

The Learning Forest: Fostering Connections with Nature

Text by Kenneth Er, Shee Zhi Qiang, Jason Wright and Angelia Sia
Images as credited

“

The Learning Forest represents a landmark approach in creating an aesthetically attractive and ecologically rich ecosystem by deconstructing natural habitats and curating their associated vegetation assemblages.

Biophilic Design

The Learning Forest represents a landmark biophilic design approach in creating an aesthetically attractive and immersive landscape, through the restoration of ecological processes, conservation of existing forest habitats and curation of an extensive plant collection to depict the essence of a freshwater wetland forest ecosystem. Traditional ecological design seeks to work sensitively with the existing ecosystem as it is. Sustainable design takes it further to include ecologically sound and effective technical solutions. With these design approaches, the restoration of ecological processes that drive the ecosystem is often overlooked, and very little attention is given to visitor experience. In Biophilic design, practitioners draw inspirations from natural processes along with an understanding of design aesthetics and curation to create environments where visitors can enjoy an immersive nature experience.

Biophilia, the love of living things, refers to our innate connection with nature. It explains why tufty clouds in the sky captivate us and why pet companionship and strolling through a park bring restorative benefits. The term was first used by Erich Fromm in 1964 to describe the psychological orientation of being attracted to all that is alive and vital. E. O. Wilson later expanded the concept in his book "Biophilia" in 1984, proposing that the deep affiliations that humans have with nature are rooted in our biology.

The Learning Forest Concept

The 10ha Learning Forest lies in the heart of the new Tyersall-Gallop Core, which is the fourth core of the Singapore Botanic Gardens (Figure 1). Envisioned as a living laboratory in a vibrant forest ecosystem, it will enhance the Gardens' capacity for research and education and provide 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.

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 bamboos, 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.

The idea of visiting a lowland rainforest and freshwater wetland forest conjures unpleasant images of having to trek through swarms of biting insects and knee-deep mud – hardly an experience that people without an already inherent love of nature would be drawn to. The Learning Forest breaks the interface between nature and manmade interventions, transforming the concept of these biologically rich yet previously inaccessible habitats through biophilic design. The design process begins with understanding the various ecological processes present and implementing strategies to strengthen them. The next stage involves overlaying an aesthetic layer to showcase the most magnificent attributes of the habitat for the visitors' delight. The final phase is to add the recreational layer to ensure the habitats are easily accessible and comfortable. This new typology of nature conservation design transforms biophobic attitudes to biophilia.



1. The Learning Forest lies at the heart of the new conservation core of the Singapore Botanic Gardens and plays an important role as part of the buffer zone for the UNESCO World Heritage Site. (Image: National Parks Board).



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

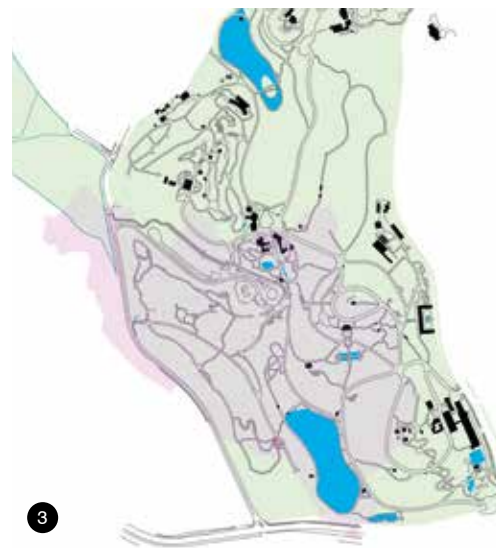
3. The catchment area for Swan Lake is shaded in purple. The watershed analysis shows that most of the Learning Forest serves as the water source for Swan Lake. (Image: National Parks Board).

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. (Image: National Parks Board).

Restoring the Hydrological Process

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, made possible by a \$2.08-million donation from Keppel Corporation.

Historical maps of the area dating as far back as the 1860s demonstrate how land use has evolved over the past 150 years (Figure 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 analysing 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 (Figure 3).



This background information became the basis of the design of the Keppel Discovery Wetlands; to function as the constant source of clean water to the Swan Lake. As the Wetlands are fed by a natural spring that produces up to 90 m³ of water per day – a quantity sufficient to fill an Olympic-sized swimming pool in a month, the team created a series of bioswales and siltation ponds to channel rainwater falling from the catchment area through the Dell and into the Swan Lake (Figure 4).

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 tigillarum*), but also fauna that are dependent on freshwater wetland forests, such as the Malayan Giant Frog (*Lymnonectes blythii*) and Malayan Box Terrapin (*Cuora amboinensis*).





“

Creating the Learning Forest as a major visitor attraction required an approach where visitor interest, accessibility and comfort are key design features.



5, 6, 7. The elevated boardwalk in the Learning Forest allows visitors to walk among the rainforest trees. (Photos: Kenneth Er).



Characteristics of Framework Species



High survival rate when planted in hot and dry deforested sites



Rapid growth



Dense, spreading crown to shade out weeds



Flowering, fruiting, or providing other resources early in its life stages to attract seed-dispersing wildlife



1. Weed Management

Weeds are removed from the area and the ground is prepared by covering it with leaf litter. Leaf litter keeps the soil moist and creates a habitat for organisms such as earthworms, fungi and insects that improve the soil.



2. Planting

Trees of various sizes are planted.



3. Site-recapture

Trees grow and mature to create a closed canopy. Over time, natural ecological processes, such as leaf litter accumulation and nutrient cycling, improve. Flowering and fruiting trees attract seed-dispersing wildlife, which bring seeds of other native plants into the regenerating forest.

8

Regenerating Lowland Rainforest

When the Singapore Botanic Gardens first 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 reforestation method (Figure 8). Invasive plants were selectively thinned out and replaced with forest species native to the region.

The first trees to be planted were relatively fast-growing, light-demanding species, such as Meranti Tembaga (*Shorea leprosula*), Sepetir (*Sindora wallichii*) and Cengal Pasir (*Hopea odorata*). Where possible, semi-mature trees of up to 15m tall were transplanted with much of their crown intact to form an instant canopy (Figure 9). This helped to regulate the microclimate in the understory, 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.

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 30m high.



9

8. An illustrated summary of the framework species method of reforestation, adapted to the Singapore Botanic Gardens Learning Forest. (Image: National Parks Board).

9. A reforestation site planted with semi-mature specimens of Meranti Tembaga (*Shorea leprosula*), Sepetir (*Sindora wallichii*) and Cengal Pasir (*Hopea odorata*).

10. The Keppel Discovery Wetlands offers three carefully curated features, all of which are linked together by a Discovery Trail. (Image: National Parks Board).

11. The Orchid Islands at the Keppel Discovery Wetlands feature both epiphytic and ground-dwelling species of threatened wetland orchids. (Photo: Shee Zhi Qiang).

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

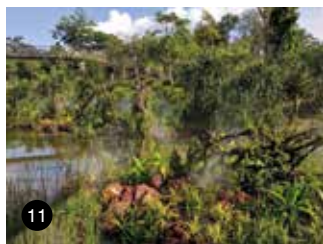
13. The Pulau Marsh serves as a refuge for the threatened flora and fauna of freshwater wetlands. (Photo: Shee Zhi Qiang).



10

Taking People Close to Nature

Through strengthening the natural processes of the lowland rainforest and freshwater wetland forest, the Singapore Botanic Gardens has been able to restore these habitats as part of Singapore's wider nature conservation masterplan. However 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 4.5 million visitors annually. Creating the Learning Forest as a major visitor attraction required an approach where visitor interest, accessibility and comfort are key design features. This is what distinguishes biophilic design from pure ecological design.



11



12



13

Keppel Discovery Wetlands

The restored freshwater wetlands has 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 (Figure 10).

The Orchid Islands present a unique display of native wetland orchids in their natural habitats (Figure 11). Many of these species have been brought back from extinction through the Gardens' Orchid Conservation Programme, including the Deer Antlered *Phalaenopsis* (*Phalaenopsis cornucervi*) and Finlayson's *Cymbidium* (*Cymbidium finlaysonianum*). One of the islands is home to the world's largest collection of Tiger Orchids (*Grammatophyllum speciosum*).

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

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

The Botanists' Boardwalk showcases plants named after famous botanists in the history of the Singapore Botanic Gardens (Figure 12). These range from trees such as Cantley's Memecylon (*Memecylon cantleyi*) and Burkill's Lime (*Burkillanthus malaccensis*) to herbs and epiphytes such as Corner's Torch Ginger (*Etilingera corneri*) and Ridley's Staghorn Fern (*Platynerium ridleyi*). The stories behind the plants illustrate the Gardens' rich tradition of research and scientific discovery; for example, the Ridley's Giant Bamboo (*Gigantochloa ridleyi*) represents Henry Ridley's early collection of this species from a village near Penang, and the Holttum's Hybrid Orchid (*x Holttumara*) commemorates Eric Holttum as the father of orchid breeding.

The Pulai Marsh serves as a refuge for the threatened flora and fauna of freshwater wetlands (Figure 13). A wide variety of plants specially adapted to wetlands are found growing here, such as the Stilted Simpoh (*Dillenia reticulata*), with its strongly arched stilt roots, and Marsh Pulai (*Alstonia spatulata*), which has swollen buttresses. Wetland birds such as the Red-legged Crake (*Rallina fasciata*) have been seen darting between the trunks and roots while kingfishers perch around the wetlands scanning for prey.

The Discovery Trail traces the expeditions of E.J.H. Corner, a former assistant director of the Singapore Botanic Gardens, where he explored the freshwater wetland ecosystems of the Malay Peninsula. Visitors will be able to experience riverine vegetation belts, travelling through a stand of Putat tree species that bear fruits in various shapes and sizes, impenetrable thickets of Pandan (*Pandanus* spp.) up to four storeys high and sandy banks of Pelawan (*Tristaniaopsis* spp.) with colourful bark (Figure 14 and 15).



14



15



16

16, 17, 18. The Learning Forest was designed to integrate with the Singapore Botanic Gardens' existing rainforest to form an enlarged forest habitat. (Photos: Kenneth Er).

“

The Learning Forest is much more than a botanical collection – it elevates the concept of a botanical garden from conserving just individual plant species to conserving entire habitats.





While sitting on the Canopy Web, one may catch a glimpse of Swan Lake across the old road, as if looking back in time.

SPH Walk of Giants

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. It was made possible by another substantial sponsorship of \$1.2 million from the Singapore Press Holdings. The focal point of the Walk of Giants is the 8m high Canopy Web, which wraps around two century-old Tembusu trees and creates the experience of moving about their canopies (Figure 19). They 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. 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 existing road, thus avoiding damage to tree roots.

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 260m loop of the Walk of Giants (Figure 20).

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 understory palms native only to some parts of Southeast Asia (Figure 21). 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*) are sure to catch the eye.



Around the bend, visitors entering the subcanopy layer are surrounded by large woody climbers such as Akar Ipoh (*Indorouchera griffithiana*) and more delicate curiosities, such as the Climbing Fern (*Stenochlaena palustris*) (Figure 22). 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.



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

20. 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: Shee Zhi Qiang).

21. (Left to right) Joey Palms, Fan Palms and the Ibul are just among the wide variety of palm species at the Learning Forest. (Photo: 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 30m. Much care was taken to avoid them where possible and much effort was made to transplant those that could not be avoided (Figure 23). However, the real stars of the show are the saplings of the true forest giants, such as *Shorea faguetiana* and *Shorea gibbosa*, which can exceed 90m 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.

22. (Left to right) The Akar Ipoh and Climbing Fern are commonly seen around the Walk of Giants, while other rarer species, such as the Sepedih and Climbing Pandan, are planted around the columns supporting the walkway. (Photo: Shee Zhi Qiang).

23. (Left to right) Mature native trees were transplanted where possible, such as the Medang, Angsana and Jambu Laut. (Photo: Shee Zhi Qiang).

An Immersive Experience

The Learning Forest achieves the fundamental objective of biophilic design in extracting the most engaging elements of the natural habitat to create an immersive experience for visitors to enjoy. As John Muir wrote in 1877, “in every walk with nature one receives far more than one seeks.” The project has set in place the next step for inculcating a love of nature for previously biophobic visitors, and has become the benchmark for future nature conservation projects within the urban environment. 

Acknowledgements

The consultants involved in the Learning Forest project are: Stephen Caffyn Landscape Design (Landscape Architect), DHI Water and Environment (Environmental Engineer), Arup Singapore Pte Ltd (Civil & Structural, Mechanical & Electrical, Transportation & Traffic Engineer), Turner & Townsend Pte Ltd (Quantity Surveyor).