

THE VASCULAR PLANT FLORA OF ABANDONED PLANTATIONS IN SINGAPORE I: CLEMENTI FOREST

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ABSTRACT. — Clementi Forest lies between Clementi Road and the former Keretapi Tanah Melayu (KTM) railway line on Singapore Island. We surveyed Clementi Forest by sampling five 20 × 20 m plots, and through some opportunistic exploration. Within each plot, all species of vascular plants were recorded, and the diameter at breast height (DBH) was recorded for all woody stems with a DBH ≥ 5 cm. A checklist of vascular plant species was compiled. Ninety-eight species of vascular plants from 54 families were recorded. Fifty-three species are native, 43 are exotic, and two are cryptogenic. One native species of note is the rediscovered terrestrial orchid, *Dienia ophrydis* (J. König) Seidenf., which was previously classified as presumed nationally extinct. Unsurprisingly, among the measured trees, the Pará rubber tree, *Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg., was found to occur most frequently on average. The fact that exotic species comprise almost half of the recorded species can be attributed to the land use history of Clementi Forest. However, the presence of a presumed nationally extinct species and a number of nationally threatened native species suggests that this forest has value for the conservation of native biodiversity.

KEY WORDS. — abandoned plantations, checklist, Clementi Road, conservation, flora, rail corridor, secondary forest

INTRODUCTION

Clementi Forest lies directly between Clementi Road and the former Keretapi Tanah Melayu (KTM) railway line on Singapore Island. It was recently brought to public attention as one of the forest patches of conservation concern along the Rail Corridor (Nature Society [Singapore], 2011). The fate of Clementi Forest is likely to be connected to the fate of the Rail Corridor, which, at the time of writing, is indeterminate (Channel News Asia, 2012).

Secondary forests have a role to play in biodiversity conservation, as they serve as refuges for some native plant and animal species, while providing resources for them (Turner & Corlett, 1996; Turner et al., 1997; McShea et al., 2009; Edwards et al., 2010, etc.). An accessible working checklist of the vascular plant species in Clementi Forest can be valuable for assessing the conservation value of the forest. Moreover, as the site is easily accessible to the public, this information can be useful for amateur naturalists who may enjoy the forest and the Rail Corridor before development commences.

MATERIAL AND METHODS

The patch of secondary forest that we have termed “Clementi Forest” (01°19'37"N, 103°46'44"E) is bound by Clementi Road to the west, the former KTM railway line to the east, King Albert Park to the north, and Holland Road to the south (Fig. 1). Based on Google Earth® satellite images, its current area is estimated to be 37.5 ha. The forest has previously been referred to in the scientific literature as “Holland Woods” (e.g., Koh & Sodhi, 2004; Castelletta et al., 2005; Bickford et al., 2010; Hassan Ibrahim et al., 2011). It has also been called “Clementi Woodlands” (Nature Society [Singapore], 2011).

Clementi Forest was part of a rubber plantation from the 1920s to the 1940s (Surveyor-General, Federated Malay States and Straits Settlements, 1924; Survey Production Centre, South East Asia, 1945). We estimate that the rubber plantation was abandoned during World War II (1941–1945; Lew, 1965; Shepherd & Shepherd, 1968), and was not reestablished thereafter. In 1963, the Jurong Line section of the KTM railway line was constructed (The Straits Times, 1963), and it diagonally intersected the forest and ran westwards under Clementi Road. Following this, in the late 1960s, low-density settlements were established within the forest (Chief Surveyor, Singapore, 1969; Singapore Mapping Unit, 1982). Subsequently, sundry cultivation of fruit trees and other food crops developed in place of the rubber plantations (Singapore Mapping Unit, 1982, 1992, 2000).

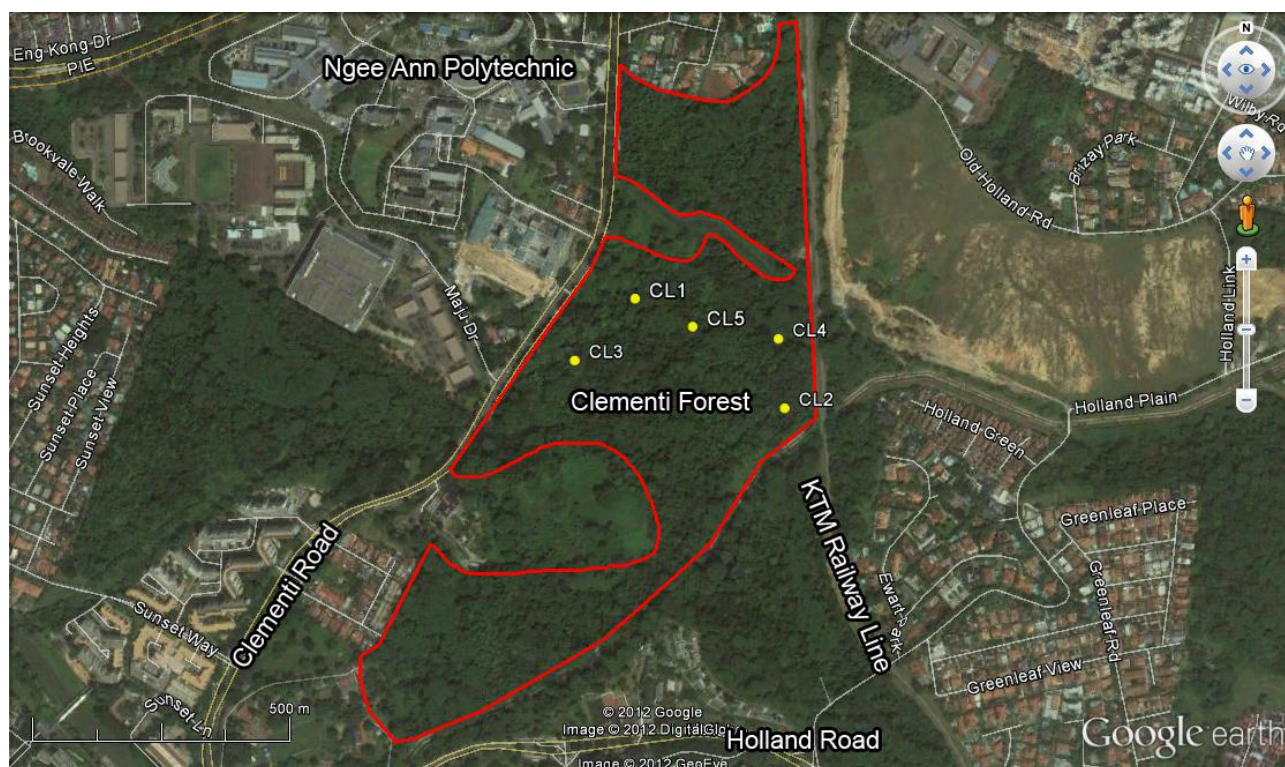


Fig. 1. Clementi Forest with respect to nearby landmarks (Google, 2012). The red outline shows the extent of the forest. The five surveyed plots are shown as yellow dots and labelled CL1 to CL5.

For this paper, we surveyed only the regions of Clementi Forest that were abandoned rubber plantation/sundry tree cultivation, and did not survey the areas of regrowth on cleared land.

We sampled the vegetation of Clementi Forest from Jul.–Aug.2011, using five 20×20 m plots. The plots were spaced at least 60 m apart, and the location of each plot was randomly derived using the fTools v. 0.6.1 plugin for the Quantum GIS software v. 1.6.0 (Quantum GIS Development Team, 2010). Within each plot, all species of vascular plants were recorded. To estimate species dominance, the stem diameter at breast height (DBH; measured 1.3 m above the ground) was recorded for all woody stems with a DBH ≥ 5 cm. Palms (Arecaceae) were not measured owing to the difficulty in measuring their true stems. Where species could not be identified in the field, specimens were collected to be further determined in the laboratory or the Herbarium, Singapore Botanic Gardens (SING). A species accumulation curve was constructed from the five sampled plots to determine how the number of recorded species increased with sampling effort. The ‘specaccum’ function implemented in the vegan v. 2.0-2 package of the statistical software R v. 2.14.1 (R Development Core Team, 2011) was used. The ‘specpool’ function in the vegan v. 2.0-2 package was used to approximate the total number of species, including unseen or undetected species, by four non-parametric species richness estimators (R Development Core Team, 2011). Measured sub-canopy and canopy species were also ranked by the mean number of stems per plot.

To supplement the forest plots, we surveyed the forest through some opportunistic exploration in 2011 and 2012. We also included species that were previously recorded in the literature from this forest.

A checklist of all vascular plant species recorded from Clementi Forest was compiled. The nomenclature and national status category of each species was derived from a recent checklist of the total vascular plant flora of Singapore (Chong et al., 2009).

RESULTS AND DISCUSSION

The list of recorded species, their native or exotic status, and their national conservation status categories, are presented in Appendix 1. A total of 98 species of vascular plants from 54 families were recorded from the sampling and opportunistic surveys of Clementi Forest. Based on Chong et al. (2009), 53 species are native, 43 are exotic, and two are cryptogenic (equivalent to “Weed of Uncertain Origin” in Chong et al. [2009]). Of the native species, two were deemed presumed nationally extinct in Chong et al. (2009), five are nationally critically endangered, two are nationally endangered, and 12 are nationally vulnerable (Table 1). The two species presumed to be nationally extinct are: the pulasan, *Nephelium ramboutan-ake* (Labill.) Leenh., and the terrestrial orchid, *Dienia ophrydis* (J.König) Seidenf.. The

Table 1. Summary of the national status categories of the vascular plants of Clementi Forest.

S/No.	National Status Category	No. of Species	Percentage (All Species)	Nativeness	Percentage (Native Species)
1.	Naturalised	16	16.3	Exotic	–
2.	Casual	16	16.3	Exotic	–
3.	Cultivated only	11	11.2	Exotic	–
4.	Cryptogenic	2	2.0	Cryptogenic	–
5.	Presumed nationally extinct (persistence from cultivation)	1	1.0	Native	1.9
6.	Presumed nationally extinct (rediscovered)	1	1.0	Native	1.9
7.	Critically endangered (persistence from cultivation)	3	3.1	Native	5.7
8.	Critically endangered	2	2.0	Native	3.8
9.	Endangered	2	2.0	Native	3.8
10.	Vulnerable	12	12.2	Native	22.6
11.	Common	32	32.7	Native	60.4

former is likely to have persisted from cultivation, while the latter was rediscovered in 2011 (Hassan Ibrahim et al., 2011). Of the five critically endangered species, three—the belinjau, *Gnetum gnemon* L. var. *gnemon*; rambai, *Baccaurea motleyana* (Müll. Arg.) Müll. Arg.; and rambutan, *Nephelium lappaceum* L.—are known food plants, and are likely to have persisted from cultivation rather than local provenance.

The list of species ordered by mean number of stems measured per plot is presented in Appendix 2. The species which was found to occur most frequently was the Pará rubber, *Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg. This species averaged 10.60 stems per plot, but occupied about 3% of the basal area of a plot on average. The most dominant species by basal area appeared to be the sea almond, *Terminalia catappa* L., but only a single individual occurred in the surveyed plots.

When the number of species recorded from the surveyed plots was plotted against sampling effort, it was found that the species accumulation curve (Fig. 2) did not plateau. This suggests that further sampling effort is required for a better approximation of the true number of species in Clementi Forest. The estimates of the total number of species in Clementi Forest are presented in Table 2. Based on the most conservative estimate (Chao), only 53% of the total number of species was sampled. The estimated total number of vascular plant species for Clementi Forest ranges from 97–151 species.

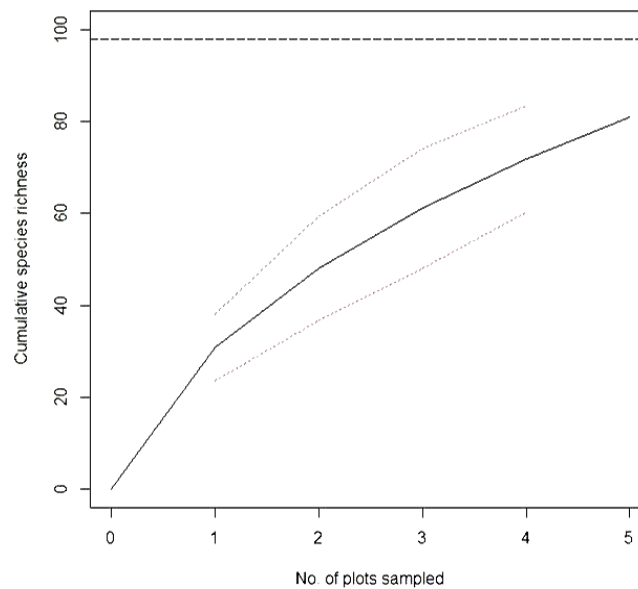


Fig. 2. Species accumulation curve showing the cumulative increase in the number of species recorded from the five sampled plots. The dotted lines represent 95% confidence intervals of the curve. The dashed line represents the total number of species recorded from Clementi Forest as presented in this paper (98 species).

Table 2. Approximated true number of species in Clementi Forest based on four commonly used species richness estimators.

Estimator	Chao	Jackknife 1	Jackknife 2	Bootstrap
Predicted number of species	151.53	117.80	138.65	97.32
Proportion of the observed number of species out of the total predicted number of species	0.53	0.69	0.58	0.83

Of the native species recorded from Clementi Forest, several are from the families typical of secondary forest (Corlett, 1991; Turner et al., 1997), such as Calophyllaceae (e.g., *Calophyllum macrocarpum* Hook.f., *Calophyllum wallichianum* Planch. & Tr. var. *incrassatum* (Hend. & Wyatt-Smith) P.F.Stevens), Lauraceae (e.g., *Litsea elliptica* Blume, *Litsea firma* Hook.f.), and Elaeocarpaceae (*Elaeocarpus petiolatus* (Jack) Wall, *Elaeocarpus stipularis* Blume). These species have probably either persisted in spite of the changes in land use, or been recently dispersed from neighbouring forest patches.

The fact that exotic species comprise almost half of the recorded species can be attributed to the land use history of the area. Of the exotic species, many are food plants, e.g., durian, *Durio zibethinus* L.; jambu, *Syzygium jambos* (L.) Alston; langsat, *Lansium domesticum* Corrêa; tapioca, *Manihot esculenta* Crantz., etc. Others may have been planted for ornamental purposes or abandoned as the site used to house nurseries and still has one nursery in the vicinity, e.g., *Aglaonema commutatum* Schott; *Dieffenbachia seguine* (Jacq.) Schott var. *seguine*; *Heliconia psittacorum* L.f. (Fig. 3b); *Syngonium podophyllum* Schott, etc.



Fig. 3. Some characteristic aspects of Clementi Forest: a, Clementi Forest as seen from Clementi Road; b, a mixed stand of exotic cultivated species, including *Heliconia psittacorum* and *Dieffenbachia seguine* var. *seguine*; c, Clementi Forest as seen from the former KTM railway line (the railway tracks removed and the ground covered with grass). (Photographs by: Ng Xin Yi).

CONCLUSIONS

The vascular flora of Clementi Forest is almost half exotic, and this can be partially explained by the land use history of the area. Rubber trees were recorded at the highest frequency, despite the abandonment of the rubber plantations about half a century ago. However, the forest also harbours rare native species, such as the recently rediscovered presumed nationally extinct orchid, *Dienia ophrydis*. Moreover, about 20% of the recorded species are nationally threatened. If Clementi Forest is to be conserved, we recommend that the native species diversity of the forest can be enhanced through enrichment planting and the removal of selected exotic species.

ACKNOWLEDGEMENTS

We would like to thank Andy Angkasa, Carmen Kee, Chen Junhao, and Ng Wen Qing for their assistance in collecting data from the field, and Ng Xin Yi for providing her photographs of the site. We are grateful to Serena Lee and Gwee Aik Teck from the Herbarium, Singapore Botanic Gardens (SING) for their aid in the identification of plant specimens, and to Jon S. Y. Tan for his help in identifying some fern species.

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APPENDIX 1

Checklist of the vascular plant flora of Clementi Forest. Nomenclature follows that of Chong et al. (2009). Species are grouped by family and arranged in alphabetical order.

S/No.	Species	Nativeness	National Status
ACANTHACEAE			
1.	<i>Asystasia gangetica</i> (L.) T.Anderson subsp. <i>micrantha</i> (Nees) Ensermu	Exotic	Naturalised
2.	<i>Thunbergia fragrans</i> Roxb.	Exotic	Naturalised
ADIANTACEAE			
3.	<i>Adiantum latifolium</i> Lam.	Exotic	Naturalised
ANACARDIACEAE			
4.	<i>Mangifera foetida</i> Lour.	Native	Vulnerable
5.	<i>Camposperma auriculata</i> Hook.f.	Native	Common
ARACEAE			
6.	<i>Aglaonema commutatum</i> Schott	Exotic	Casual
7.	<i>Alocasia macrorrhizos</i> (L.) G.Don	Exotic	Naturalised
8.	<i>Colocasia esculenta</i> (L.) Schott	Exotic	Casual
9.	<i>Dieffenbachia seguine</i> (Jacq.) Schott var. <i>seguine</i>	Exotic	Casual
10.	<i>Epipremnum aureum</i> (Linden ex André) Bunting	Exotic	Casual
11.	<i>Philodendron hederaceum</i> (Jacq.) Schott	Exotic	Casual
12.	<i>Syngonium podophyllum</i> Schott	Exotic	Naturalised
ARALIACEAE			
13.	<i>Arthropodium diversifolium</i> Blume	Native	Common
ARECACEAE			
14.	<i>Caryota mitis</i> Lour.	Native	Common
15.	<i>Elaeis guineensis</i> Jacq.	Exotic	Cultivated only
16.	<i>Livistona rotundifolia</i> (Lam.) Mart.	Exotic	Cultivated only
17.	<i>Ptychosperma macarthurii</i> (H.Wendl. ex anon.) H.Wendl. ex Hook.f.	Exotic	Naturalised
ASPARAGACEAE			
18.	<i>Dracaena fragrans</i> (L.) Ker Gawl.	Exotic	Casual
19.	<i>Dracaena surculosa</i> Lindl.	Exotic	Cultivated only
ASPLENIACEAE			
20.	<i>Asplenium nidus</i> L.	Native	Common
ASTERACEAE			
21.	<i>Mikania micrantha</i> Kunth	Exotic	Naturalised
BIGNONIACEAE			
22.	<i>Spathodea campanulata</i> P.Beauv.	Exotic	Naturalised
BLECHNACEAE			
23.	<i>Stenochlaena palustris</i> (Burm.f.) Bedd.	Native	Common
CALOPHYLLACEAE			
24.	<i>Calophyllum macrocarpum</i> Hook.f.	Native	Critically endangered
25.	<i>Calophyllum wallichianum</i> Planch. & Tr. var. <i>incrassatum</i> (Hend. & Wyatt-Smith) P.F.Stevens	Native	Vulnerable
CLUSIACEAE			
26.	<i>Garcinia mangostana</i> L.	Exotic	Casual
COMBRETACEAE			
27.	<i>Terminalia catappa</i> L.	Native	Common
CONVOLVULACEAE			
28.	<i>Erycibe tomentosa</i> Blume	Native	Common
CYATHEACEAE			
29.	<i>Cyathea latebrosa</i> (Wall.) Copel.	Native	Vulnerable
CYPERACEAE			
30.	<i>Hypolytrum nemorum</i> (Vahl) Spreng.	Native	Common
DENNSTAEDTIACEAE			
31.	<i>Microlepia speluncae</i> (L.) T.Moore	Native	Common

S/No.	Species	Nativeness	National Status
DILLENIACEAE			
32.	<i>Dillenia suffruticosa</i> (Griff. ex Hook.f. & Thomson) Martelli	Native	Common
33.	<i>Tetracera fagifolia</i> Blume	Native	Vulnerable
34.	<i>Tetracera indica</i> (Christm. & Panz.) Merr.	Native	Common
DIOSCOREACEAE			
35.	<i>Dioscorea sansibarensis</i> Pax	Exotic	Naturalised
ELAEOCARPACEAE			
36.	<i>Elaeocarpus petiolatus</i> (Jack) Wall	Native	Common
37.	<i>Elaeocarpus stipularis</i> Blume	Native	Vulnerable
EUPHORBIACEAE			
38.	<i>Acalypha siamensis</i> Oliv. ex Gage	Exotic	Casual
39.	<i>Claoxylon indicum</i> (Reinw. ex Blume) Hassk.	Native	Common
40.	<i>Codiaeum variegatum</i> (L.) A.Juss.	Exotic	Casual
41.	<i>Hevea brasiliensis</i> (Willd. ex A.Juss.) Müll. Arg.	Exotic	Naturalised
42.	<i>Manihot carthagensis</i> (Jack) Müll. Arg. subsp. <i>glaziovii</i> (Müll. Arg.) Allem	Exotic	Naturalised
43.	<i>Manihot esculenta</i> Crantz	Exotic	Naturalised
FABACEAE			
44.	<i>Adenanthera pavonina</i> L.	Exotic	Naturalised
45.	<i>Falcataria moluccana</i> (Miq.) Barneby & J.W.Grimes	Exotic	Naturalised
FLAGELLARIACEAE			
46.	<i>Flagellaria indica</i> L.	Native	Common
GNETACEAE			
47.	<i>Gnetum gnemon</i> L. var. <i>gnemon</i>	Native	Critically endangered (persistence from cultivation)
HELICONIACEAE			
48.	<i>Heliconia psittacorum</i> L.f.	Exotic	Cultivated only
HYPOXIDACEAE			
49.	<i>Molineria latifolia</i> (Dryand. ex W.T.Aiton) Herb. ex Kurz var. <i>latifolia</i>	Native	Vulnerable
ICACINACEAE			
50.	<i>Phytocrene bracteata</i> Wall.	Native	Vulnerable
LAMIACEAE			
51.	<i>Clerodendrum villosum</i> Blume	Native	Vulnerable
52.	<i>Clerodendrum laevifolium</i> Blume	Native	Common
LAURACEAE			
53.	<i>Cinnamomum iners</i> Reinw.	Native	Common
54.	<i>Litsea elliptica</i> Blume	Native	Common
55.	<i>Litsea firma</i> Hook.f.	Native	Vulnerable
MALVACEAE			
56.	<i>Durio zibethinus</i> L.	Exotic	Casual
MELASTOMATACEAE			
57.	<i>Clidemia hirta</i> (L.) D.Don	Exotic	Naturalised
MELIACEAE			
58.	<i>Aphanamixis polystachya</i> (Wall.) Parker	Native	Endangered
59.	<i>Lansium domesticum</i> Corrêa	Exotic	Cultivated only
MENISPERMACEAE			
60.	<i>Fibraurea tinctoria</i> Lour.	Native	Common
MORACEAE			
61.	<i>Artocarpus heterophyllus</i> Lam.	Exotic	Casual
62.	<i>Artocarpus integer</i> (Thunb.) Merr.	Exotic	Casual
63.	<i>Ficus benjamina</i> L.	Cryptogenic	Cryptogenic
64.	<i>Ficus fistulosa</i> Reinw. ex Blume	Native	Common
65.	<i>Ficus heteropleura</i> Blume	Native	Common
66.	<i>Ficus variegata</i> Blume	Native	Common
67.	<i>Ficus aurata</i> Miq. var. <i>aurata</i>	Native	Vulnerable

S/No.	Species	Nativeness	National Status
MUSACEAE			
68.	<i>Musa</i> cultivar	Exotic	Cultivated only
MYRTACEAE			
69.	<i>Syzygium acuminatissimum</i> (Blume) DC.	Native	Endangered
70.	<i>Syzygium borneense</i> (Miq.) Miq.	Native	Common
71.	<i>Syzygium grande</i> (Wight) Walp.	Native	Common
72.	<i>Syzygium jambos</i> (L.) Alston	Exotic	Casual
73.	<i>Syzygium polyanthum</i> (Wight) Walp.	Native	Vulnerable
74.	<i>Syzygium samarangense</i> (Blume) Merr. & L.M.Perry	Exotic	Cultivated only
OCHNACEAE			
75.	<i>Ochna kirkii</i> Oliv.	Exotic	Cultivated only
OLEANDRACEAE			
76.	<i>Nephrolepis auriculata</i> (L.) Trimen	Cryptogenic	Cryptogenic
ORCHIDACEAE			
77.	<i>Dienia ophrydis</i> (J. Konig) Seidenf.	Native	Presumed nationally extinct (rediscovered by Hassan Ibrahim et al., 2011)
OXALIDACEAE			
78.	<i>Averrhoa carambola</i> L.	Exotic	Casual
PANDANACEAE			
79.	<i>Pandanus amaryllifolius</i> Roxb.	Exotic	Casual
PHYLLANTHACEAE			
80.	<i>Aporosa frutescens</i> Blume	Native	Common
81.	<i>Baccaurea motleyana</i> (Müll. Arg.) Müll. Arg.	Native	Critically endangered (persistence from cultivation)
PIPERACEAE			
82.	<i>Piper betle</i> L.	Exotic	Casual
83.	<i>Piper sarmentosum</i> Roxb.	Native	Common
POACEAE			
84.	<i>Bambusa</i> sp.	Exotic	Cultivated only
85.	<i>Centotheca lappacea</i> (L.) Desv.	Native	Critically endangered
PTERIDACEAE			
86.	<i>Taenitis blechnoides</i> (Willd.) Sw.	Native	Common
RHIZOPHORACEAE			
87.	<i>Gynotroches axillaris</i> Blume	Native	Common
RUBIACEAE			
88.	<i>Gynochthodes sublanceolata</i> Miq.	Native	Common
89.	<i>Ixora javanica</i> (Blume) DC.	Exotic	Cultivated only
SAPINDACEAE			
90.	<i>Dimocarpus longan</i> Lour.	Exotic	Cultivated only
91.	<i>Nephelium lappaceum</i> L.	Native	Critically endangered (persistence from cultivation)
92.	<i>Nephelium ramboutan-ake</i> (Labill.) Leenh.	Native	Presumed nationally extinct (persistence from cultivation)
SCHIZAEACEAE			
93.	<i>Lygodium longifolium</i> (Willd.) Sw.	Native	Vulnerable
SMILACACEAE			
94.	<i>Smilax setosa</i> Miq.	Native	Common
THELYPTERIDACEAE			
95.	<i>Christella subpubescens</i> (Blume) Holttum	Native	Common
96.	<i>Pronephrium triphyllum</i> (Sw.) Holttum	Native	Common
URTICACEAE			
97.	<i>Cecropia pachystachya</i> Trécul	Exotic	Naturalised

S/No.	Species	Nativeness	National Status
VITACEAE			
98.	<i>Leea indica</i> (Burm.f.) Merr.	Native	Common

APPENDIX 2

Mean percentage basal area per plot of sub-canopy and canopy species sampled from Clementi Forest. Species are arranged in descending order of the mean number of stems per plot (except for species with only one individual found out of all the plots).

S/No.	Species	Mean Percentage Basal Area per Plot ± Standard Error of the Mean	Mean No. of Stems per Plot ± Standard Error of the Mean
1.	<i>Hevea brasiliensis</i>	2.84 ± 0.61	10.60 ± 4.48
2.	<i>Aphanamixis polystachya</i>	0.82 ± 0.26	7.20 ± 3.48
3.	<i>Cinnamomum iners</i>	1.34 ± 0.40	4.80 ± 1.11
4.	<i>Durio zibethinus</i>	3.52 ± 0.78	2.00 ± 1.76
5.	<i>Nephelium lappaceum</i>	16.03 ± 4.75	1.20 ± 0.80
6.	<i>Spathodea campanulata</i>	15.92 ± 5.60	1.20 ± 0.73
7.	<i>Ficus fistulosa</i>	1.80 ± 0.59	1.00 ± 0.45
8.	<i>Dracaena fragrans</i>	0.26 ± 0.04	0.80 ± 0.80
9.	<i>Artocarpus heterophyllus</i>	3.18 ± 0.84	0.80 ± 0.37
10.	<i>Dillenia suffruticosa</i>	0.47 ± 0.08	0.40 ± 0.40
11.	<i>Leea indica</i>	0.44 ± 0.03	0.40 ± 0.40
12.	<i>Terminalia catappa</i>	26.93	0.20 ± 0.20
13.	<i>Mangifera foetida</i>	5.54	0.20 ± 0.20
14.	<i>Manihot carthagensis</i> subsp. <i>glaziovii</i>	1.18	0.20 ± 0.20
15.	<i>Syzygium samarangense</i>	0.84	0.20 ± 0.20
16.	<i>Ficus variegata</i>	0.77	0.20 ± 0.20
17.	<i>Claoxylon indicum</i>	0.48	0.20 ± 0.20
18.	<i>Syzygium polyanthum</i>	0.34	0.20 ± 0.20