

THE VASCULAR PLANT FLORA OF ABANDONED PLANTATIONS IN SINGAPORE II: PUNGGOL END FOREST

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ABSTRACT. — A checklist of vascular plant species was compiled for Punggol End Forest. This secondary forest is located on the northern end of Punggol Road on Singapore Island. It is expected to be cleared within the next 15 years to make way for housing developments. Five 20 × 20 m plots were sampled within the abandoned rubber plantation region of the forest in the year 2011, and the resultant species list was supplemented with information from other surveys conducted in the years 2010–2011. Within each plot, we recorded all vascular plant species and measured the diameter at breast height (DBH) of all woody stems with a DBH ≥ 5 cm. We recorded a total of 147 species from 58 families, of which 136 are dryland forest species, and 11 are mangrove forest species. Eighty-one of the recorded species are native, 60 are exotic, and six are cryptogenic. 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 Punggol End Forest.

KEY WORDS. — abandoned plantations, checklist, flora, Punggol Road, secondary forest

INTRODUCTION

Punggol End Forest (01°24'60"N, 103°54'33"E) is found on the northern end of Punggol Road on Singapore Island. It is mostly an area of secondary regrowth forest on abandoned plantation land. However, since the forest is located close to the coast, this paper will also include the remnants of mangroves adjacent to the dryland forest to present a more comprehensive overview of its flora.

We use “Punggol End Forest” to refer collectively to the three forest patches (labelled A–C in Fig. 1) that lie on both sides of the northern, seaward end of Punggol Road. The three forest patches are separated by Punggol Road and Punggol Seventeenth Avenue (Fig. 1). Based on Google Earth® satellite images, the total area of Punggol End Forest is estimated to be 36 ha: patch A is 12.9 ha, patch B is 15.0 ha, and patch C is 8.1 ha.

From the 1920s to the 1960s, Punggol End Forest was generally a mixture of coconut plantations closer to the coast, and rubber plantations further inland (Surveyor-General, Federated Malay States and Straits Settlements, 1924; Survey Production Centre, South East Asia, 1945; Surveyor-General, Malaya, 1953; Chief Surveyor, Singapore, 1969). To the northeast of the plantations was a patch of mangrove forest drained by Sungei Dekar. By the 1970s, the land use was mostly sundry cultivation in association with low density settlements (Singapore Mapping Unit, 1975, 1982, 1987, 1992, 2000). Sungei Dekar was gradually reclaimed, and the mangrove forest was reduced to a small remnant strip drained by a concretized canal with input from the sea (Singapore Mapping Unit, 1975, 1982, 1987, 1992, 2000). The land use histories of each of the three forest patches in greater resolution are presented in Table 1.

Table 1. The respective land use histories of patches A–C of Punggol End Forest. Land use was inferred from available topographic maps of Singapore from the indicated years.

Year	Land Use of Patch A	Land Use of Patch B	Land Use of Patch C
1924	Rubber and coconut plantations	Rubber and coconut plantations	Rubber plantations
1945	Rubber plantations	Rubber and coconut plantations	Partially rubber plantations
1953	Rubber plantations	Coconut plantations	Not indicated
1969	Rubber plantations	Coconut plantations	Not indicated
1975	Sundry cultivation	Coconut plantations and sundry cultivation	Sundry cultivation and cleared land
1982	Sundry cultivation	Sundry cultivation	Sundry cultivation and cleared land
2000	Sundry cultivation	Sundry cultivation	Sundry cultivation

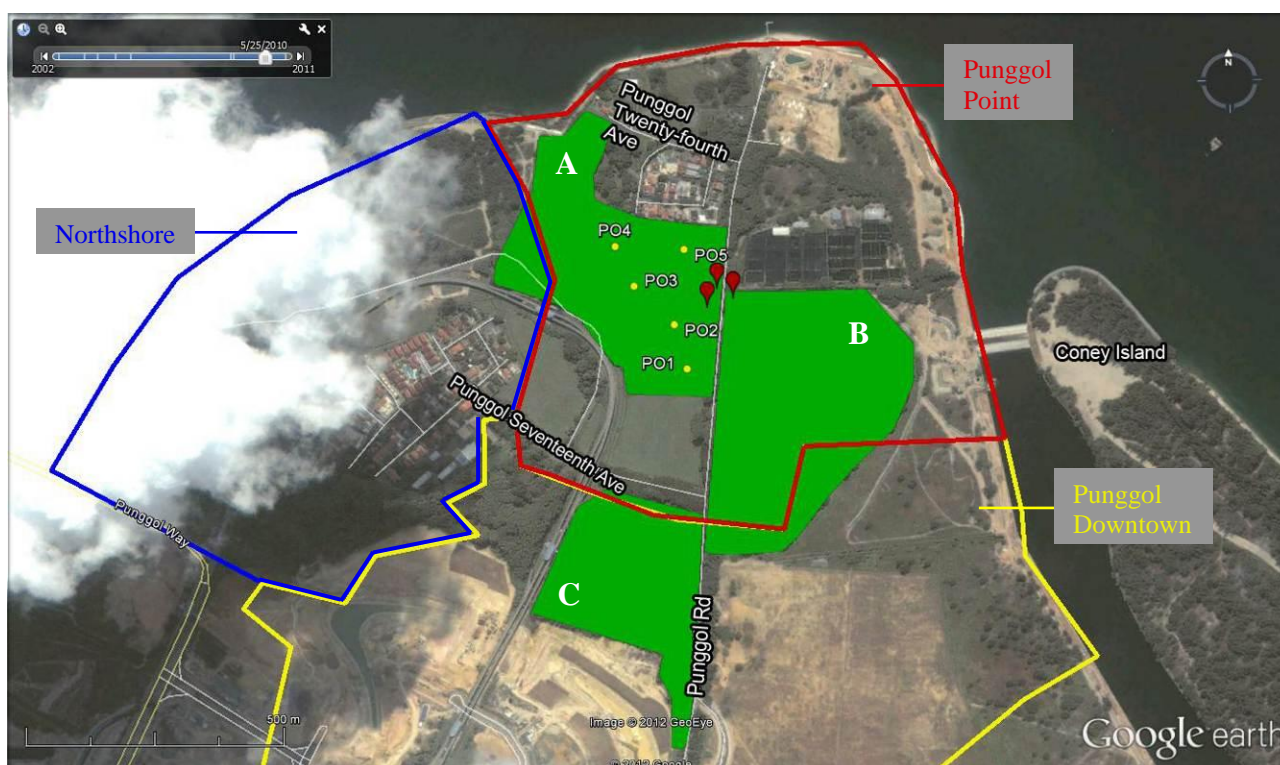


Fig. 1. Punggol End Forest with respect to nearby landmarks (Google, 2012). The shaded green polygons labelled A–C show the extent of the forest on 25 May 2010 (date that the satellite image was acquired). The five surveyed plots are shown as yellow dots and labelled PO1–PO5. The red placemarks represent remnant patches of mangrove forest. Outlined in colours are three proposed new housing districts for Punggol that are expected to affect the forest (adapted from Chin, 2012).

Punggol End Forest is expected to be completely cleared within the next 15 years to make way for the new housing developments of Punggol town (URA, 2008; Chin, 2012). Seven new housing districts have been proposed for Punggol town, and the Punggol End Forest is expected to fall within the zones of Punggol Point, Punggol Downtown, and Northshore (Fig. 1).

Secondary forests can be a refuge and resource pool for local biodiversity (Turner & Corlett, 1996; Turner et al., 1997; McShea et al., 2009; Edwards et al., 2010, etc.). Punggol End Forest is one of the few remaining patches of secondary forest in the northeast of Singapore. This paper aims to provide an accessible working checklist of the vascular plant species in Punggol End Forest, which can be used for evaluating the conservation value of the forest. In particular, nationally threatened species can be identified, and recommendations can be made for their conservation. This checklist also serves as a historical record of the flora of Punggol, Singapore.

MATERIAL AND METHODS

In Dec.2011, we surveyed five 20×20 m plots strictly within the abandoned rubber plantation region of Punggol End Forest. The extent of the rubber plantations was determined by comparing topographic maps of Singapore against the latest Google Earth satellite image of the forest (Google, 2012). The five plots were spaced at least 60 m apart from one another, and located at least 40 m from the forest edge. 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, stem diameter at breast height (DBH; measured 1.3 m above the ground) was recorded for all woody stems with a $DBH \geq 5$ 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 in 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 approximate total number of species in the species pool, i.e., including unseen or undetected species, was calculated using the ‘specpool’ function in the vegan v. 2.0-2 package (R Development Core Team, 2011). The species for which DBH was measured were also ranked by the mean number of stems per plot.

To supplement the forest plots, we also surveyed the forest through some ad hoc exploration in the year 2012. We also included plant species that were previously recorded from six 20 × 5 m transects in this forest from surveys conducted in 2010 and 2011 by YHTH (see Yeo, 2011).

A checklist of all vascular plant species recorded from Punggol End 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

A total of 147 species from 58 families were recorded from the surveys of Punggol End Forest. Of these, 136 are dryland forest species, while 11 are mangrove forest species. The list of dryland forest species, their native or exotic status, and their national conservation status categories are presented in Appendix 1. The mangrove species are listed separately in Appendix 2.

Based on Chong et al. (2009), 81 of the recorded species are native, 60 are exotic, and six are cryptogenic (equivalent to the “Weed of Uncertain Origin” category of Chong et al. [2009]). Of the native species, one was deemed presumed nationally extinct in Chong et al. (2009), five are nationally critically endangered, five are nationally endangered, and 14 are nationally vulnerable (Table 2). The species presumed to be nationally extinct is the pulasan, *Nephelium ramboutan-ake* (Labill.) Leenh., and it is likely to have persisted from cultivation. Of the five critically endangered species, four are likely to have persisted from cultivated rather than local provenance. They are: one ornamental plant species, *Epipremnum pinnatum* (L.) Engl., and three food plant species—the belinjau, *Gnetum gnemon* L. var. *gnemon*; rambai, *Baccaurea motleyana* (Müll.Arg.) Müll.Arg.; and rambutan, *Nephelium lappaceum* L.

The list of species ordered by mean number of stems measured per plot is presented in Appendix 3. The species found to occur most frequently was the Pará rubber, *Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg.. This species averaged 18.40 stems per plot, but occupied about 1% of the basal area of a plot on average. The most dominant species by basal area was the Moluccan albizia, *Falcataria moluccana* (Miq.) Barneby & J.W.Grimes, with the largest individual occupying a basal area of about 4,572 cm²; but only a total of three individuals occurred in the surveyed plots.

According to the models used, the estimated total number of species in the species pool of the abandoned rubber plantation region of the forest ranges from 77–104 species (Table 3). Based on the most conservative estimate (Jackknife 2), only 63% of the total number of species was sampled, suggesting that further sampling effort is required for a better approximation. After including the species lists from the additional surveys however, the total number of recorded species (dashed line in Fig. 2) was found to exceed the estimates of the models. This may be accounted for by the fact that the sampled plots were located away from the forest edge and only within the abandoned rubber plantation areas of the forest; the species richness estimators only apply to the forest interior of which the plots are a random sample. However, Punggol End Forest comprises a heterogeneous mix of vegetation types, and the additional surveys supplemented mangrove species and disturbance-adapted forest edge species to the species checklist.

Table 2. Summary of the national status categories of the vascular plants of Punggol End Forest.

Nativeness	National Status Category	No. of Species	Percentage (of all species)	Percentage (of all native species)
Exotic	Naturalised	28	19.05	—
	Casual	22	14.97	—
	Cultivated only	10	6.80	—
Cryptogenic	Cryptogenic	6	4.08	—
Native	Presumed nationally extinct (persistence from cultivation)	1	0.68	1.23
	Critically endangered (persistence from cultivation)	4	2.72	4.94
	Critically endangered	1	0.68	1.23
	Endangered	5	3.40	6.17
	Vulnerable	14	9.52	17.28
	Common	56	38.10	69.14

Table 3. Approximate true number of species calculated based on data from the five sampled plots, using four commonly used species richness estimators.

Estimator	Chao	Jackknife 1	Jackknife 2	Bootstrap
Predicted number of species	102.57	91.60	104.50	77.64
Proportion of the observed number of species out of the total predicted number of species	0.64	0.72	0.63	0.85

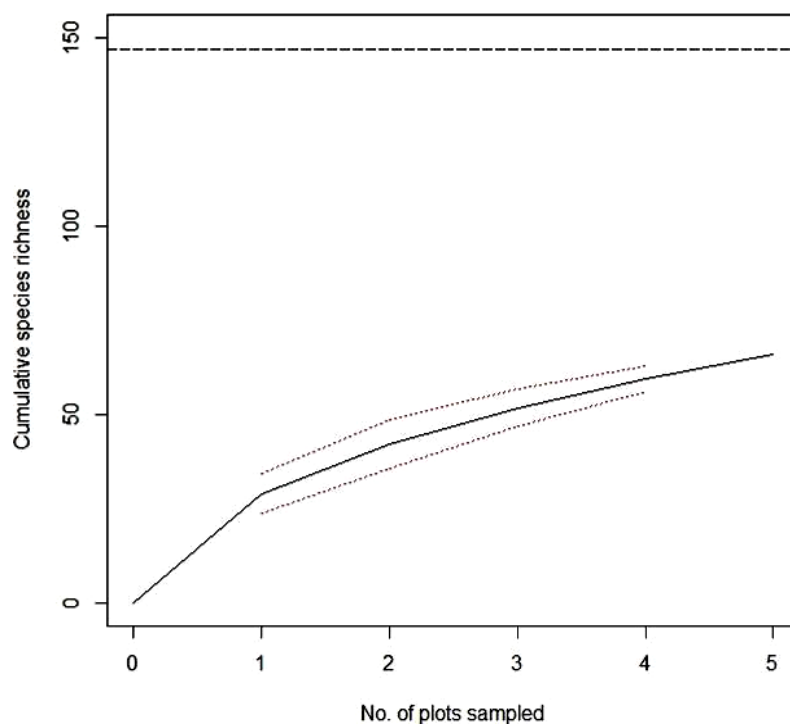


Fig. 2. Species accumulation curve showing the cumulative increase in the number of species recorded from the five sampled plots. The dotted lines represent 95% confidence intervals of the curve. The dashed line represents the total number of species recorded from Punggol End Forest (147 species).

Exotic and cryptogenic species comprise about 45% of the species recorded from Punggol End Forest, and include species such as the Moluccan albizia; black wattle, *Acacia auriculiformis* A.Cunn. ex Benth.; African tulip, *Spathodea campanulata* P.Beauv., etc., which have been known to typify the exotic-dominated secondary forest vegetation type in Singapore (e.g., Boo, 1996). The cultivation legacy of the area is also evident in the exotic food species present, e.g., durian, *Durio zibethinus* L. (Fig. 3b); jambu merah, *Syzygium malaccense* (L.) Merr. & L.M.Perry; longan, *Dimocarpus longan* Lour.; noni, *Morinda citrifolia* L., etc. Other exotics may have been planted for ornamental purposes, e.g., *Aglaonema commutatum* Schott (Fig. 3c); *Epipremnum aureum* (Linden ex André) Bunting; *Rhapis excelsa* (Thunb.) A.Henry ex Rehder; *Syngonium podophyllum* Schott, etc.

The native species recorded from Punggol End Forest include a suite of pioneer species similar to those which have been recorded from other studies of young secondary forest vegetation in Singapore (e.g., Boo, 1996; Shono et al., 2006), e.g., simpoh air, *Dillenia suffruticosa* (Griff. ex Hook.f. & Thomson) Martelli; fishtail palm, *Caryota mitis* Lour.; white-leaved fig, *Ficus grossularioides* Burm.f. var. *grossularioides*; common ivy palm, *Arthropodium diversifolium* Blume, etc.

The mangrove forest species of Punggol End Forest may be of conservation concern. Mangrove forests now comprise only about 662 ha, or 0.91% of Singapore's land area (Yee et al., 2011). If Punggol End Forest is to be cleared for development, we recommend the transplant of the seedlings or propagules found in the patch of mangrove to other areas, in order to conserve the genetic diversity of mangrove species in Singapore.

CONCLUSIONS

The vascular plant flora of Punggol End Forest is almost half exotic, and is a mark of the cultivation legacy of the Punggol district residents, comprising food and ornamental plants. About 17% of the vascular plant species recorded from Punggol forest are nationally threatened.



Fig. 3. Some characteristic aspects of the Punggol End Forest: a, Punggol End Forest as seen from Punggol Road. On the right side of the road is a remnant patch of mangrove, and it is drained by a concretized canal that leads out to the sea. b, a large durian (*Durio zibethinus*) tree estimated to be at least 30 m tall (indicated by a solid red arrow) is an emergent above the canopy layer of the forest. c, a mixed stand of exotic cultivated species in the forest, including *Hevea brasiliensis* and *Aglaonema commutatum*. (Photographs by: Letchumi d/o Mani [a, c] and Teo Siyang [b]).

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APPENDIX 1

Checklist of the vascular plant flora of Punggol End Forest. Nomenclature and national status categories follow those of Chong et al. (2009) with some modifications based on our observations. 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>Hemigraphis reptans</i> (G.Forst.) T.Anderson ex Hemsl.	Exotic	Naturalised
3.	<i>Justicia gendarussa</i> Burm.f.	Exotic	Cultivated only
4.	<i>Thunbergia fragrans</i> Roxb.	Exotic	Naturalised
ADIANTACEAE			
5.	<i>Adiantum latifolium</i> Lam.	Exotic	Naturalised
ANACARDIACEAE			
6.	<i>Campnosperma auriculata</i> Hook.f.	Native	Common
7.	<i>Mangifera indica</i> L.	Exotic	Casual
APOCYNACEAE			
8.	<i>Strophanthus caudatus</i> (L.) Kurz	Native	Critically endangered
AQUIFOLIACEAE			
9.	<i>Ilex cymosa</i> Blume	Native	Common
ARACEAE			
10.	<i>Aglaonema commutatum</i> Schott	Exotic	Casual
11.	<i>Alocasia macrorrhizos</i> (L.) G.Don	Exotic	Naturalised
12.	<i>Colocasia esculenta</i> (L.) Schott	Exotic	Casual
13.	<i>Dieffenbachia seguine</i> (Jacq.) Schott var. <i>seguine</i>	Exotic	Casual
14.	<i>Epipremnum aureum</i> (Linden ex André) Bunting	Exotic	Casual
15.	<i>Epipremnum pinnatum</i> (L.) Engl.	Native	Critically endangered (persistence from cultivation)
16.	<i>Philodendron hederaceum</i> (Jacq.) Schott	Exotic	Casual
17.	<i>Syngonium podophyllum</i> Schott	Exotic	Naturalised
18.	<i>Typhonium trilobatum</i> (L.) Schott	Exotic	Naturalised
ARALIACEAE			
19.	<i>Arthrophyllum diversifolium</i> Blume	Native	Common
ARECACEAE			
20.	<i>Areca catechu</i> L.	Exotic	Casual
21.	<i>Caryota mitis</i> Lour.	Native	Common
22.	<i>Cocos nucifera</i> L.	Exotic	Naturalised
23.	<i>Elaeis guineensis</i> Jacq.	Exotic	Cultivated only
24.	<i>Oncosperma tigillaria</i> (Jack) Ridl.	Native	Vulnerable
25.	<i>Ptychosperma macarthurii</i> (H.Wendl. ex anon.) H.Wendl. ex Hook.f.	Exotic	Naturalised
26.	<i>Rhapis excelsa</i> (Thunb.) A.Henry ex Rehder	Exotic	Cultivated only
ASPARAGACEAE			
27.	<i>Dracaena fragrans</i> (L.) Ker Gawl.	Exotic	Casual
28.	<i>Dracaena surculosa</i> Lindl.	Exotic	Cultivated only
29.	<i>Sansevieria trifasciata</i> Prain	Exotic	Casual
ASPLENIACEAE			
30.	<i>Asplenium longissimum</i> Blume	Native	Common
31.	<i>Asplenium nidus</i> L.	Native	Common
ASTERACEAE			
32.	<i>Mikania micrantha</i> Kunth	Exotic	Naturalised
BIGNONIACEAE			
33.	<i>Spathodea campanulata</i> P.Beauv.	Exotic	Naturalised
BLECHNACEAE			
34.	<i>Stenochlaena palustris</i> (Burm.f.) Bedd.	Native	Common
BORAGINACEAE			
35.	<i>Carmona retusa</i> (Vahl) Masam.	Exotic	Naturalised

S/No.	Species	Nativeness	National status
COMBRETACEAE			
36.	<i>Terminalia catappa</i> L.	Native	Common
CONVOLVULACEAE			
37.	<i>Merremia umbellata</i> (L.) Hallier f.	Cryptogenic	Cryptogenic
COSTACEAE			
38.	<i>Costus speciosus</i> (Koenig) Smith	Native	Common
CLUSIACEAE			
39.	<i>Garcinia mangostana</i> L.	Exotic	Casual
CUCURBITACEAE			
40.	<i>Coccinia grandis</i> (L.) Voigt	Exotic	Naturalised
41.	<i>Cucumis maderaspatanus</i> L.	Exotic	Naturalised
DILLENIACEAE			
42.	<i>Dillenia suffruticosa</i> (Griff. ex Hook.f. & Thomson) Martelli	Native	Common
43.	<i>Tetracera indica</i> (Christm. & Panz.) Merr.	Native	Common
DIOSCOREACEAE			
44.	<i>Dioscorea sansibarensis</i> Pax	Exotic	Naturalised
EUPHORBIACEAE			
45.	<i>Acalypha siamensis</i> Oliv. ex Gage	Exotic	Casual
46.	<i>Claoxylon indicum</i> (Reinw. ex Blume) Hassk.	Native	Common
47.	<i>Hevea brasiliensis</i> (Willd. ex A.Juss.) Müll.Arg.	Exotic	Naturalised
48.	<i>Macaranga bancana</i> (Miq.) Müll.Arg.	Native	Common
49.	<i>Macaranga gigantea</i> (Rchb.f. & Zoll.) Müll.Arg.	Native	Common
50.	<i>Macaranga triloba</i> (Thunb.) Müll.Arg.	Native	Common
51.	<i>Manihot carthagenesis</i> (Jack) Müll.Arg. subsp. <i>glaziovii</i> (Müll.Arg.) Allem	Exotic	Naturalised
52.	<i>Manihot esculenta</i> Crantz	Exotic	Naturalised
FABACEAE			
53.	<i>Acacia auriculiformis</i> A.Cunn. ex Benth.	Exotic	Naturalised
54.	<i>Adenanthera pavonina</i> L.	Exotic	Naturalised
55.	<i>Albizia saman</i> (Jacq.) Merr.	Exotic	Casual
56.	<i>Andira inermis</i> (W.Wright) Kunth ex DC.	Exotic	Casual
57.	<i>Archidendron jiringa</i> (Jack) Nielsen	Native	Vulnerable
58.	<i>Dalbergia candenatensis</i> (Dennst.) Prain	Native	Common
59.	<i>Entada spiralis</i> Ridl.	Native	Common
60.	<i>Falcataria moluccana</i> (Miq.) Barneby & J.W.Grimes	Exotic	Naturalised
61.	<i>Pterocarpus indicus</i> Willd.	Exotic	Casual
FLAGELLARIACEAE			
62.	<i>Flagellaria indica</i> L.	Native	Common
GENTIANACEAE			
63.	<i>Fagraea fragrans</i> Roxb.	Native	Common
GNETACEAE			
64.	<i>Gnetum gnemon</i> L. var. <i>gnemon</i>	Native	Critically endangered (persistence from cultivation)
LAMIACEAE			
65.	<i>Clerodendrum laevifolium</i> Blume	Native	Common
66.	<i>Clerodendrum villosum</i> Blume	Native	Vulnerable
LAURACEAE			
67.	<i>Cinnamomum iners</i> Reinw.	Native	Common
68.	<i>Lindera lucida</i> (Blume) Boerl.	Native	Vulnerable
MALVACEAE			
69.	<i>Durio zibethinus</i> L.	Exotic	Casual
MELASTOMATACEAE			
70.	<i>Clidemia hirta</i> (L.) D.Don	Exotic	Naturalised

S/No.	Species	Nativeness	National status
MELIACEAE			
71.	<i>Aphanamixis polystachya</i> (Wall.) Parker	Native	Endangered
72.	<i>Lansium domesticum</i> Corrêa	Exotic	Cultivated only
73.	<i>Sandoricum koetjape</i> (Burm.f.) Merr.	Native	Endangered
MENISPERMACEAE			
74.	<i>Fibraurea tinctoria</i> Lour.	Native	Common
MORACEAE			
75.	<i>Artocarpus heterophyllus</i> Lam.	Exotic	Casual
76.	<i>Artocarpus integer</i> (Thunb.) Merr.	Exotic	Casual
77.	<i>Ficus aurata</i> Miq. var. <i>aurata</i>	Native	Vulnerable
78.	<i>Ficus elastica</i> Roxb. ex Hornem.	Exotic	Casual
79.	<i>Ficus fistulosa</i> Reinw. ex Blume	Native	Common
80.	<i>Ficus grossularioides</i> Burm.f. var. <i>grossularioides</i>	Native	Common
81.	<i>Ficus heteropleura</i> Blume	Native	Common
82.	<i>Ficus microcarpa</i> L.f.	Native	Common
83.	<i>Ficus punctata</i> Lam.	Exotic	Cultivated only
84.	<i>Ficus religiosa</i> L.	Exotic	Naturalised
MUNTINGIACEAE			
85.	<i>Muntingia calabura</i> L.	Exotic	Naturalised
MYRTACEAE			
86.	<i>Psidium guajava</i> L.	Exotic	Casual
87.	<i>Syzygium grande</i> (Wight) Walp.	Native	Common
88.	<i>Syzygium lineatum</i> (DC.) Merr. & L.M.Perry	Native	Common
89.	<i>Syzygium malaccense</i> (L.) Merr. & L.M.Perry	Exotic	Casual
90.	<i>Syzygium polyanthum</i> (Wight) Walp.	Native	Vulnerable
91.	<i>Syzygium zeylanicum</i> (L.) DC.	Native	Common
OCHNACEAE			
92.	<i>Ochna kirkii</i> Oliv.	Exotic	Cultivated only
OLEANDRACEAE			
93.	<i>Nephrolepis auriculata</i> (L.) Trimen	Cryptogenic	Cryptogenic
OPILIACEAE			
94.	<i>Champereia manillana</i> (Blume) Merr.	Native	Common
OXALIDACEAE			
95.	<i>Averrhoa carambola</i> L.	Exotic	Casual
PASSIFLORACEAE			
96.	<i>Passiflora foetida</i> L.	Exotic	Naturalised
97.	<i>Passiflora suberosa</i> L.	Exotic	Naturalised
PHYLLANTHACEAE			
98.	<i>Aporosa frutescens</i> Blume	Native	Common
99.	<i>Baccaurea motleyana</i> (Müll.Arg.) Müll.Arg.	Native	Critically endangered (persistence from cultivation)
PIPERACEAE			
100.	<i>Piper betle</i> L.	Exotic	Casual
101.	<i>Piper sarmentosum</i> Roxb.	Native	Common
POLYPODIACEAE			
102.	<i>Drynaria quercifolia</i> (L.) J.Sm.	Native	Common
103.	<i>Phymatosorus scolopendria</i> (Burm.f.) Pic.Serm.	Native	Common
104.	<i>Pyrrhosia longifolia</i> (Burm.) Morton	Native	Common
105.	<i>Pyrrhosia piloselloides</i> (L.) M.G.Price	Native	Common
PRIMULACEAE			
106.	<i>Ardisia elliptica</i> Thunb.	Native	Endangered
107.	<i>Embelia ribes</i> Burm.f.	Native	Common
PTERIDACEAE			
108.	<i>Pteris ensiformis</i> Burm.f.	Cryptogenic	Cryptogenic
109.	<i>Taenitis blechnoides</i> (Willd.) Sw.	Native	Common

S/No.	Species	Nativeness	National status
RHIZOPHORACEAE			
110.	<i>Gynotroches axillaris</i> Blume	Native	Common
RUBIACEAE			
111.	<i>Gynochthodes sublanceolata</i> Miq.	Native	Common
112.	<i>Ixora finlaysoniana</i> Wall. ex G.Don	Exotic	Cultivated only
113.	<i>Ixora javanica</i> (Blume) DC.	Exotic	Cultivated only
114.	<i>Morinda citrifolia</i> L.	Cryptogenic	Cryptogenic
115.	<i>Morinda umbellata</i> L.	Native	Common
116.	<i>Oxyceros longiflorus</i> (Lam.) T.Yamazaki	Native	Vulnerable
117.	<i>Paederia foetida</i> L.	Native	Common
118.	<i>Timonius wallichianus</i> (Korth.) Valetton	Native	Common
RUTACEAE			
119.	<i>Clausena excavata</i> Burm.f.	Native	Common
SAPINDACEAE			
120.	<i>Dimocarpus longan</i> Lour.	Exotic	Cultivated only
121.	<i>Guioa pubescens</i> (Z. & M.) Radlk.	Native	Vulnerable
122.	<i>Nephelium lappaceum</i> L.	Native	Critically endangered (persistence from cultivation)
123.	<i>Nephelium ramboutan-ake</i> (Labill.) Leenh.	Native	Presumed nationally extinct (persistence from cultivation)
SAPOTACEAE			
124.	<i>Pouteria obovata</i> (R.Br.) Baehni	Native	Vulnerable
SCHIZAEACEAE			
125.	<i>Lygodium circinnatum</i> (Burm.f.) Sw.	Native	Vulnerable
126.	<i>Lygodium flexuosum</i> (L.) Sw.	Native	Common
127.	<i>Lygodium longifolium</i> (Willd.) Sw.	Native	Vulnerable
128.	<i>Lygodium microphyllum</i> (Cav.) R.Br.	Native	Common
SMILACACEAE			
129.	<i>Smilax calophylla</i> Wall. ex A.DC.	Native	Endangered
THELYPTERIDACEAE			
130.	<i>Amphineuron opulentum</i> (Kaulf.) Holttum	Native	Endangered
131.	<i>Christella dentata</i> (Forsk.) Brownsey & Jermy	Cryptogenic	Cryptogenic
132.	<i>Christella subpubescens</i> (Blume) Holttum	Native	Common
URTICACEAE			
133.	<i>Pipturus argenteus</i> (G.Forst.) Wedd.	Exotic	Naturalised
VERBENACEAE			
134.	<i>Lantana camara</i> L.	Exotic	Naturalised
VITACEAE			
135.	<i>Cissus hastata</i> Miq.	Cryptogenic	Cryptogenic
VITTARIACEAE			
136.	<i>Vittaria ensiformis</i> Sw.	Native	Common

APPENDIX 2

Checklist of the mangrove plant flora of Punggol End 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>Acanthus ebracteatus</i> Vahl	Native	Vulnerable
2.	<i>Acanthus volubilis</i> Wall.	Native	Vulnerable
3.	<i>Avicennia alba</i> Blume	Native	Common
4.	<i>Avicennia officinalis</i> L.	Native	Common
FABACEAE			
5.	<i>Caesalpinia crista</i> L.	Native	Vulnerable
6.	<i>Derris trifoliata</i> Lour.	Native	Common
LYTHRACEAE			
7.	<i>Sonneratia alba</i> Sm.	Native	Common
MALVACEAE			
8.	<i>Talipariti tiliaceum</i> (L.) Fryxell	Native	Common
PTERIDACEAE			
9.	<i>Acrostichum aureum</i> L.	Native	Common
RHIZOPHORACEAE			
10.	<i>Bruguiera cylindrica</i> (L.) Blume	Native	Common
11.	<i>Rhizophora apiculata</i> Blume	Native	Common

APPENDIX 3

Mean percentage basal area per plot of sub-canopy and canopy species sampled from Punggol End 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>	1.42 ± 0.32	18.40 ± 5.09
2.	<i>Cinnamomum iners</i>	1.21 ± 0.24	5.60 ± 3.93
3.	<i>Nephelium lappaceum</i>	3.04 ± 1.02	2.80 ± 1.07
4.	<i>Durio zibethinus</i>	4.80 ± 2.02	2.40 ± 1.17
5.	<i>Syzygium grande</i>	10.58 ± 3.46	2.00 ± 0.89
6.	<i>Falcataria moluccana</i>	24.41 ± 3.50	0.60 ± 0.40
7.	<i>Terminalia catappa</i>	20.55	0.40 ± 0.40
8.	<i>Syzygium lineatum</i>	5.64 ± 2.79	0.40 ± 0.24
9.	<i>Baccaurea motleyana</i>	0.54 ± 0.38	0.40 ± 0.40
10.	<i>Aphanamixis polystachya</i>	0.38 ± 0.08	0.40 ± 0.40
11.	<i>Syzygium polyanthum</i>	1.00	0.20 ± 0.20
12.	<i>Sandoricum koetjape</i>	0.98	0.20 ± 0.20