LIVING COLLECTIONS AT THE SINGAPORE BOTANIC GARDENS – HISTORIC AND MODERN RELEVANCE

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RESUMO
O papel das coleções vivas no Jardim Botânico de Singapura é descrito nos termos de seu valor no campo do patrimônio, contribuindo com as inscrições dos Jardins Botânicos na Lista do Patrimônio Mundial da Unesco, e sua importância em termos de pesquisa científica, manutenção da diversidade da flora e em termos de educação. Um resumo das mais relevantes coleções é apresentado e o tema é introduzido e trabalhado no context de uma breve história dos Jardins Botânicos.

PALAVRAS-CHAVE
Patrimônio Cultural, conservação,

ABSTRACT
The role of the living collections at the Singapore Botanic Gardens is described in terms of their heritage value, contributing to the Gardens' inscription on UNESCO's World Heritage List, and their importance in support of scientific research, conservation of plant diversity and public education. A summary of the most significant taxonomic collections is appended and the subject is introduced and placed in context with a brief history of the Gardens.

KEY-WORDS
cultural heritage, economic botany, conservation

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Introduction

This essay will describe the relevance and significance of the living collections held at the Singapore Botanic Gardens (SBG), which was founded in 1859. In July 2015, SBG was inscribed on to the UNESCO World Heritage List as a Cultural Landscape, being only the third botanic garden to be listed as such and the first located in the tropics (TAYLOR, 2015: 2–5). The living collections at SBG made a most important contribution to gaining this international accolade, as the following notes hope to explain. They are what primarily define the Gardens' historic landscape and purpose; they include 59 Heritage Trees, many other heritage specimens and 6 hectares of primary rain forest; they support the scientific research of the institution and its public education role; and, critically, they are vital *ex situ* and *in situ* resources for the conservation of biological diversity in the SE Asian region. Before describing these aspects, however, it is necessary to give a brief history of the Gardens in order to place its living collections in a proper context. This and subsequent sections will frequently draw on the work by Taylor & Davis (2015).

Brief history of SBG

The Singapore Botanic Gardens was founded at the close of 1859 through a gift of 22.4 hectares of land in the Tanglin District, given to the Agri-Horticultural Society by the Governor of the Straits Settlements (an eastern outpost of the British Empire). The Society was funded by the subscriptions of its members and consequently SBG was not freely open to the public for the first 15 years of its existence. In 1860, the Society appointed a Scotsman, Lawrence Niven, as Manager (later called Superintendent), who laid out the site in the style of the English Landscape Movement (TAYLOR, 2013). At the start, the undulating land comprised a large expanse of secondary vegetation, smaller areas of freshwater swamp and 6 hectares of virgin forest, the latter being retained and still surviving today.

Over the following 15 years Niven developed a system of roads and paths, with grassed over lawns between, created a band parade area for musical concerts, dammed up the outlet of the southernmost swamp to fill an extensive lake (now called Swan Lake), and planted up flowerbeds from which the Society's members could cut flowers for their homes. A further 12 hectares of land was purchased in 1866 and during 1867–68 a plantation style Anglo-Malay residence was built for Niven on the newly acquired land. This residence, however, was constructed with borrowed funds and by the close of 1874 the Society had still not repaid the loan and found itself bankrupt. It petitioned the government to settle its debts, in return offering the Gardens to the authorities, which offer was accepted. This resulted in the appointment of a new Superintendent, James Murton, who had been trained at the Royal Botanic Gardens, Kew (England) and was botanically qualified, whereas Niven was primarily a gardener (who died while on home leave in Scotland in 1876).

From the arrival of Murton in 1875 the Gardens became truly botanical in nature, whereas under the Agri-Horticultural Society it was best described as a pleasure garden, lacking a botanical focus. Murton set about acquiring many plant species from both the region and farther afield. The public were now free to enter this attraction, but soon there was also an emphasis on economic botany, as indeed there was in nearly all of the 100+ colonial gardens across the British Empire (CRANE, 2001: 5–6). By 1879 much of the land available to Murton was fully utilised and so the government generously gifted a further 41 hectares to the north of the original site and this exclusively for the trialling of economic plants (the Economic Garden). These trials included Pará Rubber (*Hevea brasiliensis*), which had been introduced from the Brazilian Amazon via Kew Gardens in 1877. Later, under the influence of its first Director, Henry Ridley (in office

1888–1912), this plantation crop would transform the economy of SE Asia and cause the concomitant collapse of the *serengueiro* extractive industry based in Manaus, Brazil (ANON., 2006: 74). In parallel with the study of economic botany, the Gardens began its herbarium and library, eventually amassing reference collections that now form the basis for understanding the botany of SE Asia (TINSLEY, 2009: 211–217).

Economic botany at SBG appeared to be coming to a close when, in the mid-1920s, most of the Economic Garden's land was annexed for the construction of Singapore's first university, Raffles College. However, the arrival of a new Director, Eric Holttum, took this aspect of science and horticulture in a new direction, using the extensive living collection of orchids that had been assembled over the previous half century. Holttum employed a little-known *in vitro* laboratory technique for raising orchid hybrids from seed and soon founded a new industry and, indeed, a craze for breeding orchids, which soon took root in the region, involving amateurs and commercial nurseries alike. This remains a key activity at SBG, where the orchid team currently includes five orchid breeders, whose successes are regularly displayed in the National Orchid Garden (within SBG itself) and have made the Republic of Singapore synonymous with orchids. These spectacular hybrids have also been the focus of a high profile VIP Orchid Naming programme over the past 60 years, during which the heads of more than 90 nations have been awarded these plants, exclusively named in their honour, during state visits to Singapore.

The next phase in SBG's history was what is popularly called 'The Greening of Singapore'. This began in 1963 when founding Prime Minister Lee Kuan Yew began developing his vision of Singapore as a green city in which outsiders would want to invest, in preference to the 'concrete jungles' that other cities might offer. The Botanic Gardens was the obvious source of both plants and expertise as indeed it had been in the 1880s, when an earlier movement to repair the island's forests was launched by the colonial government. Today the Gardens holds more than 8500 species of vascular plants and increasingly focuses on acquiring species from the SE Asian region for both 'greening' purposes and *ex situ* conservation. Many species of orchids and ginger relatives have been reintroduced to external habitats from the Gardens' living collections in an attempt to reverse the damage done when the island was extensively deforested during the 19th century.

Living collections with heritage value

While SBG's living collections include various ancient trees that were growing on the site before its foundation, whether planted or naturally-occurring, the oldest surviving planting post-1859 is actually a remarkable herbaceous plant that we claim to be the World's oldest and largest specimen of an orchid species (TAYLOR, 2015: 8–11). In 1861, Lawrence Niven planted the giant Tiger Orchid (*Grammatophyllum speciosum*) beside the north end of Office Gate Road, which later became the junction with the Main Gate Road. A photographic archive dating from the 1870s until the present time shows this orchid plant gradually increasing in size. It is now 5 metres in diameter and must weigh several tonnes. We have recently placed a fence (or 'tiger cage') around it as protection, because its immense age and pedigree makes it exceptionally valuable. I use the word pedigree because its date of planting was well before this species officially went 'Extinct-in-the-Wild' in Singapore early in the 20th century, so it is most likely, genetically speaking, a surviving element of Singapore's island flora. Seedlings raised from this specimen will be used to reintroduce this local genotype into Singapore habitats.

Further heritage specimens, also not to be regarded as trees, include various ancient palms, some of which almost certainly antedate the Gardens foun-

dation. A massive clump of Nibung (*Oncosperma tigillarium*) growing in the remains of a freshwater swamp, between the National Orchid Garden's nursery and Symphony Lake, must be many centuries old when its size is compared with another large clump planted in 1878 by Murton in his first Palmetum near Office Gate Road. Also growing in the swamp remnant is a clump of the East Malesian Sago Palm (*Metroxylon sagu*), and there is another near the Tanglin Gate adjacent to Holland Road. These are recorded as planted before 1859 and were almost certainly being cultivated for their abundant edible starch, which was used long before rice came to dominate the local diet. A third palm represented by large, old specimens is the native, but now very rare, Ibul (*Orania sylvicola*), found in the Gardens' Rain Forest as well as near Corner House Gate, where its progeny are also thriving. These represent important genetic resources for a species that is rated as Critically Endangered in Singapore (Loo *et al.*, 2014: 84). In the former Economic Garden seven very old African Oil Palms (*Elaeis guineensis*) are a reminder that SBG was one of the earliest suppliers of seed for what has latterly become one of the World's largest and environmentally most destructive agro-industries. These specimens were planted in 1920, so are now more than 95 years old. They surprise visitors who are familiar with the modern plantations of the species, because with age their trunks have lost the characteristic scale-like leaf bases that are usually home to many epiphytes and thus are quite bald. The largest of these specimens exceeds 10 metres in height. Last, but not least, with its striking red crown shafts, is the attractive Sealing Wax Palm (*Cyrtostachys renda*), which is the Botanic Gardens' brand symbol, seen on everything from staff corporate clothing to SBG branded merchandise and our official letterhead. It is planted in many places in the Gardens, but most prominently as an avenue established by Henry Ridley in 1905. Its choice as the Gardens' brand symbol is also ecologically appropriate, because it is a native of freshwater swamp forest, which used to exist along the western edge of SBG. Many other majestic palms representing over 200 species can be seen in Palm Valley, established in 1879 and the most sublime piece of SBG's landscape, besides being the setting for weekend concerts on the Shaw Symphony Stage.

As already noted, SBG has 59 officially endorsed Heritage Trees, part of a scheme launched in 2002 to encourage Singaporean residents to cherish the island's finest arboreal specimens. As of October 2015, SBG's tally amounts to more than 25% of all such trees recognised in Singapore. Here, space does not permit us to describe or illustrate all of these, but some examples will give a flavour of their significance in terms of Singapore's environmental history and the Gardens' former economic purpose (SHEE *et al.*, 2014; TAYLOR, 2014).

One category of Heritage Tree at SBG is that of native survivors that pre-date the Gardens foundation, i.e. trees that were not planted, but formed a part of the original natural vegetation, or had regenerated after that wild forest was removed. These are important reminders of the first half of the 19th century when much of Singapore was still clothed in a dense tropical forest, and some represent significant genetic resources for what are now very rare species amongst the island's fragile flora. Most famous amongst these is the so-called '$5-tree', the Tembusu (*Cyrtophyllum fragrans*) that is illustrated on the reverse of Singapore's $5 banknote. This tree, which stands within a protective fence on Lawn E, is unmistakeable for its long low branch. This branch tells us clearly that the tree grew up in an open setting, not in forest, since in a forest such a branch would be shaded out by the dense canopy and would not have survived. Thus, this tree almost certainly regenerated from the time when the land had been deforested for the cultivation of gambier (*Uncaria gambir*) and black pepper (*Piper nigrum*), crops indicated on maps drawn up in the 1830s/40s (TAYLOR & VELAUTHAM, 2014). Indeed, the Botanic Gardens has many other Tembusu trees of similar size and age, doubtless originating in the same way, and it seems that this

tropical forest species is one of the very few trees that was able to regenerate within the poor grade secondary scrub (or '*belukar*') that followed deforestation. The image of the '$5-tree' on the banknote is, however, symbolic of the place where it grows rather than just the tree itself. It symbolises the fact that for more than 150 years the Botanic Gardens has been a meeting place for residents and even the site where arranged marriages were brokered. Moreover, it was the place from which the Garden City movement took off (nowadays rebranded as the City-in-a-Garden vision).

A much rarer native tree found nearby on Lawn H is the Pulai Basong (*Alstonia pneumatophora*). This Heritage Tree is typical of freshwater swamp and is believed to have been growing naturally in the Gardens before its habitat was converted into Swan Lake in 1866. Certainly, there is no record of it ever having been planted and it appears as a mature tree in an historic photograph dating from before 1927. It is one of less than 20 individuals of the species remaining in Singapore and is quite isolated from its brethren. However, it recently produced viable seed and its offspring will be used in the recreation of a swamp forest in the Gardens' soon-to-be-opened Tyersall Learning Forest. This will be an opportunity for public education as well as conservation of the tree's germ plasm.

Seven Heritage Trees are found in SBG's surviving tract of rain forest and all are native there as well as being huge examples of their species. Three belong to the Meranti genus of Dipterocarps (*Shorea gratissima, S. macroptera* & *S. pauciflora*). This genus and its family, Dipterocarpaceae, is one of the most important components of tropical forest in SE Asia, much of which has been cleared for other purposes, such as the cultivation of African Oil Palm. Together with the Rain Forest's Jelawai (*Terminalia subspathulata*), Jelutong (*Dyera costulata*), Antoi (*Cyathocalyx sumatranus*) and gigantic strangling Johor Fig (*Ficus kerkhovenii*), these trees enable the Gardens' visitor to have some understanding of the great forest that once clothed the island of Singapore. To be able to observe such huge trees just 15 minutes' walk from Singapore City's famous Orchard Road shopping district is truly remarkable and probably unrivalled anywhere else in the World!

The largest category of Heritage Trees is those introduced and planted for their economic potential, primarily as sources of timber, latex, nuts/seeds, medicinal benefits or dyestuffs. Some of these are in the former Economic Garden in the northern half of the site, which was not open to the public until relatively recent times, but many are planted in the historic Tanglin Core of the Gardens and have always been on public display. Timber trees tend to dominate, such as the 1884 Burmese Teak (*Tectona grandis*) at Botany Centre, the similar-aged Andiroba (*Carapa guianensis*) on Lawn E, the true Mahogani (*Swietenia mahogani*) beside the entrance to the National Orchid Garden, the West Indian Locust beside Corner House Lawn (*Hymenaea courbaril*) and two tropical conifers, the 1882 Mountain Teak (*Podocarpus neriifolius*) and Malayan Yellow-wood (*Dacrycarpus imbricatus*), both to the east of Swan Lake. Besides Pará Rubber, of which only third generation descendants survive, the latex producers include two White Gutta trees (*Palaquium obovatum*) located in the former Economic Garden where they were planted in 1897 as part of an early *ex situ* conservation effort. Gutta is a tree that literally changed worldwide communications in the second half of the 19th century. Its latex was used to insulate the first undersea copper cables, reducing the months it took for letters to arrive on board sailing ships to messages received in seconds. The unsustainable over-exploitation of native stands of the tree in SE Asia nearly drove species of the genus to extinction – hence examples were conserved in the Gardens. Heritage Trees introduced for their nuts and seeds include three very fine Monkey Pots (*Lecythis pisonis*), which arrived via Kew Gardens from Brazil in the 1920s; a SE Asian species of Petai or Stink Bean (*Parkia timoriana*) and the Keluak (*Pangium edule*) produce seeds that are important ingredients in local cuisine; then there is the 1897 Candle Butter Tree (*Pen-*

tadesma butyracea) in the Healing Garden, whose seeds contain more than 40% fat, and the 1890 Tahitian Chestnut (*Inocarpus fagifer*), a very peculiar member of the legume family. Heritage Trees with medicinal properties include the 1926 Copaiba (*Copaifera officinalis*) on Lawn H and the huge Penaga Laut (*Calophyllum inophyllum*) that dominates Botany Centre and caused the adjacent Cluny Road to be moved c. 100 metres further east so that adequate space for the building could be granted and the tree preserved – a powerful tree indeed!

Research & Conservation Collections

In terms of SBG's history, we know that prior to Superintendent James Murton's arrival in 1875 there was already an orchid house in the Gardens, orchids probably being the first taxonomic group to be focused on. After the orchids, perhaps the second and third groups were the conifers and cycads, which Murton concentrated in plantings between the Main (Tanglin) Gate and Swan Lake, on the north side of Main Gate Road. Next in order he established a fernery, then a collection of Bromeliads (Bromeliaceae), these being situated between the Bandstand area and Cluny Road to the east.

In 1878, he planted up Office Gate Road with palms and the following year was beginning to develop Palm Valley, which today holds one of the world's most important collections of tropical palms. A decade then passed before another taxonomic group was planted in a defined area. This was the legumes, on Lawn F, to the west side of Swan Lake. From 1890, a collection of ginger relatives ("Scitamineae", nowadays Zingiberales) was begun around what is now the Potting Yard.

During the administrations of Directors Henry Ridley and Henry Burkill (1888–1925) the living collections were heavily focused on economic botany and no new major taxonomic groups appear to have been established. However, with the succession of Eric Holttum as Director in 1925 a renewed interest in plants of scientific and horticultural merit ensued. *Bougainvillea* (Nyctaginaceae) and *Plumeria* (Apocynaceae) were notable foci and in modern times have resulted in large collections of species and especially hybrids. In the 1950s a collection of trees from the Nutmeg family (Myristicaceae) was established in the area between the present Healing Garden and NParks Headquarters, this in furtherance of the botanical studies of J F Sinclair, Curator of the SING Herbarium from 1948–1965.

The remaining taxonomic collections identified in Appendix I (below) have been established in more modern times, from the 1970s onwards. Some of these are nowadays of primary significance for the purposes of *ex situ* conservation, rather than for traditional taxonomic studies, e.g. Dipterocarpaceae. However, it is true to say that most of the earliest established taxonomic living collections remain important today, whether for research or public display, such as orchids, palms, gingers, *Bougainvillea,* Bromeliaceae and frangipani. The conifers and cycads play an important role in public education, being key elements in SBG's Evolution Garden, which traces the history of plants on land from 470 million years before present until today.

Of the groups supporting taxonomic and conservation research, the largest in order of numbers of species are the gingers and relatives (1300 species), orchids (c. 1000 spp.) and palms (300 spp.), the first two supporting the Gardens' own research teams, with high outputs of publications. Both are also increasingly focused on the reintroduction and reinforcement of native species in Singapore, which, in the case of the orchids has been on-going for more than 20 years (YAM, 2013). Amongst gingers and the unrelated monocotyledons from the genus *Hanguana*, Singapore has recently described, rare, endemic species, which are being propagated at SBG for reintroduction and reinforcement of the populations in the island's nature reserves and other protected areas (LEONG-

ŠKORNIČKOVA, 2015: 20; 2015: 29). For other ginger relatives an alternative or addition to planting in reserves is their use along roadside 'Nature Ways', which are manmade wildlife corridors linking parks and reserves via the road network. Thus, the role of SBG's living collections in the conservation of plant diversity is an increasingly significant one and is the institution's determined response to the environmental crises that face all of us.

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Appendix I: Taxonomic plantings at SBG

1. Palms (Arecaceae), Palm Valley, established 1879, Lawns W, Y, XA and area of Heliconia Walk (c. 220 species) and under-storey species south side of Maranta Ave, Lawn S; avenues of Sealing Wax Palms (*Cyrtostachys renda*), 1905, and Caribbean Royal Palms (*Roystonea oleracea*), 1950, Lawns J (Lower Ring Road) and K, respectively. Office Gate Road was historically planted up with a palm collection in 1878, but only a large clump of Nibung Palm (*Oncosperma tigillarium*) remains from this time at the north end of Lawn D. Notable palms are also found on Lawn A (sago), Lawn D (Double Coconut/Coco-de-Mer etc.) and Lawn T (*Johannesteijsmannia* spp.). Overall SBG has one of the largest palm collections in the world.

2. Gingers & relatives (Zingiberales), Ginger Garden and surroundings, est. 2003, Lawns P, R & S; also Heliconia Walk in Palm Valley where, besides the *Heliconia* spp., a comprehensive collection of Strelitziaceae has been planted from 2013. Including behind-the-scenes material in SBG's nurseries, probably the largest

collection of this order in the world.

3. Orchids (Orchidaceae), National Orchid Garden, est. 1995, Lawns T, X & Z; also 20,000 stems of Singapore's National Flower, Vanda 'Miss Joachim' west of the Bandstand, Lawn O.

4. Bromeliads (Bromeliaceae), Lady MacNeice collection inside the National Orchid Garden, est. c. 1995.

5. Legumes (Fabaceae/Leguminosae), est. 1889, Lawn F. Note that leguminous species are found in many other parts of the Gardens, but Lawn F is the only area originally designated for this family.

6. Conifers (Coniferales), Tanglin Gate area, est. 19thC, Lawns B, C & D; Evolution Garden area; National Orchid Garden around Cool House (*Araucaria*). Whilst historically conifers were planted near the Tanglin (Main) Gate, the tall *Araucaria* specimens seen in early pictures of this area have gone. These trees are particularly susceptible to termite attack.

7. Cycads (Cycadales), Evolution Garden, est. 2005, and in front of the adjacent National Parks Headquarters, beside the above ground car park.

8. Ferns and allies (Monilophytes), Fernery, c. 1970s, Lawn M (incl. Plant House extension formerly an orchid house), recently expanded northwards into former Shade Rockery, 2010/11; Evolution Garden (tree ferns and *Selaginella*); a former fernery was sited at The Dell (c. 1882), Lawn G, which still includes a number of *Selaginella* species.

9. Nutmegs (Myristicaceae), est. 1950s, area between Healing Garden and road to NParks Headquarters.

10. Aroids (Araceae), north-east of The Bandstand, Lawns O/M.

11. Dipterocarps (Dipterocarpaceae), Tanglin Gate area, Lawns A, B & D; other Dipterocarp plantings (timber trees) are located above the road to Corner House Gate, adjacent to the Evolution Garden; many young examples of the family have been planted over the past decade in the northern end of the Bukit Timah Core and as reinforcements in SBG's Rainforest, Lawns Q, U & V. A new Dipterocarp Arboretum is being established in the Gallop Road extension to SBG, where it is planned to plant more than 200 species from SE Asia.

12. Bamboo (Poaceae-Bambusoideae), est. 1990s, Bukit Timah Core between Melati and Bukit Timah station gates; the bamboo collection was formerly on Lawns B & E, where two clumps remain as they are home to a rare species of bat; another notable bamboo planted outside of the Bukit Timah Core collection is the century old clump of *Gigantochloa ridleyi* on Lawn Y.

13. Fig/Mulberry Family (Moraceae), est. c. 1970s, Lawn J near Swiss Granite Ball Fountain

14. Myrtle Family (Myrtaceae), est. 2010, in front (east) of Raffles Building.

15. Frangipani (*Plumeria*) collection (Apocynaceae), Lawn J.

16. *Bougainvillea* collection (Nyctaginaceae), est. 1996, Bukit Timah Core, east of Melati Gate.

17. Ebony/Persimmon (*Diospyros*) collection (fam. Ebenaceae), Lawns C & D, behind Ridley Hall.

18. *Hoya* (Apocynaceae). A large collection of this genus (c. 300spp.) in support of monographic studies by Dr. Michele Rodda, but almost entirely kept in behind-the-scenes nursery facilities at present, so not on public display.

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Figura 1. Aerial view of Palm Valley. Credit: NParks Board, Singapore

Figura 2. Figura 5. The '$5 tree", Cyrtophyllum fragrans, on Lawn E of the Singapore Botanic Gardens. This image was made before a fence was placed around the tree to protect it from soil compaction. Credit: N. Taylor.

Figura 3.SBG logo featuring the Sealing Wax Palm, Cyrtostachys renda. Credit: NParks Board, Singapore

Figura 4.The Giant Tiger Orchid (Grammatophyllum speciosum) planted by Lawrence Niven in 1861, here seen flowering in 2014 before a fence was placed around to protect it. Credit: T. Yam

5. Pulai Basong (Alstonia pneumatophora) Heritage Tree on Lawn H of SBG. Credit: D. Zappi.

6. Jelawai (Terminalia subspathulata) Heritage Tree, c. 50 metres tall, at entrance to SBG's Rain Forest. Credit: N. Taylor.

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7. 95 years old African Oil Palm (Elaeis guineensis) in former Economic Garden, with bald trunk. Credit: N. Taylor

8. White Gutta (Palaquium obovatum) Heritage Tree, planted 1897, in former Economic Garden. Credit: N. Taylor

9. Torch Ginger (Etlingera elatior) in SBG's Ginger Garden. Credit: Mrs Simon Longman