CHAPTER 3

The Learning Forest: A Habitat Restoration Project that Ecologically Connects with the Singapore Botanic Gardens Rainforest

Kenneth Er, Shee Zhi Qiang, Jason Wright, Elango Velautham & Angelia Sia

The idea of visiting a lowland rainforest and freshwater wetland forest conjures images of having to trek through swarms of biting insects and knee-deep mud – hardly an experience that people without an inherent love of nature would be drawn to. The Learning Forest at the Singapore Botanic Gardens is a habitat restoration project that transforms the concept of these biologically rich yet previously inaccessible habitats. The process began with understanding the various ecological processes present and implementing strategies to strengthen them. The next stage involved overlaying an aesthetic layer to showcase the most magnificent attributes of the habitat for the visitors' delight. The final phase was to introduce recreational amenities to ensure that these habitats became easily accessible to all visitors.

Conceptualising the Learning Forest

The 10-hectare Learning Forest lies at the heart of the Tyersall-Gallop Core, which is the fourth core of the Singapore Botanic Gardens (Fig. 1). The other three cores are a) the heritage Tanglin Core, b) the Central Core hosting the tourist attractions, and c) the educational and discovery zone of the Bukit Timah Core. Envisioned as a living laboratory in a vibrant forest ecosystem, the Learning Forest enhances the Gardens' capacity for research and education and provides the public with opportunities to learn about forest ecology in an experiential setting. It also plays an important role as part of the buffer zone for the Singapore Botanic Gardens UNESCO World Heritage Site.

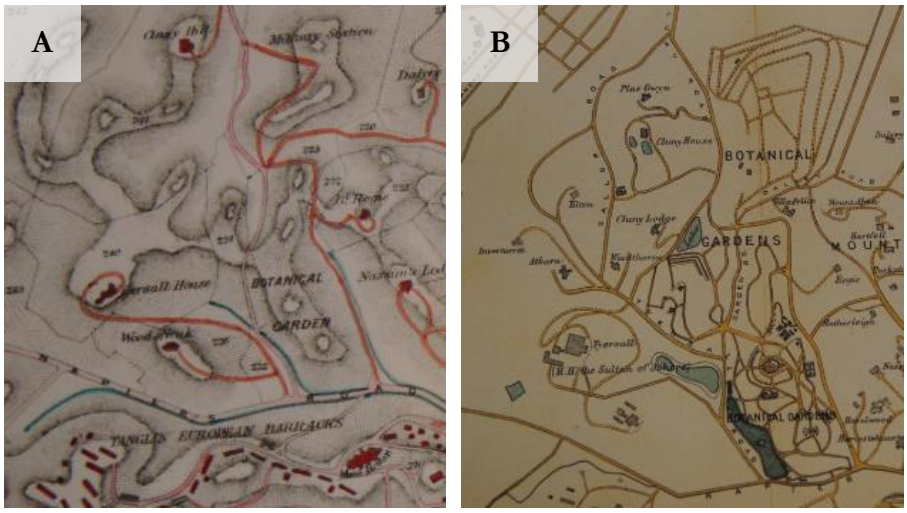
Fig. 1. The Learning Forest lies at the heart of the conservation core of the Singapore Botanic Gardens and plays an important role as part of the buffer zone for the UNESCO World Heritage Site.

The Learning Forest is a conservation project that involves the restoration of a lowland rainforest and a freshwater wetland forest. Home to over 700 species of plants, it is an exposition of the region's botanical heritage, including over 300 species of rainforest trees, 50 species of wild fruit trees, 30 species of bamboo, 30 species of climbing plants and 25 species of native orchids. However, the Learning Forest is much more than an impressive botanical collection – it elevates the concept of a botanical garden from conserving just individual plant species to conserving entire habitats, creating a unique, refreshing experience in the process.

Restoring a freshwater wetland

Swan Lake, in the historic Tanglin Core of the Singapore Botanic Gardens, is Singapore's oldest man-made lake. It was constructed in a low-lying, perpetually waterlogged part of the Gardens that was formerly freshwater wetland forest. This unique and increasingly threatened habitat used to occupy a broad swathe stretching from the northern half of the Learning Forest into the Tanglin Core. The Keppel Discovery Wetlands is a restoration of this original habitat.

Historical maps of the area dating as far back as the 1860s demonstrate how land use has evolved over the past 150 years (Fig. 2). Some of the oldest maps document the early years of the Singapore Botanic Gardens and show a stream flowing from the Learning Forest into the area now occupied by Swan Lake. The stream was converted into a series of ponds by the early 20th century but by 1924, the ponds had all but disappeared from the maps. By further analysis of the topography of the area, the Singapore Botanic Gardens was able to identify the watershed for Swan Lake and thus estimate the previous extent of the wetland (Fig. 3).



Figs. 2. These maps of the area now occupied by the Learning Forest show how the wetlands have changed from (A) a stream in 1860 to (B) a series of ponds in 1913. (Photo credit: National University of Singapore Central Library)

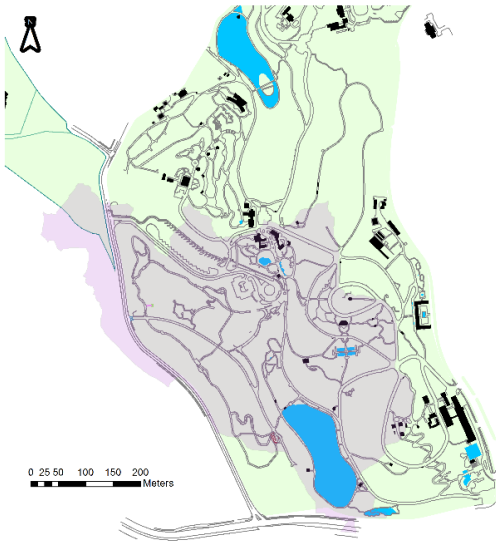


Fig. 3. The catchment area for Swan Lake is shaded in purple. The watershed analysis shows that most of the Learning Forest serves as the water source for Swan Lake.

This background information became the basis of the design of the Keppel Discovery Wetlands to function as the constant source of clean water to Swan Lake. As the Wetlands are fed by a natural spring that produces up to 90 m^3 of water per day (sufficient to fill an Olympic-sized swimming pool in a month), the team, using the Sustainable Drainage Systems (Wright & Yu, 2022), created a series of bioswales and siltation ponds to channel rainwater falling from the catchment area through the Dell and into Swan Lake (Fig. 4).

Fig. 4. Rainwater falling onto the catchment area of the Wetlands is channelled through a series of bioswales and siltation ponds, eventually finding its way through the Dell and into Swan Lake.

The Keppel Discovery Wetlands is home to remnant populations of wetland species. These include not only plants such as Penarahan Pianggu (*Horsfieldia irya*) and Nibung Palm (*Oncosperma tigillarium*), but also fauna that are dependent on freshwater wetland forests, such as the Malayan Giant Frog (*Limnonectes blythii*) and Malayan Box Terrapin (*Cuora amboinensis*).

The restored wetlands have been curated to bring out the rich diversity of freshwater plant communities in Southeast Asia. Key features include the Orchid Islands, Botanists' Boardwalk and Pulai Marsh, all of which are linked by a Discovery Trail (Fig. 5–10). This trail traces the expeditions of EJH Corner, a former assistant director of the Singapore Botanic Gardens, who

explored the freshwater wetland ecosystems of the Malay Peninsula. Visitors can experience travel through a range of riverine vegetation belts, travelling through a stand of Putat trees (*Barringtonia* spp.) that bear fruits in various shapes and sizes, impenetrable thickets of Pandan (*Pandanus* spp.) up to four storeys high and sandy banks of Pelawan (*Tristaniopsis* spp.) with colourful bark.

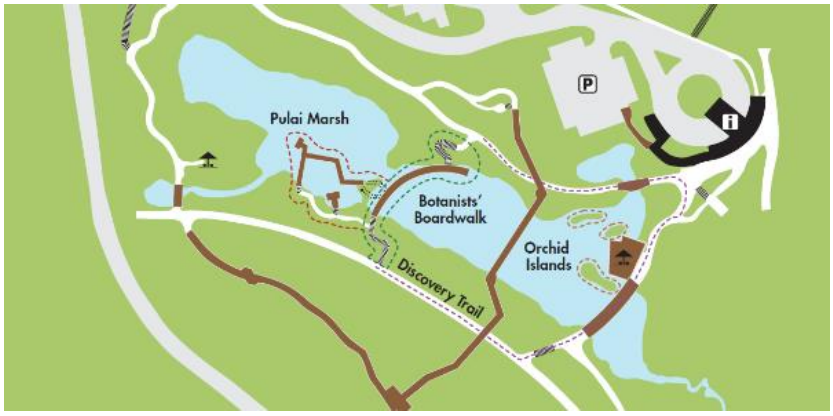


Fig. 5. The Keppel Discovery Wetlands offers three carefully curated features, all linked together by a Discovery Trail.

Fig. 6. The Botanists' Boardwalk showcases plants named after famous botanists in the history of the Singapore Botanic Gardens. (Photo credit: Shee Zhi Qiang)

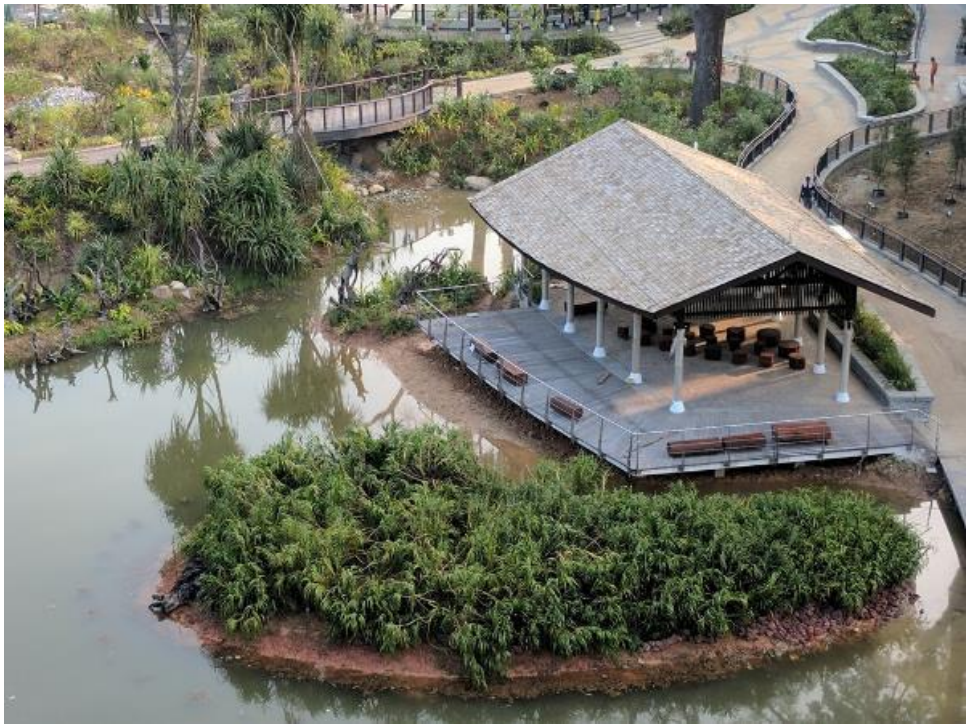


Fig. 7. The Orchid Islands at the Keppel Discovery Wetlands. The world's largest collection of Tiger Orchids is in the foreground, while the islands in the background feature both epiphytic and ground-dwelling species of threatened wetland orchids. (Photo credit: Shee Zhi Qiang)

Fig. 8. Pulai Marsh serves as a refuge for the threatened flora and fauna of freshwater wetlands. (Photo credit: Shee Zhi Qiang)

Fig. 9. The Putat-belt along the Discovery Trail mimics a riverine vegetation belt described by EJH Corner. The various species of Putat trees bear fruits in various shapes and sizes. (Photo credit: Shee Zhi Qiang)

Fig. 10. Visitors can appreciate the wide variety of bark colours exhibited by Pelawan trees on this sandy bank above the Keppel Discovery Wetlands. (Photo credit: Shee Zhi Qiang)

Regenerating the lowland rainforest

When the Singapore Botanic Gardens initiated the project in 2009, the lowland rainforest was infested with invasive weeds, such as Panama Rubber (*Castilla elastica*), African Oil Palm (*Elaeis guineensis*) and Zanzibar Yam (*Dioscorea sansibarensis*). An intensive habitat enhancement programme was undertaken using an adaptation of the Framework Species Method (Fig. 11). Invasive plants were selectively thinned out and replaced with forest species native to the region.

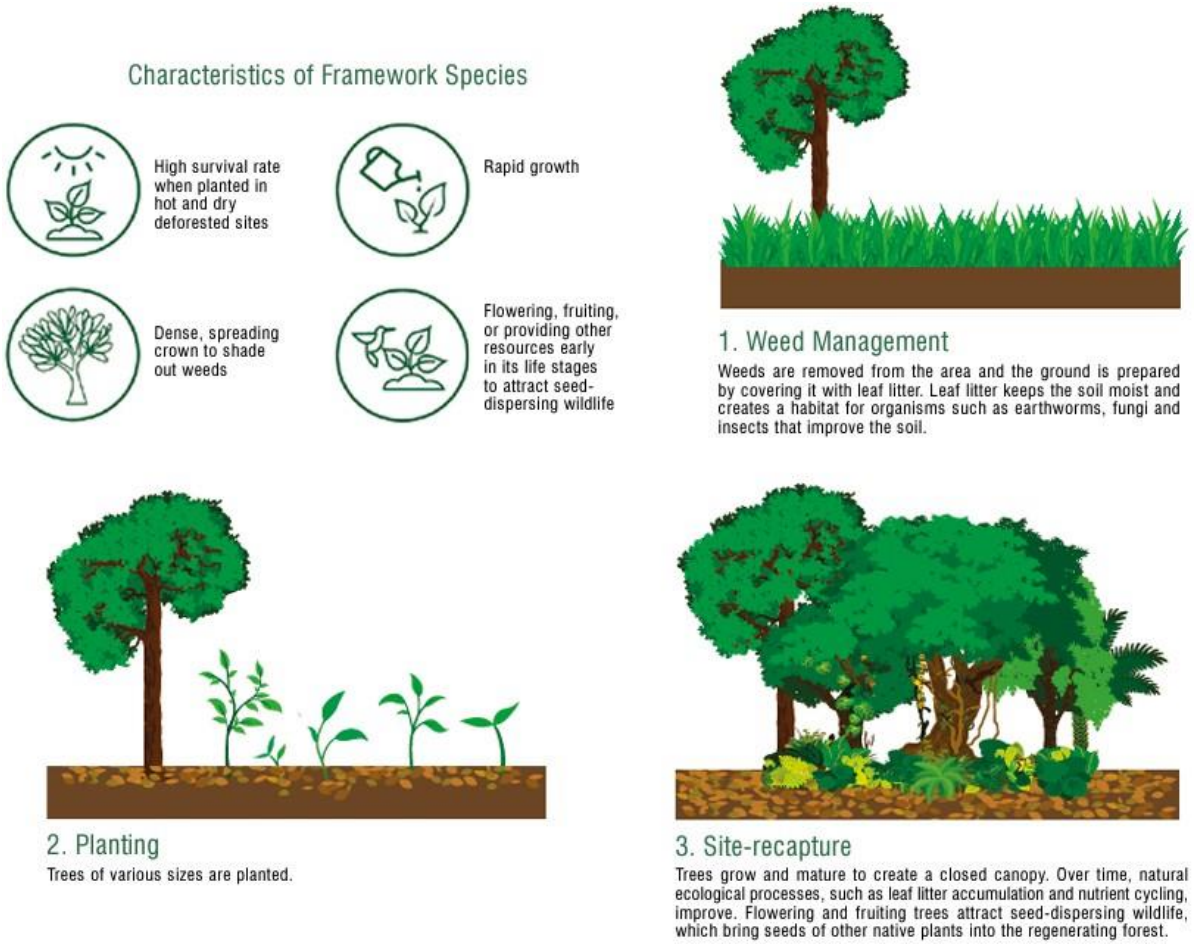


Fig. 11. An illustrated summary of the Framework Species Method of reforestation, adapted to the Singapore Botanic Gardens Learning Forest.

The first trees to be planted were relatively fast-growing species, such as Meranti Tembaga (*Rubroshorea leprosula*), Sepetir (*Sindora wallichii*) and Cengal Pasir (*Hopea odorata*). Where possible, semi-mature trees of up to 15 m tall were transplanted with much of their crown intact to form an instant canopy (Fig. 12). This helped to regulate the microclimate in the understorey, maintaining the conditions of high humidity and low light that are most amenable to the growth of shade-tolerant species found only in climax forests.

Figs. 12. (A) A reforestation site planted with semi-mature specimens of Meranti Tembaga (*Rubroshorea leprosula*), Sepetir (*Sindora wallichii*) and Cengal Pasir (*Hopea odorata*) in 2016. (B) The same site in 2019, showing the succession of vegetation as canopy cover increases. In the understorey, light-demanding species such as Balik Angin (*Mallotus paniculatus*) and wild bananas (*Musa* spp.) have been replaced by more shade-tolerant species such as Medang Kelawar (*Prunus polystachya*) and fan palms (*Licuala* spp.). (Photo credit: Shee Zhi Qiang)

The lowland rainforest today is dominated by mature specimens of Tembusu (*Cyrtophyllum fragrans*), Jambu Laut (*Syzygium grande*) and Giant Mahang (*Macaranga gigantea*), with isolated populations of Medang (*Litsea elliptica*) and Buah Kenari (*Canarium vulgare*). The oldest of these trees is estimated to be just over a century in age and they form a continuous canopy about 30 m high.

The SPH Walk of Giants, an elevated walkway, was built to take visitors from the forest floor up into the canopy of these forest giants. The focal point of the Walk of Giants is the 8 m-high Canopy Web, which wraps around two century-old Tembusu trees and creates the experience of moving about their canopies (Fig. 13). The two trees belong to a row of Tembusu trees that were originally planted to line the old Tyersall Avenue. While sitting on the Canopy Web, one may catch a glimpse of Swan Lake across the old road, as if looking back in time (Fig. 14). The Canopy Web was specially designed to accommodate the multi-stemmed form of the Tembusu trees and most of the structure supporting it was also built on the old road, thus avoiding damage to tree roots.

Fig. 13. The Canopy Web creates the experience of moving about the canopy of a forest giant. (Photo credit: Shee Zhi Qiang)

The Canopy Web is built on much lower ground than the rest of the Walk of Giants, allowing visitors to gain ground gradually as the forest floor drops away below them. Besides facilitating universal access, the gentle grade encourages appreciation of the forest at a comfortable pace. The many layers of the rainforest can be explored from top to bottom within the 260 m loop of the Walk of Giants (Fig. 14).

Fig. 14. The SPH Walk of Giants takes visitors on a journey through the many layers of the rainforest, from the forest floor to the top of the canopy. (Photo credit: Shee Zhi Qiang)

Starting from the forest floor, palms in myriad shapes and sizes can be found, including all four known species of Joey Palm (*Johannesteijsmannia*), a genus of understorey palms native only to some parts of Southeast Asia (Fig. 15). Massive clumps of the slow-growing Palas Fan Palm (*Licuala ferruginea*) bear testament to the maturity and complexity of the regenerating forest. Further along, the bright orange leaf shafts of the Ibul (*Orania sylvicola*) and the Endau Fan Palm (*Livistona endauensis*) catch the eye.

Figs. 15. (A) Joey Palms, (B) Fan Palms and (C) the Ibul are just among the wide variety of palm species at the Learning Forest. (Photo credit: Shee Zhi Qiang)

Around the bend, visitors entering the subcanopy layer are surrounded by large woody climbers such as Akar Ipoh (*Indorouchera griffithiana*) and more delicate plants, such as the Climbing Fern (*Stenochlaena palustris*) (Fig. 16). A peek at the columns supporting the Walk of Giants reveals that they are planted up with over 20 native climber species, such as the Sepedih (*Ficus sagittata*) and Climbing Pandan (*Freycinetia sumatrana*). This part of the forest is frequented by forest birds such as the Banded Woodpecker (*Picus miniaceus*) and Greater Racket-tailed Drongo (*Dicrurus paradiseus*) during the day and by forest specialist bats such as the Whiskered Myotis (*Myotis muricola*) at night.

Figs. 16. (A) The Akar Ipoh and (B) Climbing Fern are commonly seen around the Walk of Giants, while other rarer species, such as (C) the Sepedih and (D) Climbing Pandan, are planted around the columns supporting the walkway. (Photo credit: Shee Zhi Qiang)

Finally, what would the Walk of Giants be without the giants themselves? Mature secondary forest trees such as the Tembusu and Jambu Laut now tower over the elevated walkway at heights of up to 30 m. Much care and effort were taken to avoid them where possible and much effort was made to transplant those that could not be avoided (Fig. 17). However, the real stars of the show are the saplings of the true forest giants, such as *Richetia faguetiana* and *Richetia gibbosa*, which can exceed 90 m in height – taller than a 30-storey building! They will take hundreds of years to grow to that majestic size, underscoring the Singapore Botanic Gardens' long-term commitment to conservation.

Figs. 17. Mature native trees were transplanted where possible, such as (A) the Medang, (B) Jambu Laut and (C) Angsana. (Photo credit: Shee Zhi Qiang)

Creating an immersive experience

The Learning Forest represents a landmark approach in creating an aesthetically attractive and ecologically rich ecosystem from a previously inaccessible nature area, by deconstructing natural habitats and curating their associated vegetation assemblages. What sets the Learning Forest apart from many other nature conservation sites is its location within a major visitor attraction, the Singapore Botanic Gardens, which receives over five million visitors annually. Creating the Learning Forest required an approach where aesthetic appeal, accessibility and comfort are key design features. The project represents the next step for inculcating a love of nature for all visitors, and serves as a benchmark for future nature conservation projects within the urban environment.

References

Er K, Shee ZQ, Wright J & Sia A (2017) The Learning Forest: Fostering Connections with Nature. CityGreen, 14: 40–49.

Wright J & Xu A (2022) Designing a City in Nature. Singapore: National Parks Board, 172 pp.