slower growing plants; removing plants if too many of the same species were competing against each other to guarantee the full growth of each plant; maintaining flowering and fruit-bearing plants like *Melastoma malabathricum* and *Morinda citrifolia* as a food source for fauna; maintaining a mown edge around the garden and placing a boardwalk through the rewilded area to allow further appreciation of the garden.

Because of this site's location between the forest of Kent Ridge Park and the wooded areas of Clementi Woods Park, the garden became a connector between the two. The area exhibited a rapid increase of flora species from a manicured lawn with the initial dominant species *Axonopus compressus* into a diverse garden hosting various plant communities with heterogeneous structures, including tree seedlings, and associated fauna species, including mammals (see Table 1). This garden has become an outdoor laboratory for students and researchers in biology, environmental science, and landscape architecture. It is also a useful platform for testing sustainable management practices and conducting professional workshops for practitioners in the landscape industry.

2. A pair of Spotted Wood Owls *Strix occidentalis*, a critically endangered species in Singapore, have been spotted in the garden (left). Spontaneously grown *Melastoma malabathricum* attracts a variety of bees and butterflies (right). Photo credit: Yue Zi En Jonathan

3. The perimeter of a 2,500m² lawn area was fenced and left to grow with selective interventions. The top image is from 2010 and the bottom from 2014. Photo credit: Tan Yi Chuan (Top) and Yue Zi En Jonathan (Bottom)

CUGE Backyard Garden

The small 100m² backyard lawn of the Centre for Urban Greenery and Ecology (CUGE) office located on the edge of the Singapore Botanic Gardens was converted into a rewilded garden in 2017. The idea was to replace the existing lawn consisting of the native grass *Digitaria longiflora* which was difficult to maintain. The immediate action was to stop mowing the lawn and allow the natural succession process of spontaneously growing plants and to leave them to take over the native grass patches. To speed up this process, as well as to diversify plant species and attract various fauna groups, a dozen typical spontaneous plant species with different vegetative structures (e.g. tall shrub *Melastoma malabathricum*, *fern Dicranopteris linearis*, tall grass *Pennisetum polystachion*, and short herb *Asystasia intrusa*) were planted as 'seed plants'. These spontaneous species were brought in from other spontaneous vegetated areas, including the NUS Ventus Garden and School of Design and Environment green roof; they are heat and drought tolerant and known to be suited for rewilded gardens from previous usage in this capacity. A Tembusu tree sapling (*Cyrtophyllum fragrans*) that naturally grew in the corner of the garden was also transplanted to the center to ensure it had sufficient room to grow. Regular maintenance activities were minimal; these included selective weeding of aggressively growing creepers and grasses (e.g. Lalang, *Imperata cylindrica*) and thinning of overpopulated trees, to increase species richness and help create the various microclimate conditions that could maximize the capacity of the plot to become a flora-rich and structurally diverse vegetation patch.

As a result of these interventions, as of December 2018, the garden had more than 30 plants species, with a wide range of vegetative structures; 104 fauna species were recorded as well (see Table 1). In the garden, an example of exotic flora has filled an ecological niche: the spontaneously grown White Mulberry (*Pipturus argenteus*) is deemed an invasive tree species but has attracted native birds like the *Dicaeum cruentatum*, *Pycnonotus goiavier*, and *Aplonis panayensis* as regular consumers of its fruits within the plot. It is also the host plant of the Malayan Eggfly butterfly. Even though it occupies a relatively small area, the garden has a good range of species. This may be partly attributed to the plot's proximity to the Singapore Botanic Gardens, with its substantial biological diversity and extensive living plant collection. The plant community in the garden is dynamic and still in flux; it provides a habitat for a high diversity of fauna with minimal selective maintenance.

Bishan-Ang Mo Kio Park

This 25-hectare park was first developed in 1988 as a recreational park for new residential towns in Bishan and Ang Mo Kio and upgraded in 2012 by interweaving open spaces and urban greenery with a natural meandering waterway that was converted from a 2.7km straight fenced concrete channel. For this upgrade, the park and water authorities worked together with the leading design team, Ramboll Studio Dreiseitl, to build a close and positive relationship between people and the urban water system and provide a multi-functional green space to meet the needs of park users and the urban ecosystem – flash flood management, biodiverse local habitats, and human health.

While most of the park, i.e. non-flood zones, consists of large existing trees and homogeneous lawns and follows the standard intensive maintenance routine of biweekly grass cutting, native plants and water resilient species have been added in the newly designed areas. Maintenance within flood zones includes pruning overgrown trees and

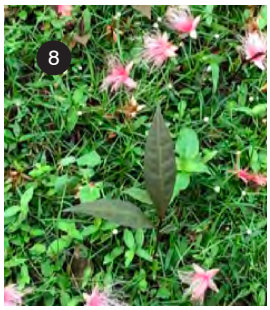
4. A variety of spontaneously growing plants flourish in the corner of the garden Photo credit: Yue Zi En Jonathan

5. CUGE garden before rewilding in March 2017 (left) and a year later, in May 2018 (right) Photo credit: Ling Seow Kang

6. Aerial view of Bishan-Ang Mo Kio Park Site B in 2012 (left) in 2018 (right) Photo Credit:Patrick Bingham-Hall (left), Patil Mayura Anil (right)

7. *Ixobrychus sinensis* observed in Bishan-Ang Mo Kio Park Site A. Photo Credit: Chan Jie Yi

8. *Barringtonia asiatica*, spontaneously growing local critically endangered species observed in Bishan-Ang Mo Kio Park Site B. Photo Credit: Patil Mayura Anil



shrubs and clearing sagging tree branches, only if the branches are obstructing the river's flow. In our 2018 observation of two areas within the park, we identified 62 (Site A) and 65 (Site B) species of flora and 222 (Site A) and 196 (Site B) species of fauna (see Table 1).

In Site A, the species richness has doubled since the year the project was started, and 51% of the total observed flora species in September 2018 had grown spontaneously. There is a significant increase in the number of groundcover species (from 29 to 58). The lawns in this site are intensely managed, but the aim is not to achieve the aesthetics of a carpet lawn. Rather, lawns are given space for the growth of spontaneous plants. In Site B, although the total species richness has not changed much (69 to 71), the species and composition of species have changed over time. Of the total plant species, 41% are spontaneously growing, including a flowering shrub attractive to birds, *Cheilocostus speciosus*, as well as tropical native trees such as *Syzygium glaucum*, a critically endangered species, *Sterculia macrophylla*, and seedlings of the critically endangered local native tree, *Barringtonia asiatica* (Figure 7). This wonderful habitat created along the river also offers spots to take photos of wild animals and attracts regular visitors for that purpose. As trees (e.g. *Pometia pinnata, Cyrtophyllum fragrans*) grew and shrubs (e.g. *Asystasia gangetica*, *Lantana camara*) became denser, more birds and insects are observed in the area. A high abundance of dragonflies (e.g. *Neurothemis fluctuans*) is observed along the natural river edge, and plants along the river host nesting places for water-birds, such as *Amaurornis phoenicurus* and *Ardea purpura*. Although most of the fish observed in the flowing water, such as *Oreochromis spp.* and *Amphilophus citrinellus*, are commonly observed elsewhere in Singapore, they attract otters to this park. The park is one of the most popular heartland parks for urban dwellers, and it is equally important for nature, with enormous potential to be further developed as a critical part of an ecological network given its proximity to the central catchment nature reserve.

Key Takeaways from the Observation

The three rewilded urban green spaces demonstrate that spontaneous growth of vegetation can help achieve a higher level of biodiversity in a tropical context. Three key lessons to be learned from the observation are the following. Firstly, allowing spontaneous growth of plants on rewilded lawns has helped increase species richness in all three sites, but the types and abundance of species, speed of growth, and growth structure vary across sites. Secondly, planting strategic plants that increase the vegetative structural heterogeneity of the site and support nearby habitats significantly facilitates a higher level of biodiversity. Thirdly, management regimes need to be altered to create biodiverse gardens to manage the spontaneous growth mentioned earlier. Monitoring is especially important, as the required maintenance varies between areas and during different growth stages. Rewilding urban green spaces through design and management to enhance their biodiversity could provide a unique opportunity to develop novel paradigms to address long-term resource management in tandem with a city's ecosystem. For the successful implementation of rewilded urban spaces, however, their socio-cultural influence and acceptance and their economic ramifications need to be considered simultaneously with their resource value. These will be explored in later articles.

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