



Contract CR2005  
Provision of Services to Conduct Environmental  
Impact Study

# Environmental Impact Study (Windsor & Eng Neo Avenue Forest) Final Report

Study Stage: Final

Volume 2 of 5

Submitted by:  
AECOM Singapore Pte Ltd

Submitted to:  
Land Transport Authority

07 October 2022

## 7. Biodiversity

### 7.1 Introduction

The Biodiversity Impact Assessment (BIA) aims to establish baseline biodiversity information of the three Study Areas and the mitigated worksites. In addition, the BIA also aims to evaluate the impacts of the proposed construction works on existing flora and fauna.

Baseline information was first gathered through reviews of past and present biodiversity records, published literature, and in consultation with taxonomic experts. Actual field surveys were then carried out to verify and supplement the data.

Through the desktop and field assessments, important habitats, species of flora and fauna of conservation significance were identified. The information was then used to evaluate the extent of the impacts of construction and operational works. Mitigation measures were then recommended to reduce and/or minimise the impacts.

This section reports on the biodiversity field findings of surveys conducted between 16<sup>th</sup> December 2019 and 15<sup>th</sup> September 2020 at Eng Neo Avenue Forest and Windsor, and for surveys conducted between 13<sup>th</sup> September and 24<sup>th</sup> November 2021 at Sites I and II (Forested Area Adjacent to Fairways Quarters).

### 7.2 Methodology

#### 7.2.1 Study Areas

The floristic and faunistic field assessments covered a total area of 85.6 ha (Table 7-1), comprising two worksites and adjacent areas of known or potential ecological sensitivity. Arboricultural surveys covered a total of 26.6 ha (in Eng Neo Avenue Forest and Windsor) while tree mapping was carried in Sites I and II (16.7 ha) under the scope of concurrent study carried out by AECOM in the vicinity.

**Table 7-1 Size of Floristic and Faunistic Study Areas, Arboricultural and Tree Mapping Study Areas**

Site	Worksite	Flora and Fauna (ha)	Arboriculture (ha)	Tree mapping (ha)
Eng Neo Avenue Forest	A1-W2	39.2	17.6	–
Sites I and II	A1-W2	16.8	–	16.7
Windsor	A1-W1	29.7	9.0	–
<b>Total area</b>	<b>N.A.</b>	<b>85.6</b>	<b>43.3</b>	<b>16.7</b>





ENG NEO AVENUE FOREST



WINDSOR

**Legend**

- Study Area
- Arboricultural area
- Worksite and alignment (Base)

**Rev.**   **Date**   **By**   **Description**   **Chk'd**   **App'd**

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG
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**Qualified Person Endorsement :**  
NA

**LTA Endorsement :**  
NA

**Consultant :**  
**AECOM**

**Project Title :**  
**CONTRACT CR2005  
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(WINDSOR AND  
ENG NEO AVENUE FOREST)**

<b>Designed</b> JW	<b>Checked</b> JAG	<b>Approved</b> JAG
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**Figure Title :**  
**STUDY AREAS FOR FLORISTIC AND  
FAUNISTIC SURVEYS AND  
ARBORICULTURAL SURVEYS AT  
ENG NEO AVENUE FOREST AND WINDSOR**

<b>Figure No. :</b> 7 - 1	<b>Rev.</b> -	<b>Sheet</b> 1 of 1
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Study Area

Tree mapping area

Worksites, access roads and alignment (Mitigated)

N

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Figure Title :  
**STUDY AREAS FOR FLORISTIC AND  
FAUNISTIC SURVEYS AND  
TREE MAPPING AT FORESTED AREA  
ADJACENT TO FAIRWAYS QUARTERS**

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1 of 1

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## 7.2.2 Nomenclature, Taxonomy and Definitions

### 7.2.2.1 Nomenclature and Taxonomy

The nomenclature and taxonomy for each taxonomic group follows these key references:

- Plants: World Checklist of Selected Plant Families and Plants of the World Online
- Aculeate hymenopterans: Soh and Ngiam (2013) and Ascher and Pickering (2018)
- Odonates: Soh et al. (2019)
- Butterflies: Khew (2015)
- Freshwater fish: Suzuki et al. (2015), Kottelat (2013) and Ho et al. (2016)
- Freshwater decapod crustaceans: Ng (1997) and Cai et al. (2007)
- Birds: Gill and Donsker (2020)
- Amphibians, reptiles, non-volant mammals and bats: Baker and Lim (2012)

### 7.2.2.2 Flora Classification System

Species of flora were first classified as native, exotic, or cryptogenic (i.e., they do not have a known origin). Native species are then further classified as nationally Extinct or Extant, i.e., still surviving. Extant native species are additionally classified as Common, Vulnerable, Endangered, or Critically Endangered. Exotic species are classified as Cultivated Only, Casual, or Naturalised (Table 7-2). The definitions were adapted from Chong et al. (2009).

**Table 7-2 Classification System for Species of Flora**

Origin	Status	Definition
<b>Native</b>		<i>Species that have originated in an area without human intervention or have arrived there without intentional or unintentional intervention of humans</i>
	Extinct	Native species that have not been seen or collected locally from the wild in the last 30 years
	Extant	Native species that are common, i.e., have more than 1,000 mature individuals locally, vulnerable, endangered, or Critically Endangered
<b>Exotic</b>		<i>Species that are present in an area as a result of intentional or unintentional human involvement</i>
	Cultivated Only	Exotic species that persist locally as a result of cultivation or other direct human care
	Casual	Exotic species that persist locally by repeated introductions or limited asexual reproduction and do not form self-replacing populations
	Naturalised	Exotic species that persist locally without direct human intervention and are self-replacing, usually through sexual reproduction
<b>Cryptogenic</b>		<i>Species with no historical or biogeographical evidence of being exotic, yet are restricted to only habitats modified or disturbed by humans</i>

### 7.2.2.3 Species of Conservation Significance

The assessment of whether certain species are of conservation significance is important for highlighting the need and priorities for conservation.

Threatened species of flora — i.e., listed in Chong et al. (2009) as nationally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (which indicates a rediscovery) — were assessed to determine whether they are of conservation significance. While the national conservation status of threatened species is true of wild populations that originate in an area without direct or indirect human intervention, some populations may be relics that persist from past cultivation or escapees from present-day cultivation that do not belong to native genetic stock. The assessment of whether a threatened species is of conservation significance is based on, but not limited to,



information on the following: (1) land use history, (2) presence of large parent tree(s), (3) commercial availability, (4) data from previous environmental impact assessments, (5) reforestation efforts, (6) natural range, and (7) importance for associated fauna. If the origin of a threatened species population is disputable or difficult to determine, we will corroborate findings from field surveys of fauna and/or adopt the more conservative approach by considering them of conservation significance. In carrying out such assessments, we are then able to prioritise conservation needs and focus resources in conserving them.

Faunal species of conservation significance include both threatened and non-threatened species which are regarded as notable records. Threatened species of fauna are those listed as Vulnerable, Endangered, Critically Endangered, or Extinct under its global or national status. Both global and national conservation statuses were considered to provide a holistic view of the conservation value of the Study Areas. The national conservation statuses reference the Singapore Red Data Book (SRDB; Davison et al., 2008) and other more updated local checklists, where available, such as Soh et al. (2019) for odonates and Jain et al. (2018) for butterflies. The global conservation status references the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN, 2012).

Few resources with the national conservation status of species from the order Hymenoptera are available. Only a few bee species are listed in the SRDB (Davison et al., 2008). A paper on the updated conservation status of bees and wasps found in Singapore by Ascher et al. is in preparation. However, no comparable study has been done for stinging wasps. For this study, the assessment was conducted based on personal records by Lee JXQ, together with specimen records in the Lee Kong Chian Natural History Museum (LCKNHM) and NUS' Insect Diversity Lab (IDL) collections. The assessment adopts the same conservation statuses used in Ascher et al. (in prep).

Notable records of non-threatened species include species that are deemed of conservation interest within the Study Areas. The Study Areas may provide important habitats for these species, including breeding sites. Species deemed sensitive to construction impacts may also be highlighted as a notable record and regarded as a species of conservation significance.

**Table 7-3 Definition of Each Global and/or National Conservation Status Following the IUCN Red List (IUCN, 2012) and Singapore Red Data Book (Davison Et Al., 2008)**

National conservation status	Definition
Vulnerable ( <b>VU</b> )	Species facing a high risk of extinction in the wild/in Singapore
Endangered ( <b>EN</b> )	Species facing a very high risk of extinction in the wild/in Singapore
Critically Endangered ( <b>CR</b> )	Species facing an extremely high risk of extinction in the wild/in Singapore
Presumed Nationally Extinct ( <b>NE</b> )	There is no reasonable doubt that the last reproductively capable individual within Singapore has died or disappeared in the last 50 years (fauna) or 30 years (vascular plants).

### 7.2.3 Desktop Assessment

Historical and present-day land use of the Study Areas were reviewed. Information on land use history was primarily gathered from old maps in the online collection of the National Archives of Singapore (NAS) as well as historical maps on the OneMap and the National University of Singapore (NUS) Libraries portals. A list of faunal species that are likely to occur at the site ("species of probable occurrence") was also generated using information on past faunal records and existing habitat types and past fauna records up to 2 km from the Study Areas.

Past and present floristic as well as faunistic species composition were examined using relevant key references that include books, scientific publications, unpublished literature, and online databases. Sources of databases include The Biodiversity of Singapore by Lee Kong Chian Natural History Museum (LCKNHM, 2020), Flora and Fauna Web by National Parks Board (NParks, 2020) and iNaturalist. Other key references include the Singapore Red Data Book (Davison et al., 2008), Singapore Biodiversity Records, encyclopaedia on Singapore's biodiversity (Ng et al., 2011) and the database of flora and fauna records compiled by Camphora Pte Ltd.

Local and regional references were examined for the various taxonomic groups:

- Plants (Boo, 1996; Keng, 2003; Chong et al., 2009);



- Aculeate hymenopterans (Soh & Ngiam, 2013; Ascher & Pickering, 2018; BOS);
- Odonates (Tang et al., 2010; Ngiam & Cheong, 2016; Soh et al., 2019);
- Butterflies (Khew, 2015; Jain et al., 2018; Theng et al., 2020);
- Freshwater fish (Ng & Lim, 1997; Giam et al., 2011; Ho et al., 2016; Tan et al., 2020);
- Freshwater decapod crustaceans (Ng, 1997; Cai et al., 2007; Wowor & Ng, 2010; Yeo, 2010; Ho et al., 2016);
- Birds (NSS, 2020; Singapore Birds; Singapore Bird Group; Singapore Birds Project);
- Herptofauna, (Baker & Lim, 2012);
- Non-volant mammals and bats (Corlett, 1992; Teo & Rajathurai, 1997; Brook et al., 2003; Lane et al., 2006; Chua & Lim, 2011; Baker & Lim, 2012).

## 7.2.4 Floristic Field Assessment

The field assessment for flora consists of (1) vegetation mapping, (2) vegetation plot sampling, (3) floristic surveys, and (4) arboricultural surveys or (5) tree mapping.

The Windsor Biodiversity Study Area comprised two fragments, namely, (1) Windsor's Northern Forest Fragment and (2) Windsor Nature Park. Owing to permit and access restrictions in Windsor Nature Park, vegetation plots could not be set up and sampled. Instead, general floristic walking surveys were conducted along existing boardwalks within the nature park. Plants within 5–10 m left and right of the boardwalks were identified to species, whenever possible. Locations of large and other plant specimens of value found along the boardwalks were also recorded. Locations of nationally threatened species, however, were not recorded as there is a mix of managed and natural vegetation within the nature park, making it challenging to ascertain which specimens were planted or naturally occurring. On the other hand, vegetation plots could be set up in Windsor's Northern Forest Fragment; this is detailed in Section 7.2.4.2 below.

### 7.2.4.1 Vegetation Mapping

A preliminary vegetation map for each of the three Study Areas was prepared based on visual interpretations of satellite images from Google Earth 7.1.2.2041 (Google Inc. 2013). Preliminary classification of the vegetation types—for example, forest, grassland, or managed vegetation—was determined using visual features, such as textures and colours, observed in the satellite images. Adjustments were then made to the preliminary maps according to actual observations during ground truthing. Ground truthing was conducted throughout the survey area with the aid of the GPS receiver. Photographs were also taken. The boundaries of each vegetation type were tracked on the GPS receiver and mapped out on Google Earth 7.1.2.2041. The classification of forest types—excluding scrublands and managed vegetation—references NParks (2021) and Yee et al. (2016).

### 7.2.4.2 Vegetation Plot Sampling

A total of 10 vegetation plots measuring 20 × 20 m were set up (Figure 7-4) – eight in Eng Neo Avenue Forest and two in Windsor's Northern Forest Fragment. The number of plots in each site were determined based on the sampling density of one plot for every 5 ha of spontaneous vegetation. Hence, the number of vegetation plots is proportionate to the relative size of the spontaneous vegetation within the site, i.e., vegetation that occurs naturally and is neither manicured nor managed by humans.

Locations of the vegetation plots were first randomly generated. The actual locations were then adjusted on-site based on accessibility and suitability, i.e., not covered in dense vegetation and/or tree falls that would render the site inaccessible. We identified to species and measured the girth of all tree and shrub specimens, as well as single-stemmed palms, of ≥ 0.05 m girth. Specimens with < 0.05 m girth were also counted. For *Ficus* stranglers and palm clusters, we measured the circumference of each aerial root or stem, respectively, of ≥ 0.05 m girth. All other plant species observed in the plots were also recorded.





**Figure 7-3 A 20 × 20 m Vegetation Plot Set Up**

#### **7.2.4.3 Floristic Surveys**

All plants observed in the Study Areas during floristic surveys were identified to species whenever possible. A checklist of plant species recorded from the present floristic surveys was compiled. For plants that could not be immediately identified with certainty in the field, photographs and/or voucher specimens were taken. They were then identified using identification keys, taxonomic descriptions, online plant photo databases, with the help of taxonomic experts, and/or by matching the pressed and dried collected specimens with existing specimens in the Singapore Botanic Gardens' Herbarium (SING). For very tall unidentifiable trees with leaves that were too high in the canopy to photograph, dried leaves matching these trees were collected from the forest floor and used to aid in species identification.

##### **7.2.4.3.1 Plant Species of Conservation Significance**

Threatened species of flora—i.e., listed in Chong et al. (2009) as nationally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (which indicates a rediscovery)—were assessed to determine whether they are of conservation significance. The geographic coordinates of plants of conservation significance were marked using a Global Positioning System (GPS) handheld receiver (Garmin GPSMap® 64s). Where there are clusters of plants of conservation significance—i.e., more than one individual occurring within 5 m or less of another individual—the geographic coordinates of the approximated centre of the area is marked using the GPS receiver.

##### **7.2.4.3.2 Large Plant Specimens**

The GPS handheld receiver was used to record locations of all trees—excluding that of storm-vulnerable species, such as *Spathodea campanulata* and *Falcataria moluccana* (Figure 7-4)—of  $\geq 3.0$  m girth, as well as bamboo clusters and strangling *Ficus* species of  $\geq 3.0$  m spread. We identified the individuals to species, whenever possible. Girth (for trees) and spread (for bamboo clusters and strangling *Ficus* species) were measured and estimated, respectively. The height of the specimens was also estimated and recorded.



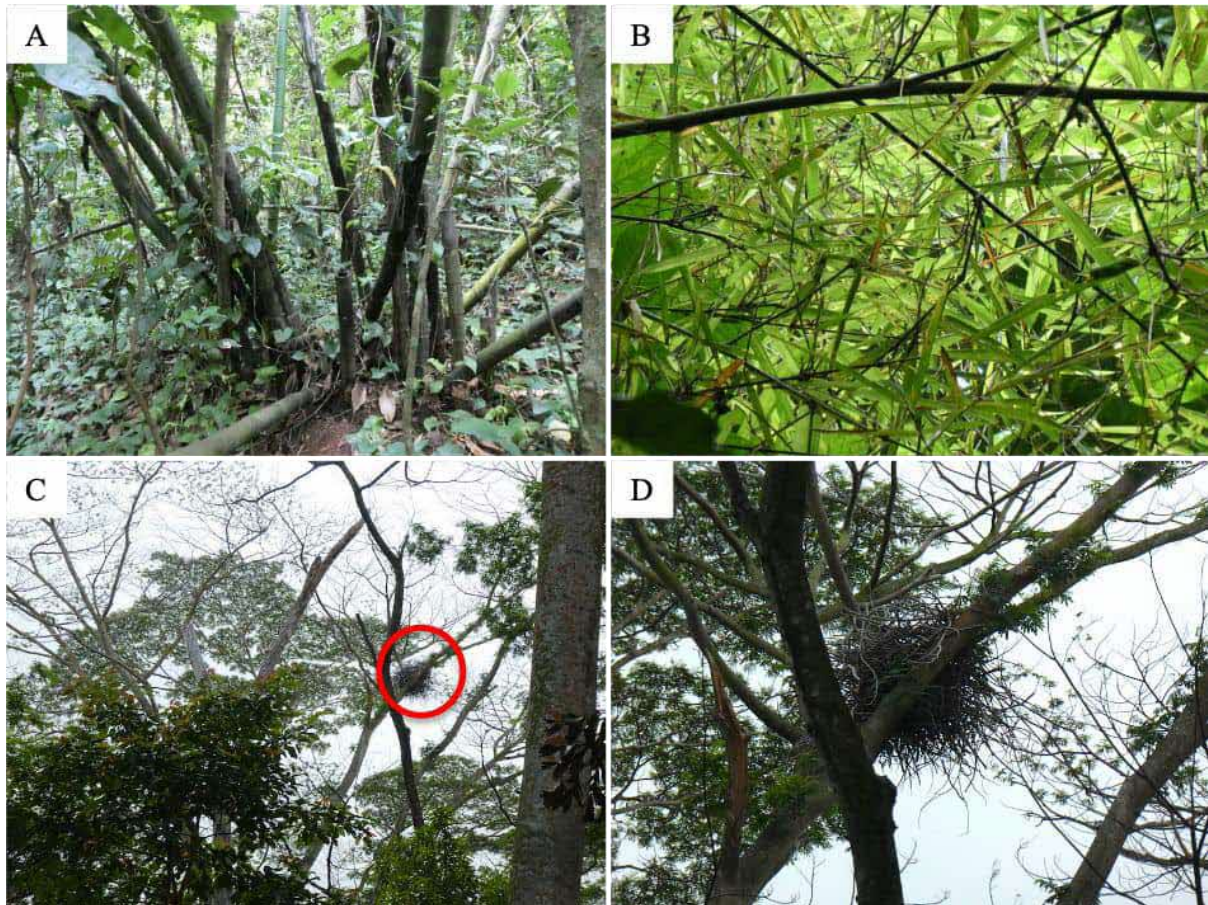


Figure 7-4 *Falcataria moluccana*. (A) A Standing Tree; (B, C) Trees that have Fallen Over Owing to the Storm-Vulnerable Nature of this Species That Causes the Trees to be Prone to Failing.

#### 7.2.4.3.3 Other Plant Specimens of Value

Locations of other specimens that do not meet the minimum size requirement detailed in Section 7.2.4.3.2 above but are of value, were also recorded using the GPS receiver. Examples of such specimens include bamboo clusters of < 3 m spread but may be important refugia for rare bamboo bats, amongst others, as well as exotic trees with raptor nests (Figure 7-5).





**Figure 7-5 Other Plant Specimens of Value. (A) Bamboo Cluster of < 3 m Spread; (B) A Close-up of the Bamboo Leaves; (C) Raptor Nest on a *Falcataria moluccana* Tree; (D) A Close-up of the Raptor Nest.**

#### 7.2.4.4 Arboricultural Surveys

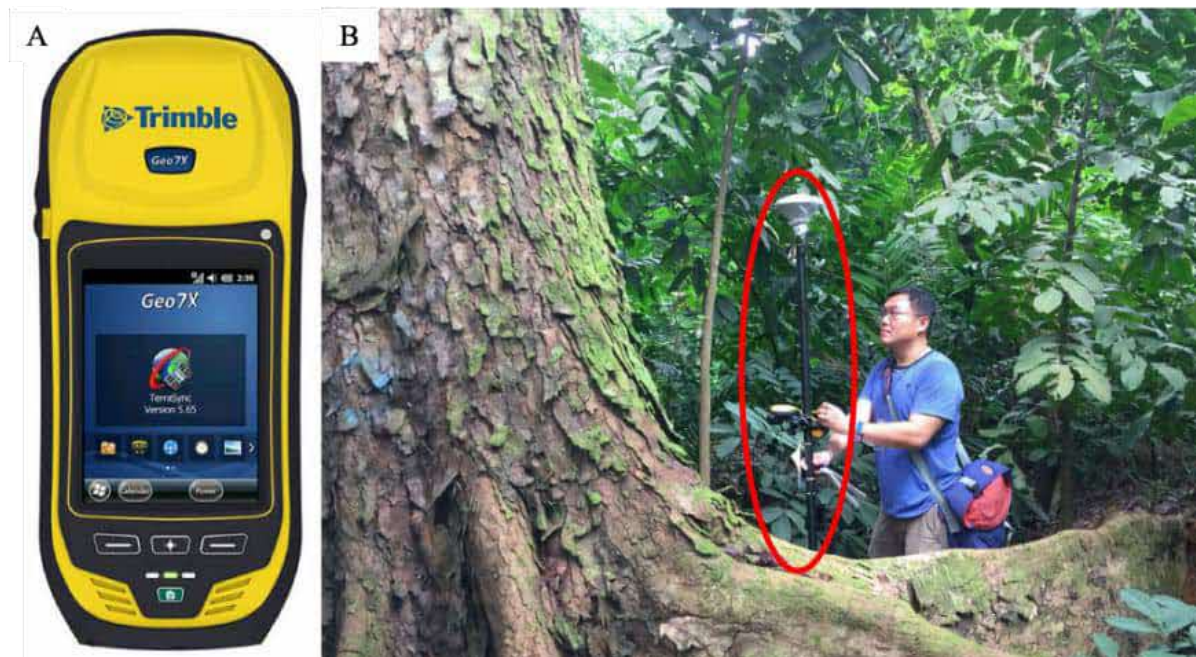
Plant health and structural stability were assessed for all trees, single-stemmed palms, and strangling *Ficus* species of  $\geq 1.0$  m girth or spread, respectively, as well as those of species of conservation significance of  $\geq 0.3$  m girth or spread in Eng Neo Avenue Forest and Windsor's Northern Forest Fragment. Single-stemmed palms were defined in this study as having one obvious and erect stem (Figure 7-6). The assessment was conducted using the Safe Useful Life Expectancy (SULE) method by certified arborists. Plant health and structural stability was assessed by observing for damages, decays, and/or canopy asymmetry, of which, if present, may compromise plant longevity and stability (Barrell, 1993).





**Figure 7-6 Single-Stemmed Palms, Defined in this Study as Having One Obvious and Erect Stem. (A–B) *Elaeis guineensis*; (C) *Caryota no.***

Specimens were tagged with a unique serial number. Geographic locations, girth/spread and height were also recorded. A Differential Global Positioning System (DGPS) receiver (Trimble® Geo 7X or CHC® Navigation HCE320 GNSS data controller with the CHC® Navigation i90 Pro GNSS receiver and Leica DISTO™ D810 touch rangefinder) (Figure 7-7; Figure 7-8) was used to record geographic locations of the specimens using the SVY21 plane coordinate system. Where there are clusters of specimens of the same species occurring within 1–2 m of each other, all the specimens within the cluster were assessed by certified arborists, but only one specimen was tagged with its location marked using the DGPS. The survey areas are shown in Figure 7-1.



**Figure 7-7 Trimble® Geo 7X. (A) Handheld Controller (source: [gpsforestry-suppliers.com](http://gpsforestry-suppliers.com)); (B) How it is Used in the Field**





**Figure 7-8 (A) CHC® Navigation HCE320 GNSS Data Controller (Source: Geo-matching.com); (B) How It is Used in the Field**

#### 7.2.4.5 Tree Mapping

Tree mapping was carried out in Sites I and II. This was done in a similar manner as arboricultural surveys; all plant specimens with the aforementioned criteria (Section 7.2.4.4) were tagged and mapped, except that they were not assessed for plant health and structural stability.

### 7.2.5 Faunistic Field Assessment

#### 7.2.5.1 Targeted Field Surveys

Targeted field surveys were carried out for the following taxa: aculeate hymenopterans (bees and stinging wasps, excluding ants), odonates (dragonflies and damselflies), butterflies, freshwater decapod crustaceans, freshwater fish, herpetofauna (amphibians and reptiles), birds, non-volant mammals and bats. These taxa were chosen because they are of general interest to the public, well-documented, generally easy to survey, have important ecological roles in the ecosystem and serve as ecological indicators. Amongst these groups, the aculeate hymenopterans are the least well-studied. Yet, as expertise was available, they were included in the study to provide a better representation of the site's faunal diversity.

All terrestrial fauna (except bats) were surveyed via visual and/or auditory encounter surveys along terrestrial sampling routes traversing major habitat types within all Study Areas. Four sampling routes measuring 8.6 km in total were identified within the Study Areas (Figure 7-9; Figure 7-10). At least two surveyors walked along the sampling routes at approximately 1 km/h to search for targeted fauna.

Aquatic fauna was sampled at each aquatic sampling point placed at 100–150-m intervals along each waterbody based on accessibility and availability of water (Figure 7-9; Figure 7-10). At Windsor, points were placed at locations where visual observations were possible from trails or boardwalk in the Windsor Nature Park, which are approximately 200 m apart. Five-minute point counts, tray netting, and minnow trapping were conducted at each sampling point.

Locations of all fauna sightings were recorded using a handheld GPS receiver (Garmin GPSMap® 64s). Each diurnal and/or nocturnal surveys were conducted twice for each taxon, including a reverse direction during the second session. For aculeate hymenopterans, surveys were conducted once along each sampling route at Eng Neo Avenue Forest and Windsor, and twice at Sites I and II. All fauna encountered were identified to species, or the next highest taxonomic level possible. Important observations were also noted down, such as reproductive



behaviour (e.g., displaying, guarding, mating, ovipositing), and plant species that butterflies and birds are observed to be feeding on, laying eggs or nesting on, and/or with caterpillars.

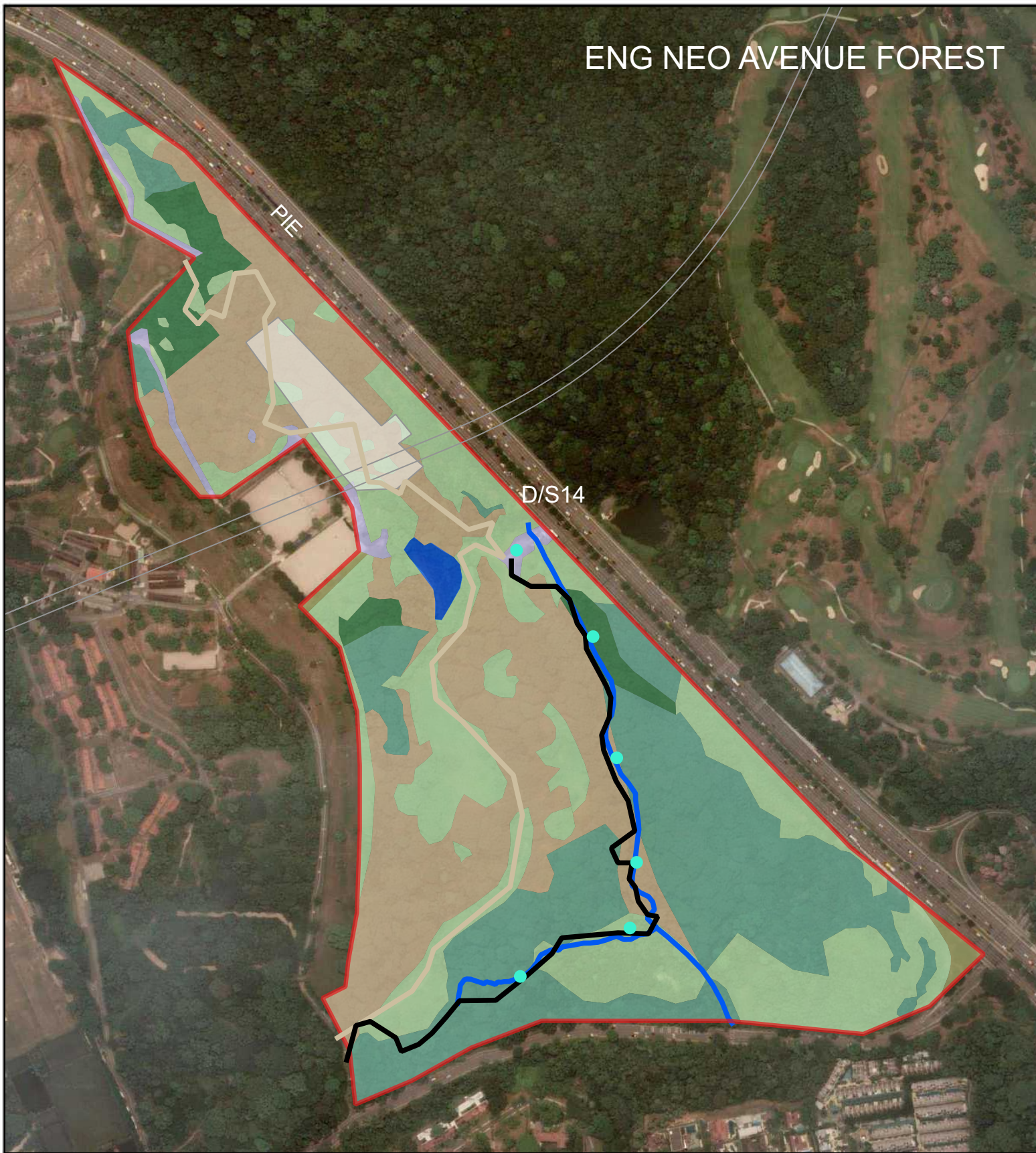
While bat trapping had been initially planned for and was conducted once at Eng Neo Avenue Forest, it was subsequently cancelled in light of the COVID-19 outbreak. Instead, roost emergence surveys for bamboo bats were conducted for bamboo clusters present within worksite areas (if any) to determine if there are potentially conservation significant bamboo bats residing in them. Butterfly trapping was only conducted in Eng Neo Avenue Forest, and subsequently not adopted as a method in the other Study Areas due to lack of results. In addition, camera trapping was conducted to complement the documentation of mammal composition within the Study Areas, illustrated in survey methods for non-volant methods below.

A summary of the survey methods for each faunal group is provided in Table 7-4 and further described in the following section.

**Table 7-4 Description of Sampling Locations at Each Study Area**

Site	Description	Length/No. of Sampling Points
<b>Eng Neo Avenue Forest [39.2 ha]</b>		
<b>T1 (western route)</b>	North of Study Area (including worksite) and along old gravel road	2.30 km
<b>T2 (eastern route)</b>	East of Study Area running adjacent to the stream	1.34 km
<b>D/S14 (main stream)</b>	Stream runs in the eastern part of the Study Area	1.00 km (6 aquatic sampling points)
<b>No. terrestrial camera traps</b>	Deployed on ground/base of tree	6
<b>Sites I and II [16.8 ha]</b>		
<b>T1</b>	Location of mitigated A1-W2 worksite, (both Sites I and II)	1.93 km
<b>D/S15</b>	Stream within Site I, running parallel to adjacent road (Fairways Drive)	0.36 km (2 aquatic sampling points)
<b>D/S16</b>	Naturalised canal within Site I, located within horse track	0.46 km (5 aquatic sampling points)
<b>No. terrestrial camera traps</b>	Deployed on ground/base of tree	5
<b>Windsor [29.7 ha]</b>		
<b>T1</b>	Squirrel & Drongo trail of Windsor Nature Park, Island Club Road and Northern Forest Fragment	3.06 km
<b>D/S26 (northern stream)</b>	Stream within the Northern Forest Fragment, running along Upper Thomson Road	0.31 km (3 aquatic sampling points)
<b>D/S27 (northern stream)</b>	Stream within the Northern Forest Fragment draining towards Island Club Road; likely connected to A1	0.15 km (2 aquatic sampling points)
<b>D/S13 (southern stream)</b>	Stream within Windsor Nature Park	0.68 km (5 aquatic sampling points)
<b>No. of arboreal camera traps</b>	Deployed on forest canopies	6
<b>No. terrestrial camera traps</b>	Deployed on ground/base of tree	8





<div><b>Legend</b></div> <div><div><div><div></div><div>Study Area</div></div></div><div><div><div>Vegetation</div><div><div><div>Native-dominated secondary forest</div><div>Abandoned-land forest</div><div>Waste woodland</div><div>Scrubland and herbaceous vegetation</div><div>Windsor Nature Park</div><div>Managed vegetation</div><div>Waterbody</div><div>Others (infrastructure)</div></div></div><div><div><div>Worksite and alignment (Base)</div><div>Boardwalk</div><div>Terrestrial sampling route 1</div><div>Terrestrial sampling route 2 (Eng Neo Avenue Forest only)</div><div>Roadkill transect along Island Club Road (Windsor only)</div><div>Aquatic sampling point</div></div></div></div><div><div><div></div><div>N</div></div></div></div></div>							<div>Qualified Person Endorsement : NA</div> <div>LTA Endorsement : NA</div>	<div>Consultant : <div>AECOM</div></div>			<div><div><div>Land Transport Authority</div><div>We Keep Your World Moving</div></div></div>			
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**Legend**

Study Area

Worksites, access roads and alignment (Mitigated)

Vegetation

Native-dominated secondary forest

Mixed forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route

Aquatic sampling point

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG
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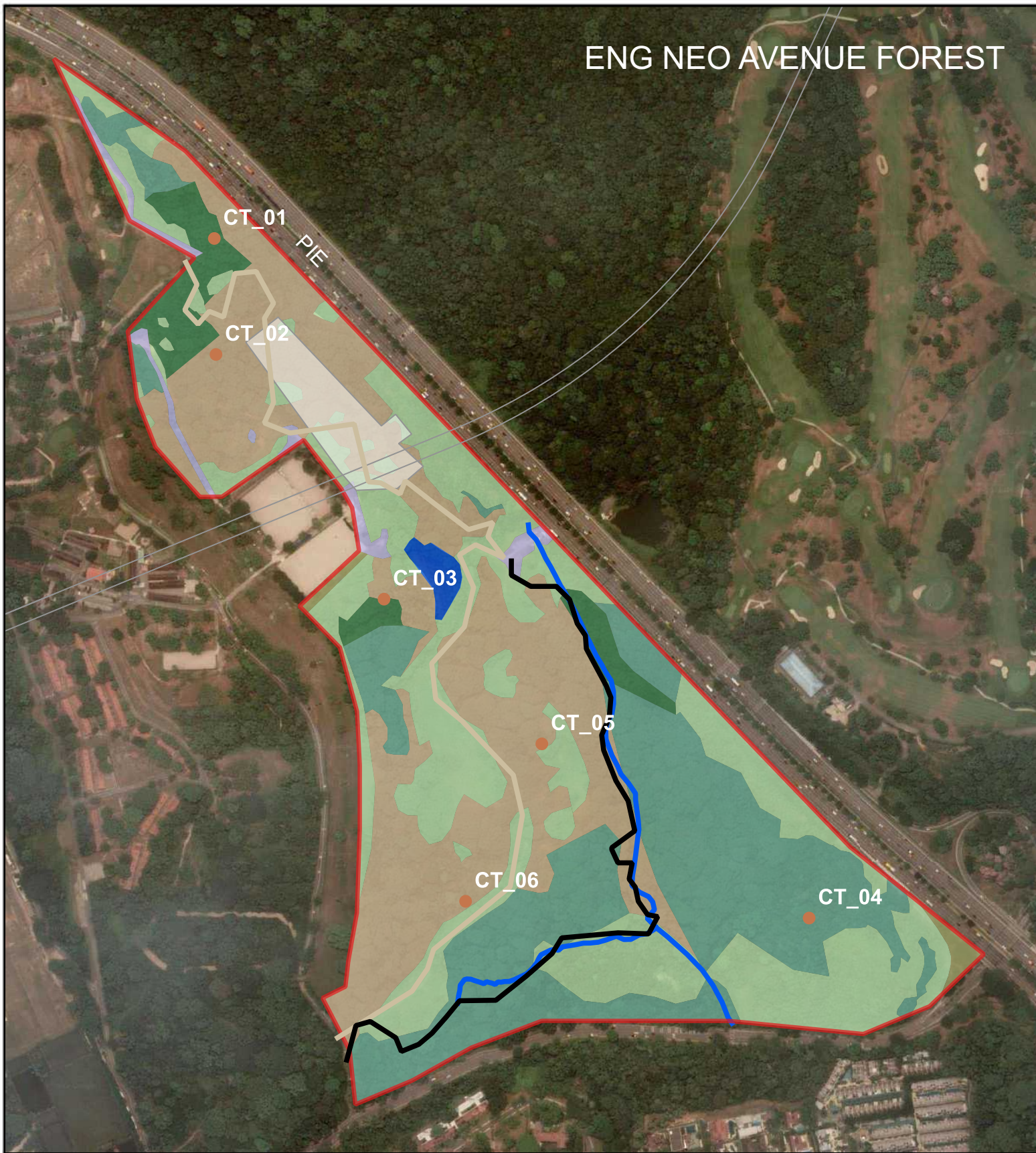
Figure Title :  
**TERRESTRIAL SAMPLING ROUTES  
AND AQUATIC SAMPLING POINTS AT  
FORESTED AREA ADJACENT TO  
FAIRWAYS QUARTERS**

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**Legend**

Study Area

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Windsor Nature Park

Managed vegetation

Waterbody

Others (infrastructure)

Worksite and alignment (Base)

Boardwalk

Terrestrial sampling route 1

Terrestrial sampling route 2 (Eng Neo Avenue Forest only)

Roadkill transect along Island Club Road (Windsor only)

Arboreal camera trap

Terrestrial camera trap

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ENVIRONMENTAL IMPACT STUDY  
(WINDSOR AND  
ENG NEO AVENUE FOREST)**

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Figure Title :  
**LOCATIONS OF ARBOREAL AND  
TERRESTRIAL CAMERA TRAPS AT  
ENG NEO AVENUE FOREST AND WINDSOR**

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**Legend**

- Study Area
- Worksites, access roads and alignment (Mitigated)
- Vegetation
  - Native-dominated secondary forest
  - Mixed forest
  - Abandoned-land forest
  - Scrubland and herbaceous vegetation
  - Managed vegetation
  - Waterbody
  - Others (infrastructure)
- Terrestrial sampling route
- Camera trap

N

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LTA Endorsement :  
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(WINDSOR AND  
ENG NEO AVENUE FOREST)**

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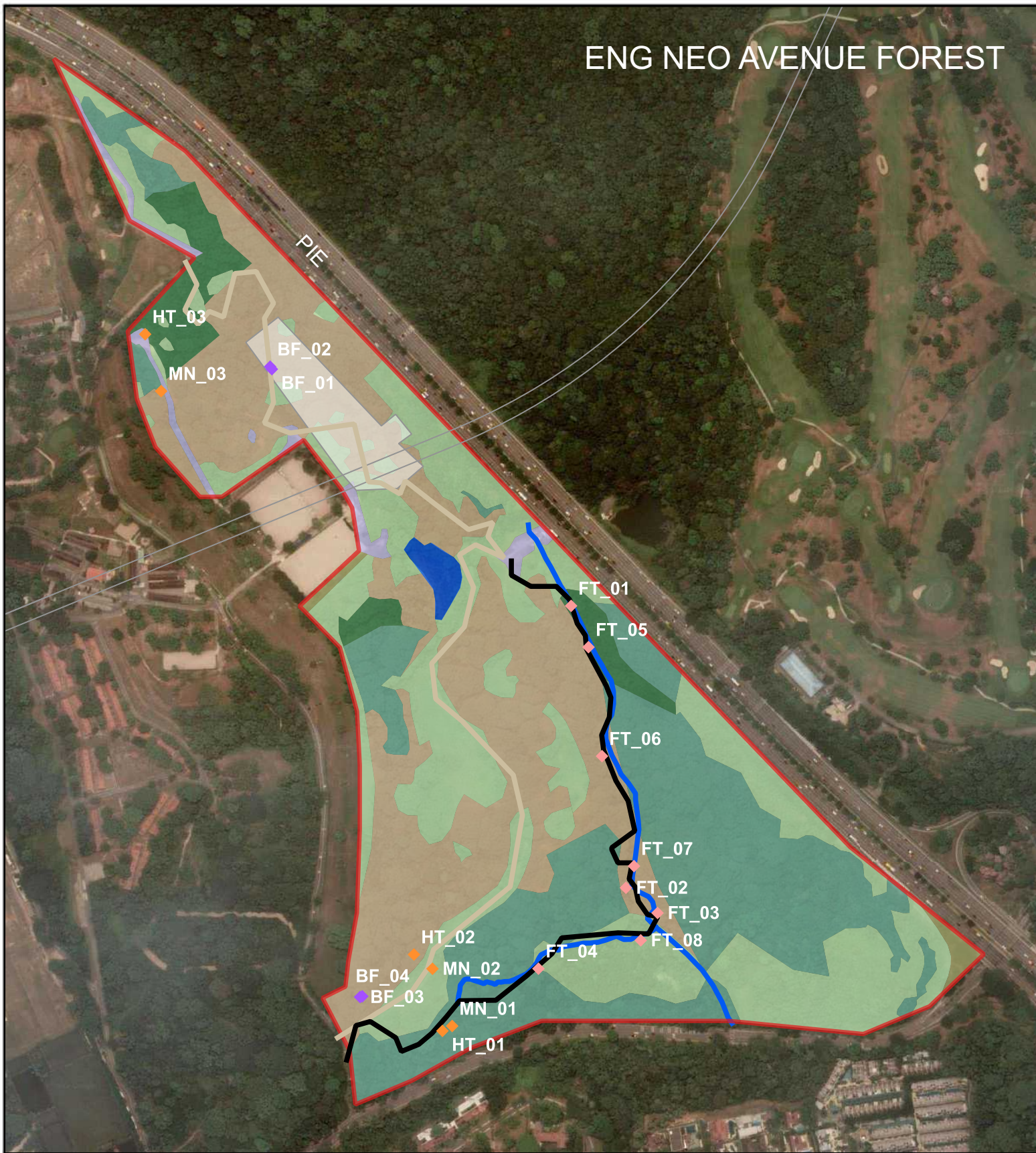
Figure Title :  
**LOCATIONS OF TERRESTRIAL CAMERA  
TRAPS AT FORESTED AREA ADJACENT  
TO FAIRWAYS QUARTERS**

Figure No. : 7 - 12	Rev. -	Sheet 1 of 1
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<b>Legend</b> <div><div><div>Study Area</div></div><div><div>Vegetation</div><div><div>Native-dominated secondary forest</div><div>Abandoned-land forest</div><div>Waste woodland</div><div>Scrubland and herbaceous vegetation</div><div>Windsor Nature Park</div><div>Managed vegetation</div><div>Waterbody</div><div>Others (infrastructure)</div></div><div><div>Worksite and alignment (Base)</div><div>Boardwalk</div><div>Terrestrial sampling route 1</div><div>Terrestrial sampling route 2 (Eng Neo Avenue Forest only)</div><div>Roadkill transect along Island Club Road (Windsor only)</div><div>Butterfly trap</div><div>Fish trap</div><div>Bat trap</div></div></div><div><div><div>N</div></div></div></div>							Qualified Person Endorsement : NA	Consultant : <div><div>AECOM</div></div>	Land Transport Authority We Keep Your World Moving								
													Project Title :  CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (WINDSOR AND ENG NEO AVENUE FOREST)	Figure Title :  LOCATIONS OF BUTTERFLY, FISH AND BAT TRAPS AT ENG NEO AVENUE FOREST AND WINDSOR			
										LTA Endorsement : NA							





**Legend**

Study Area

Worksites, access roads and alignment (Mitigated)

Vegetation

Native-dominated secondary forest

Mixed forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route

Fish trap

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
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NA

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Figure Title :  
**LOCATIONS OF FISH TRAPS  
AT FORESTED AREA ADJACENT  
TO FAIRWAYS QUARTERS**

Figure No. : 7 - 14	Rev. -	Sheet 1 of 1
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CAD File Name : NA

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Table 7-5 Summary of Survey Methods for Each Faunal Group

Faunal Group	Survey Timing (h)	Description
<b>Aculeate Hymenopterans</b>	0900–1600	Diurnal visual encounter surveys along four terrestrial sampling routes.
<b>Odonates</b>	0900– 1600	Diurnal visual encounter surveys along seven terrestrial sampling routes and diurnal point counts at 23 aquatic sampling points.
<b>Butterflies</b>	0900–1600	Diurnal visual encounter surveys along seven terrestrial sampling routes.
<b>Freshwater Decapod Crustaceans And Fish</b>	0900–1600, 2000–0000	Diurnal point count surveys with tray-netting at 23 aquatic sampling points Nocturnal point count surveys with spot-lighting at 23 aquatic sampling points Minnow trapping at 11 strategic locations along waterbodies (for fish)
<b>Herpetofauna (Amphibians And Reptiles)</b>	0700–1600, 2000–0000	Diurnal and nocturnal visual and auditory encounter surveys along seven terrestrial sampling routes Diurnal and nocturnal point count surveys at 23 aquatic sampling points
<b>Birds</b>	0700–1000, 2000–0000	Diurnal and nocturnal visual and auditory encounter surveys along seven terrestrial sampling routes
<b>Non-Volant Mammals</b>	0700–1000, 2000–0000	Diurnal and nocturnal visual and auditory encounter surveys along seven terrestrial sampling routes 19 terrestrial camera traps and 6 arboreal camera traps deployed across the Study Areas
<b>Bats</b>	1830–0000, 2000–0900 (overnight for harp traps only)	Live-trapping using ground mist nets and ground harp traps + acoustic recording once at Eng Neo Avenue Forest (live trapping at the other Study Areas were cancelled in light of the Covid-19 outbreak) Visual roost emergence surveys conducted between 1830 h and 2100 h for 15 bamboo clusters within 20 m of worksites

**Aculeate hymenopterans (bees and stinging wasps, excluding ants)** – Adult bees and stinging wasps, nests, and food plants were visually surveyed along the terrestrial survey route. Surveys were conducted between 0900h and 1600h. Bees and wasps were identified by sight or photography whenever possible. Otherwise, they were captured using handheld insect nets. Individuals were released immediately after identification. When identification in the field was not possible, live specimens were collected and examined *post-hoc* under microscope. The specimens were identified to the lowest taxonomic level possible using relevant references, identification keys, or in consultation with taxonomic experts.

**Odonates (dragonflies and damselflies)** – Visual encounter surveys were conducted along terrestrial sampling route and five-minute point counts were conducted at each aquatic sampling point between 0900h and 1600h. Owing to the difficulties in sampling and identification, aquatic larvae and exuviae were not surveyed. Adults were identified by sight (with the aid of binoculars where necessary) in flight or while perched. Specimens were also photographed or caught with insect nets if required for species identification. Individuals collected were released immediately after they have been identified.

**Butterflies** – Visual encounter surveys were carried out for adult butterflies, caterpillars, pupae, eggs, and host plants along terrestrial sampling routes from 0900h to 1600h. Butterflies were identified by sight (with the aid of binoculars where necessary), photographed, or captured using insect nets. In addition, focused trap-sampling was conducted to target rarer fruit-feeding nymphalid butterflies that are attracted to rotten fruits and decaying matter. The trapping design and method reference a standard butterfly trapping protocol for rapid assessments (Larsen, 2016). Butterfly traps were deployed at two locations along the terrestrial sampling routes at each Study Area, based on presence of palms or habitats deemed favourable for nymphalids. At each location, one pair of butterfly traps were deployed 2 m apart in the understorey at approximately 1.5 m above ground. One trap contained fermented banana bait while the other rotten prawn or sambal bait (Figure 7-16A). The traps were deployed for



one day and then retrieved the following day. Captured individuals in the insect nets and traps were released immediately after identification.

**Freshwater decapod crustaceans and fish** – Surveys comprised diurnal (0900h–1600h) and nocturnal (2000h–0000h) five-minute visual point counts at aquatic sampling points, tray netting and minnow trapping. Point counts involved tray netting using a rigid-frame push net (61 × 49 cm; 5 mm mesh) to capture species within the water column or on the streambed. However, where tray-netting was deemed unsuitable because of low water levels, visual surveys were conducted instead. In addition, minnow traps were baited with halal meat (e.g., sausage or liver) (Figure 7-15A) and systematically deployed at locations with deeper water (Figure 7-15). A total of 11 traps were deployed – eight at Eng Neo Avenue Forest and three at Sites I and II. Traps were left overnight, then checked and removed the following morning. Nocturnal point counts involved spot-lighting for nocturnal species, especially the walking catfishes (*Clarias* spp.). However, only visual diurnal and nocturnal point counts were conducted at selected locations along boardwalks and trails at Windsor, in compliance with NParks' regulation. Tray netting and minnow trapping were not conducted.



Figure 7-15 Examples of (A) Tray Netting and (B) Minnow Trap

**Herpetofauna (amphibians and reptiles)** – Diurnal (0700h–1600h) and nocturnal (2000h–0000h) surveys were performed along both terrestrial sampling routes and at aquatic sampling points. As herpetofauna occupy a wide range of habitat types, both surveys involved searching for individuals on the ground, below rocks, logs, leaf litter and debris, in the water, and on vegetation. For nocturnal spotlighting surveys, torches were used to elicit eyeshine. For species that are capable of quick retreats and escapes, the individuals were captured by hand, or using hooks, tongs, or dip nets for identification. Vocalising geckos and frogs were also located or identified by call recognition, whenever possible.

**Birds** – Surveys comprised diurnal (0700h–1000h) and nocturnal (2000h–0000h) visual encounter surveys performed along terrestrial sampling routes. All birds were identified by sight (with the aid of binoculars and cameras where necessary) and/or through call recognition. Nocturnal birds (e.g., owls and nightjars) were detected using torches to elicit eyeshine and through call recognition. All surveys were conducted within the bird migratory season (Sep–Mar), except for nocturnal surveys within Windsor Nature Park as survey permits were only obtained after.

**Mammals** – Surveys comprised diurnal (0700h–1000h) and nocturnal (2000h–0000h) visual encounter surveys performed along terrestrial sampling routes. Mammals were surveyed on the ground and on vegetation, and in burrows and tree holes. In addition, tracks and scats were also recorded as they can aid in species identification. All mammals were identified by sight (with the aid of binoculars and cameras where necessary). Squirrels were also identified through call recognition. Nocturnal mammals were detected using torches to elicit eye shine, which aids in detection at night.

A total of 19 terrestrial camera traps were deployed – six at Eng Neo Avenue Forest, five at Sites I and II collectively, and eight at Windsor (Figure 7-12). The camera traps were distributed equally across the Study Areas, with approximately one camera trap per 4 ha. Each terrestrial camera trap was kept at least 20 m away from terrestrial sampling routes, where possible, to maximise coverage of areas not visible from terrestrial sampling routes. Six arboreal camera traps were also deployed at Windsor due to the presence of rare arboreal mammals expected to occur, unlikely for the rest of the Study Areas. Among the six arboreal camera traps, four were deployed near



canopy connections along Island Club Road to determine possible usage of the canopy connections, while two were deployed within the forest.

Each terrestrial camera trap was deployed at approximately 20–30 cm above ground. They operated 24 h a day and were programmed to record 10-s footage per motion trigger with a 10-s quiet period following each trigger. Each camera trap was deployed for at least 60 nights per location. The camera trap model used is Browning Dark Ops HDB Pro X BTC-6HDPX (Figure 7-16B).



Figure 7-16 A Setup of (A) Butterfly Trap And (B) Camera Trap



Figure 7-17 Canopy Connections along Island Club Road – (A) Lamp Post 17–18 and (B) at the Western End after SICC Guardhouse

**Bats** – A handheld acoustic detector, the Echo Meter Touch 2 Pro (Wildlife Acoustics, Inc.), connected to a mobile device, was used during nocturnal surveys along terrestrial sampling routes to detect insectivorous bats. Insectivorous bats produce ultrasonic echolocation calls that are unique to each species and can be used to identify bats (Fenton and Bell, 1981). The detector converts the ultrasonic calls to low frequency signals below 20 kilohertz



(kHz), a range that is audible to the human ear, which are then streamed on a spectrogram of the Echo Meter Touch app. All bat calls are automatically recorded on the device.

Owing to the difficulty in finding roost sites and the inability to visually identify bats to the species-level in flight, bats were sampled using live-trapping and acoustic detection. However, in light of the COVID-19 outbreak, bat trapping was only conducted once for Eng Neo Avenue Forest, where three harp traps and three mist nets were deployed in each site (Figure 7-13). Live trapping involved the use of mist nets and harp traps. Mist nets target the larger-sized fruit/nectar bats (Megachiroptera), while harp traps target the smaller insectivorous bats (Microchiroptera). At least two ground mist nets and two ground harp traps were deployed for each trapping session. Typically, each ground mist net and harp trap were placed near each other. Traps were set up between 1730h–1930h and trapping lasted from 1930h–2100h, during which traps were repeatedly checked. Mist nets were disassembled by 2100h, while harp traps were left overnight and checked the following morning between 0800h and 0900h and removed. Bats collected in the traps were identified and released immediately.

Roost emergence surveys were conducted at bamboos within 20 m from the worksites to determine the possible residency of bamboo bats. The surveys occurred between 1830h–2100h, during which two to three personnel were stationed around each bamboo to observe for bats flying out from or towards the bamboo, and identify slits that are at least 1-cm wide and 1-cm long. Active slits and the number of individuals residing within each slit were recorded. An acoustic detector was also used to obtain acoustic recordings.



**Figure 7-18 A Setup of (A) Mist Net and (B) Harp Trap during Bat Trapping**

## 7.2.6 Data Analyses

### 7.2.6.1 Flora

#### 7.2.6.1.1 Species Accumulation Curves

All statistical analyses for this study were carried out in the statistical programming environment R version 3.4.3 (R Development Core Team, 2016). Community data analyses were conducted using the “vegan” package 2.5-6 (Oksanen et al., 2019) and “iNEXT” package 2.0.20 (Hsieh et al., 2019).

Species accumulation curves (SAC) were plotted using data on floristic diversity from the vegetation plots at Eng Neo Avenue Forest and Windsor’s Northern Forest Fragment. Species richness was plotted against sample coverage, as opposed to survey effort, to estimate sample completeness/ survey adequacy, i.e., how extensively we have sampled the species in the community. According to Chao and Jost (2012), sample coverage refers to “the proportion of the total number of individuals in a community that belong to the species represented in the sample.” The curve was extrapolated to provide an estimation of species richness and sample coverage if sample size was doubled. The associated standard error and 95% confidence interval was also computed. Standard error represents the range of uncertainty of the estimate, while 95% confidence interval is the interval in which there is a 0.95 probability of containing the estimated true species richness.

As some species will always remain undetected after sampling all the vegetation plots, total species richness had to be estimated via extrapolation. This was done using the Chao estimator.



### 7.2.6.1.2 Forest Regeneration

The trees were broadly categorised into two main girth-size classes:  $\geq 0.5$  m and  $< 0.5$  m. They were first ranked by abundance and examined to see which species made up the larger and smaller trees, respectively. The ten most abundant species present in the vegetation plots were then ranked according to their size-class distribution and examined.

Forest regeneration analyses were carried out for Eng Neo Avenue Forest and Windsor only as vegetation plot sampling were conducted for these Study Areas.

### 7.2.6.2 Fauna

#### 7.2.6.2.1 Acoustic Bat Recordings

Bat recordings were processed using Kaleidoscope v.4.5.4 (Wildlife Acoustics, Inc.) to separate extraneous noise from files with bat echolocation calls. The signal parameters for recognising a potential bat echolocation call were configured as follows: frequency range of 20–200 kilohertz (kHz), duration of 2–500 millisecond (ms), maximum inter-syllable gap of 500 ms and a minimum of 2 pulses. These files were then visually processed to identify bat species based on call structures, peak frequency, minimum frequency and call duration Pottie et al. (2005). They were identified with reference to those in Pottie et al. (2005), which provides echolocation signatures for bats in Singapore, and other relevant references (Collen, 2012; Hughes et al., 2011).

#### 7.2.6.2.2 Camera Trapping

Camera trap location, species identity, and the number of individuals were recorded for each video with a positive capture of faunal species (i.e., with a faunal species recorded on the video). An independent detection constitutes video(s) of one or a group of individuals of the same faunal species occurring within 60 minutes at each camera trap. The number of independent detections were used to calculate detection rate of all mammalian species.

#### 7.2.6.2.3 Species Accumulation Curves

Species accumulation curves (SAC) were plotted for each faunal taxon using data collected along terrestrial sampling routes, aquatic sampling points, and camera traps. The observed sample of incidence data was used to compute estimated coverage and species richness. Similar to that for plants, the associated standard error and 95% confidence interval were computed. The estimated species richness and sample coverage with doubled of sample size were also computed.

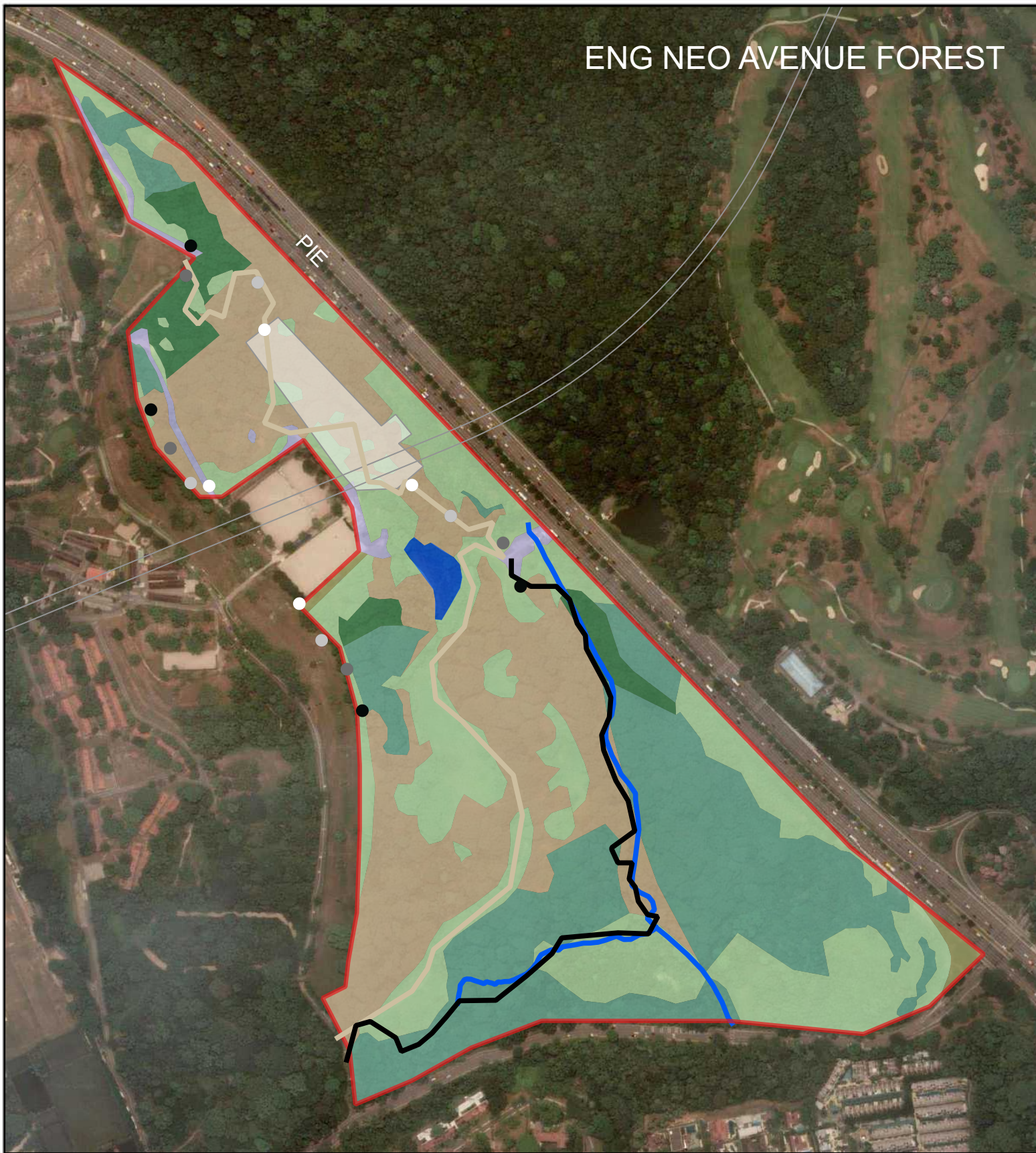
### 7.2.7 Light, Temperature, and Humidity Sampling

Light, temperature and humidity (LTH) was measured at 0 m (i.e. edge of worksite), 50 m, 100 m and 150 m in four cardinal directions from each worksite, where possible (Figure 7-19). This information may be used during construction or operational phases to inform mitigation measures. These points were generated using QGIS. Points were that lie within non-forested environment were removed. Measurements were done in the day (0800h–1100h) and night (2000h–0000h), and replicated. This is with the exception of at Windsor, where nocturnal measurements were not taken at two locations that were off-trail to avoid disturbances to nocturnal fauna. A handheld Sper Scientific Mini Environmental Quality Meter (850070) was used. The LTH was measured for Eng Neo Avenue Forest and Windsor only under the CR2005 and no other secondary data from parallel studies were available for these aspects.

**Table 7-6 Number of LTH Sampling Points at Each Interval for Each Worksite**

Site (Worksite)	No. of 0-m Interval Sampling Points	No. of 50-m Interval Sampling Points	No. of 100-m Interval Sampling Points	No. of 150-m Interval Sampling Points
Eng Neo Avenue Forest (A1-W2)	0	1	1	1
Windsor (A1-W1)	3	3	1	3





**Legend**

Study Area

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Windsor Nature Park

Managed vegetation

Waterbody

Others (infrastructure)

Worksite and alignment (Base)

Boardwalk

Terrestrial sampling route 1

Terrestrial sampling route 2 (Eng Neo Avenue Forest only)

Roadkill transect along Island Club Road (Windsor only)

LTH point (m interval)

○ 0

● 100

● 50

● 150

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**LOCATIONS OF LIGHT, TEMPERATURE  
AND HUMIDITY SAMPLING AT  
ENG NEO AVENUE FOREST AND WINDSOR**

<div>Figure No. : 7 - 19</div>	<div>Rev. -</div>	<div>Sheet 1 of 1</div>
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## 7.3 Baseline Findings

### 7.3.1 Local Geographical Context

All three Study Areas are situated in proximity to the CCNR and BTNR, two important biodiversity hotspots in Singapore. Not only are they important habitats for flora and fauna, the forested areas are also potentially valuable green corridors in the fragmented landscape of Singapore. The ecological connectivity of the areas to other forest fragments is discussed in Section 4.6. Findings from surveys of flora and fauna highlight the importance of the areas as extended habitats where plants and animals disperse and forage, respectively.

### 7.3.2 Eng Neo Avenue Forest

#### 7.3.2.1 Light, Temperature and Humidity

The light levels ranged between 172.5 to >20000 lux in the day. Locations located in open areas (e.g., LTH\_03, LTH\_04 and LTH\_1002) had higher light levels above 1000 lux. Locations located within the forest/under canopy had lower light levels below 1000 lux. Across the day and night sessions, the humidity ranged between 71.2 to 85.5 rH and the temperature ranged between 28.6 to 34.6°C, with no observable trends within distance to forest edge. The findings are summarised in Table 7-7.

**Table 7-7 Light, Temperature and Humidity Levels at Eng Neo Avenue Forest**

Sampling Point	Light (lux)		Humidity (rH)		Temperature (°C)	
	AM	PM	AM	PM	AM	PM
LTH_01	477.8	0.0	82.6	83.1	31.4	29.0
LTH_02	1131.0	0.0	77.0	81.1	32.4	29.4
LTH_03	1769.8	0.0	73.8	81.5	31.7	28.6
LTH_04	5662.5	0.0	76.3	81.6	29.9	28.8
LTH_501	959.3	0.0	79.7	82.3	32.2	29.5
LTH_502	172.5	0.0	81.7	78.2	31.7	29.4
LTH_503	3445.0	0.0	72.1	81.2	31.5	28.9
LTH_504	>20000	0.0	75.7	83.1	31.5	28.7
LTH_1001	1171.3	0.0	82.8	85.4	31.4	29.0
LTH_1002	>20000	0.0	72.7	80.0	33.2	29.4
LTH_1003	2297.5	0.0	73.8	80.8	31.7	28.8
LTH_1004	5760.0	0.0	73.7	80.2	31.8	28.9
LTH_1501	4067.5	0.0	73.5	82.8	32.4	29.2
LTH_1502	>20000	0.0	71.2	85.5	34.6	29.8
LTH_1503	5638.0	0.0	76.0	82.8	34.5	29.1
LTH_1504	3120.0	0.0	72.9	82.2	32.3	29.3



### 7.3.2.2 Habitat and Vegetation Types

Eng Neo Avenue Forest consists of five vegetation types (Table 7-8). The three dominant vegetation types comprise waste woodland (13.1 ha; 33.4%), scrubland and herbaceous vegetation (12.2 ha; 31.1%), and abandoned-land forest (10.8 ha; 27.6%). A few small patches of native-dominated secondary forest add up to a total of 1.8 ha (4.6%). About 1.3 ha (3.3%) of the Study Area has been cleared of vegetation and/or planted up.

Total species richness in the abandoned-land forest plot is the highest among all four vegetation types. This is followed by, native-dominated secondary forest, scrubland and herbaceous vegetation, and waste woodland in descending order. Even though the absolute species count of the native-dominated secondary forest is less than that of the abandoned-land forest, majority of the species in the former are native (43 out of 55; 78.2%), compared to 49 out of 84 (57.1%) in the latter.

**Table 7-8 Absolute (ha) and Relative (%) Sizes, Number of Vegetation Plots, and Species Richness of Each Vegetation Type in Eng Neo Avenue Forest**

	ha	%	Plots	Species Richness Per Vegetation Type		
				Total*	Native	Exotic And Cryptogenic
<b>Native-Dominated Secondary Forest</b>	1.8	4.6	1	<b>55</b>	43	12
<b>Abandoned-Land Forest</b>	10.8	27.6	3	<b>84</b>	49	35
<b>Waste Woodland</b>	13.1	33.4	1	<b>29</b>	18	11
<b>Scrubland And Herbaceous Vegetation</b>	12.2	31.1	3	<b>50</b>	25	25
<b>Managed Vegetation</b>	0.3	0.8	N.A.	–	–	–
<b>Waterbody</b>	0.3	0.8				
<b>Cleared Area</b>	0.7	1.8	N.A.	–	–	–
<b>Total Spontaneous Vegetation</b>	<b>37.9</b>	<b>96.7</b>	<b>8</b>	–	–	–
<b>Total Area</b>	<b>39.2</b>	<b>100.0</b>	–	–	–	–

Note: \*refers to the total number of species recorded across all plots in each vegetation type





Study Area

Worksite and alignment (Base)

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Vegetation plot

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
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LOCATIONS OF VEGETATION PLOTS IN  
ENG NEO AVENUE FOREST**

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### 7.3.2.2.1 *Native-dominated Secondary Forest*

There are three patches of native-dominated secondary forest in Eng Neo Avenue Forest. Altogether, they occupy 1.8 ha (4.6%) of the Study Area.

There are a few features unique to this forest in Eng Neo Avenue Forest. Firstly, its floristic assemblage is largely comprised of common and rare native species. Many species found in these areas in Eng Neo Avenue Forest can also be found in the CCNR (Wong et al., 1994) and are less commonly encountered in other secondary forests in Singapore. Interestingly, some species associated with older forests and are rare even in the NSSF, such as the nationally Critically Endangered *Prunus arborea* var. *stipulacea* (Figure 7-29B), are also recorded in the Study Area. This has contributed to the high overall native species richness at the site, a feature characteristic of late-successional forests in Singapore (Yee et al., 2016). The complete flora inventory is in Appendix C1.

Secondly, native specimens are widespread and occur in high numbers in the area. For example, *Piper flavimarginatum*, a nationally Critically Endangered climber species, was found throughout the forested area. Most of them are concentrated in the northern-most native-dominated forest patch. A second example that highlights this feature unique to the forest type is a population of *Calophyllum tetrapterum* specimens found in high numbers, also mostly in the northern-most native-dominated forest patch. The specimens include several seedlings (Figure 7-21D), saplings, and trees. The trees are between 0.3–0.7 m girth range and 70% of those assessed during arboricultural surveys have good health with no visible structural defects (Appendix G1). This species is not known to be cultivated locally nor sold in commercial markets. Hence, the specimens belong to the native genetic stock. The presence of seedlings and trees in such high numbers suggests that the population is reproducing and self-replacing.

Thirdly, large parent trees are present in the area. Four large *Cyrtophyllum fragrans* trees with girths exceeding 3 m were also all found in the northern-most native dominated secondary forest patch (Figure 7-21A; Appendix E3). Although trees of this species are planted locally, it is unlikely that the large trees in the Study Area are cultivated propagules; this common native tree species is known to be slow-growing. For the specimens to attain their present size, it is almost certain that they have been at the site for a long time before which this species was neither sold in commercial markets nor planted locally. A large *Archidendron jiringa* tree of 2.4 m girth was also found in the native-dominated forest patch south of the horse training stable (Figure 7-21B). Seedlings and saplings of this species growing in the understorey near the large tree were also in very high concentration (Figure 7-21C). As this species is known to be widely cultivated in Singapore, many propagules present in the secondary forest are suspected to have spread from cultivation. However, the presence of a large tree in the Study Area suggests a likelihood that young specimens could belong to the native genetic stock. In this study, a conservative approach was adopted; specimens of this species were included as those of conservation significance (Appendix D1).

Lastly, many native species listed as nationally Common were also widespread within the patches. This includes *Prunus polystachyus*, *Morella esculenta*, *Aporosa frutescens*, *Gironiera nervosa*, and *Elaeocarpus mastersii*, amongst others. Some of them belong to late-successional secondary forest (Yee et al., 2016). Such widespread distribution of these species is relatively uncommon in the secondary forests of Singapore. Upon examination of historical maps and the land use history of Eng Neo Avenue Forest, it appears that a portion of the Study Area was previously part of the Central Catchment (Section 4.4.1). Unfortunately, the construction of the PIE separated the north of present-day Eng Neo Avenue Forest from most of the nature reserve. The area that was separated, nonetheless, continues to host a diversity of rare species, and is termed “northern-most native-dominated forest patch” here.





Figure 7-21 (A) A Large *Cyrtophyllum fragrans* Tree of more than 3.0 m Girth; (B) A Large *Archidendron jiringa* Parent Tree of 2.4 m Girth with V-Shaped Bifurcation; (C) Seedlings and Saplings of *Archidendron jiringa* in the Forest Understorey near The Parent Tree; (D) *Calophyllum tetrapterum* Seedlings; (E) *Piper flavimarginatum* Growing on the Forest Floor; (F) *Oncosperma tigilarium* Palm Cluster Showing the Long Black Spines; (G) *Horsfieldia polyspherula* Seedling

#### 7.3.2.2.2 Abandoned-land Forest

Abandoned-land forest takes up the third largest area of 10.8 ha, which is 27.6% of the Study Area. The abandoned-land forest of Eng Neo Avenue Forest is dominated by fruit trees such as chempedak *Artocarpus integer* and rambutan *Nephelium lappaceum* (Figure 7-22). Occasionally, some areas were found to be dominated by ornamental plants such as *Heliconia* sp. and *Dieffenbachia seguine*.





**Figure 7-22 Abandoned-Land Forest in Eng Neo Avenue Forest. (A) Chempedak *Artocarpus integer* (Red Arrow), One of the Fruit Crop Species Commonly Found in this Forest Type; (B) A Generic Shot of this Forest Type with Rambutan *Nephelium lappaceum* Saplings (Red Circle) in the Understorey**

### 7.3.2.2.3 Waste Woodland

Waste woodland occupies the largest area in Eng Neo Avenue Forest, taking up to 33.4% (13.1 ha) of the total area. This forest type is fairly common in Singapore where sites had been cleared or highly disturbed. Typically, these areas are occupied by a few fast-growing exotic tree species capable of establishing themselves in such environments, forming closed canopies over scrubland and herbaceous vegetation (Yee et al., 2016). Depending on the conditions and quality of underlying substrates, succession can occur in patches. This can be observed in the vegetation distribution pattern of the Study Area, where waste woodland generally does not form a single continuous forested patch, but is interspersed with other vegetation types, especially scrubland (Figure 7-20).

The dominant tree species established in Eng Neo Avenue Forest is the naturalised *Falcataria moluccana*, a common wayside tree in the past (Figure 7-23B; Wee & Corlett, 1986). *Cecropia pachystachya* has also been observed in the waste woodland, but in relatively smaller numbers than *Falcataria moluccana* (Figure 7-23A). Some areas within the waste woodland have been cleared, presumably to make pathways for horses moving around the training stables (Figure 7-23C–D). During floristic surveys between March and April 2020, it was also observed that several *Falcataria moluccana* trees were being felled by workers. The felling activities are likely to be carried out by private Contractors and are exclusively for albizia trees only (LTA, Pers. comms.). While it not known how extensive the felling activities are, it is likely that the estimated size of waste woodland in Eng Neo Avenue Forest, as shown in Figure 7-20, will reduce.





Figure 7-23 Waste Woodland in Eng Neo Avenue Forest with (A) *Cecropia pachystachya* Trees (Red Arrow) and (B) *Falcataria moluccana* Trees Forming Canopies over Areas Dominated by Herbaceous Vegetation; (C–D) Areas within the Waste Woodland Cleared for Pathways

#### 7.3.2.2.4 Scrubland and Herbaceous Vegetation

Scrubland and herbaceous vegetation occupy the third largest area in Eng Neo Avenue Forest, taking up 31.1% (12.2 ha) of the total area. This vegetation type can be found throughout the site (Figure 7-20). Most patches are interspersed within waste woodland areas (Figure 7-24A), most likely because these highly-disturbed areas are still in the earlier stage of succession and trees have not yet replaced the scrub (Yee et al., 2016). Many of the scrubland patches in Eng Neo Avenue Forest could have been previously cleared and taken over by spontaneous sun-loving herbaceous species (Figure 7-24B). Given time and available seed sources, among other abiotic and biotic conditions, trees may grow over these areas and form closed canopies that will eventually shade out the herbs and shrubs. Currently, this vegetation is largely dominated by non-native species, such as *Mikania micrantha*, *Isachne globosa*, and *Pennisetum purpureum*.





**Figure 7-24 Scrubland and Herbaceous Vegetation in Eng Neo Avenue Forest. (A) Scrubland has Completely Open Canopy (Contrast this with the Closed Canopy Waste Woodland in the Background); (B) Area that Had Been Cleared Previously and Now Taken over by Spontaneous Herbs and Shrubs**

#### 7.3.2.2.5 *Managed Vegetation*

The two areas with managed vegetation are (1) a lawn of 5–10 m width with some planted trees on one side southeast of the rectangular horse training stable (Figure 7-25A) and (2) some hedges, trees, and lawn along a bend of Eng Neo Avenue leading to the PIE (Figure 7-25B). The areas are both planted with exotic species. During floristic surveys from March–April 2020, it was observed that some forested areas were being cleared and planted up, especially around the horse training stable. It is not known how extensive forest clearing is/will be. Hence, the size of managed vegetation in Figure 7-20 is likely to be underestimated.



**Figure 7-25 Managed Vegetation in Eng Neo Avenue Forest. (A) Managed Lawn with Planted Trees on One Side of the Horse Training Stable; (B) Planted Trees, Managed Lawn, and *Bougainvillea* Hedges along A Bend of Eng Neo Avenue Leading to the PIE**

#### 7.3.2.2.6 *Waterbodies*

Within Eng Neo Avenue Forest, waterbodies and ponds are present (Figure 7-26). The locations and alignment of the waterbodies is shown in Figure 7-10.

There is a single stream system that runs from north to south on the eastern edge of the Study Area (D/S14; Figure 7-26A–D). The waterway flowing through the site encompasses both forest streams and open-country streams.

Some smaller waterbodies are also present on site. Man-made shallow waterbodies are present parallel to the old road, which likely formed from water accumulation in channels left behind after construction of the old road (Figure 7-26E). Some waterlogged sections were also observed around the stream, particularly in the southern and western part. There is a large pond (~20m by 20m) present in the centre portion of the site. The pond is filled with wood debris and covered in algae (Figure 7-26E). It is located within open scrubland.





**Figure 7-26 Waterbodies in Eng Neo Avenue Forest. (A) Upstream of Outflow From Culvert under the PIE, D/S14; (B) Semi-Open Country Stream, A1; (C–D) Forested Streams with Canopy Cover; (E) Man-Made Shallow Waterbodies along the Old Road; (F) Large Pond in the Centre Portion of the Study Area.**

### 7.3.2.3 Floristic Field Findings

#### 7.3.2.3.1 Overall

A total of 284 species and species groups, i.e., plants that could not be identified to species with certainty, belonging to 89 families were recorded from the present study's floristic surveys at Eng Neo Avenue Forest (Appendix C1). Seven species groups could not be identified with certainty – they are (1) *Gnetum* sp., (2) *Khaya* cf. *nyasica*, (3) *Knema* cf. *malayana*, (4) *Litsea* cf. *cordata*, (5) *Syzygium* sp., (6) Burseraceae, (7) unknown.

The two specimens identified as *Gnetum* sp. were located within the northern-most patch native-dominated secondary forest, where many other rare native plants were found (Section 7.3.2.2.1). These specimens have a climbing growth habit. Currently, climbing *Gnetum* species are not known to be sold commercially nor planted in the past or present. Assuming the two specimens are native, their national conservation status would be Critically Endangered as all climbing *Gnetum* species recorded in Singapore have been assigned this conservation status.



(Chong et al., 2009). Hence, this species group and the locations where the specimens were found were included in Appendix D1.

Specimens of *Knema* cf. *malayana* and *Litsea* cf. *cordata* could not be identified with certainty based on photographs and/or voucher specimens, but they could potentially be nationally threatened species. Likewise, *Khaya* cf. *nyasica*, an exotic tree species that is mostly likely introduced from commercial markets, also could not be identified with certainty.

*Syzygium* sp. was excluded in the tabulation of total species count because there is a likelihood that the specimen belongs to one of the six *Syzygium* species recorded in Eng Neo Avenue Forest (Appendix C1). Hence, it was excluded to prevent double counting. It is, however, challenging to ascertain the conjecture as the specimen was a young seedling yet to have distinguishing characters for it to be identified with greater certainty. For two other specimens, one could, at best, only be identified to its family Burseraceae, while the other could not be identified at all.

There are 171 (60.2%) native species, 96 (33.8%) exotic species, and 15 (5.3%) cryptogenic species (Table 7-9). The percentage of native species is relatively high. Of the native species at Eng Neo Avenue Forest, up to 31.6% (90 species) are nationally threatened. This could be attributed to the high native species richness of the native-dominated secondary forest patches in Eng Neo Avenue Forest (Section 7.3.2.2.1).

**Table 7-9 Number and Percentage of Species Belonging to Each Status Category in Eng Neo Avenue Forest**

Origin		Status	Number of Species	Percentage
<b>Native</b>			<b>171</b>	<b>60.2</b>
	Common		82	28.9
	Vulnerable		44	15.5
	Endangered		18	6.3
	Critically Endangered		24	8.5
	Presumed Extinct		3	1.1
	Not assessed; recently rediscovered		1	0.4
<b>Exotic</b>			<b>96</b>	<b>33.8</b>
	Cultivated Only		15	5.3
	Casual		27	9.5
	Naturalised		46	16.2
	Not assessed		7	2.5
<b>Cryptogenic</b>			<b>15</b>	<b>5.3</b>
<b>Unidentified species</b>			<b>2</b>	<b>0.7</b>
<b>Total</b>			<b>284</b>	<b>100.0</b>

#### 7.3.2.3.2 Plant Species of Conservation Significance

Eighty species in Eng Neo Avenue Forest are considered of conservation significance (Table 7-10). Of these, 75% (60 species) are found in the native-dominated forest patches even though they have the smallest relative size (Table 7-8).

Up to 520 individuals and clusters of specimens of conservation significance were recorded from Eng Neo Avenue Forest. A large number of these specimens are concentrated in the northern half of the Study Area, especially within the native-dominated secondary forest patch (Figure 7-20). Beyond these hotspots, the specimens appear to be generally distributed throughout the forested areas parallel to the PIE, especially within the waste woodland and abandoned-land forest adjacent to the native-dominated forest patch in the north. This accounts for the high number of species of conservation significance in the waste woodland patches, which are more often than not species-poor.

Forty specimens of conservation significance belong to sixteen species lie within the proposed worksites in Eng Neo Avenue Forest (Figure 7-27).

**Table 7-10 Number of Plant Species of Conservation Significance in Eng Neo Avenue Forest**

	VU	EN	CR	EX	RR	Total
<b>Non-Cultivated Threatened Species</b>	22	17	17	0	1	57
<b>Cultivated Threatened Species</b>	20	0	3	0	0	23
<b>Total Number of Species of Conservation Significance</b>	<b>42</b>	<b>17</b>	<b>20</b>	<b>0</b>	<b>1</b>	<b>80</b>

Note: VU – Vulnerable; EN – Endangered; CR– Critically Endangered; EX – Presumed Extinct; RR – Recently Rediscovered (not assessed).

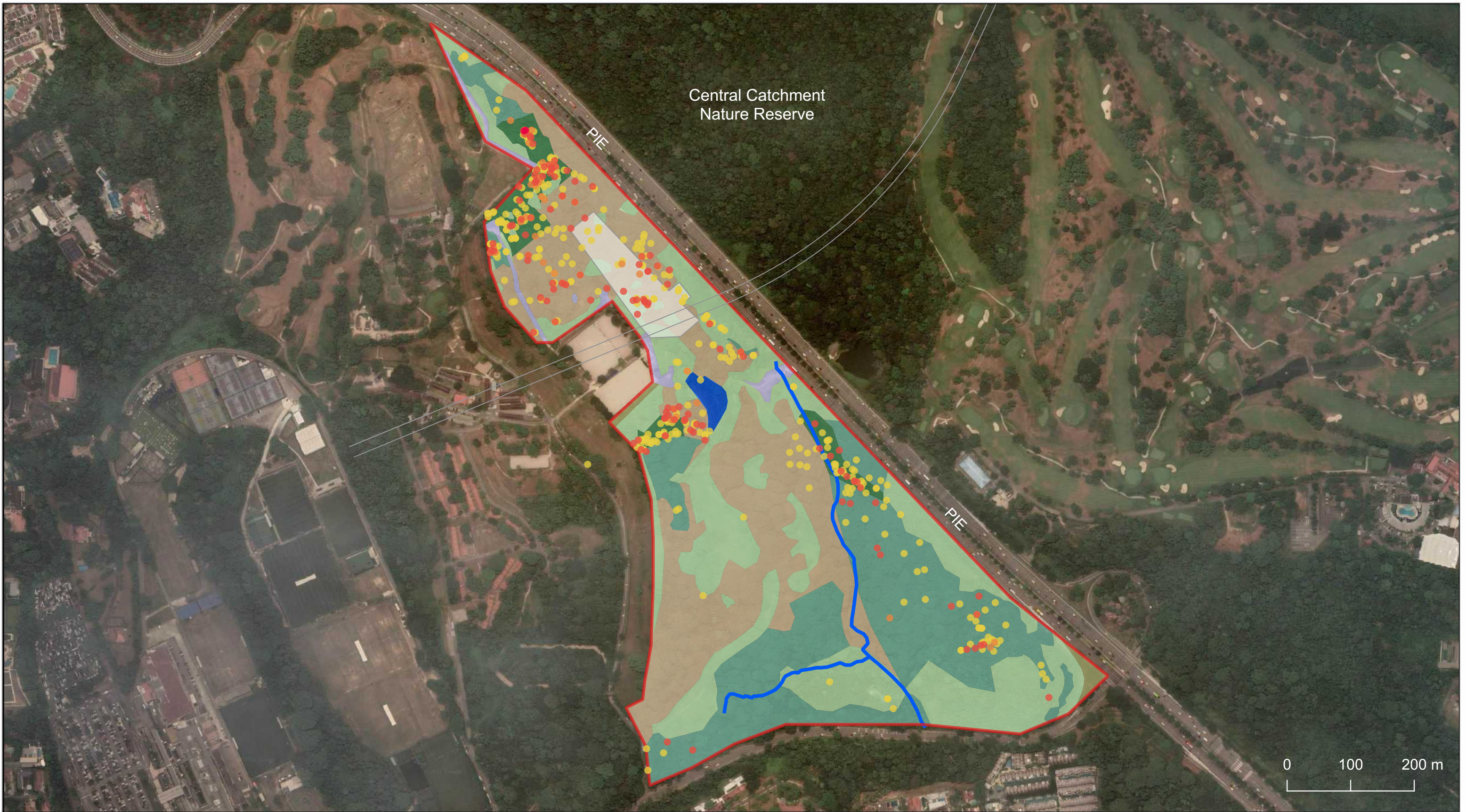


**Table 7-11 Number of Plant Specimens and Species of Conservation Significance in Each Vegetation Type in Eng Neo Avenue Forest**

	Number of Individuals and Clusters					Number of Species				
	VU	EN	CR	RR	Total	VU	EN	CR	RR	Total
<b>Native-Dominated Secondary Forest</b>	157	18	41	2	<b>218</b>	31	13	15	1	<b>60</b>
<b>Abandoned-Land Forest</b>	67	5	21	0	<b>93</b>	20	5	7	0	<b>32</b>
<b>Waste Woodland</b>	112	9	46	0	<b>167</b>	17	5	9	0	<b>31</b>
<b>Scrubland and Herbaceous Vegetation</b>	33	1	6	0	<b>40</b>	13	1	3	0	<b>17</b>
<b>Cleared Area</b>	2	0	0	0	<b>2</b>	2	0	0	0	<b>2</b>

Note: Total species richness of the Study Area is not the sum of species richness per vegetation type as some species occur in more than one vegetation type. VU – Vulnerable; EN – Endangered; CR – Critically Endangered; RR – Recently Rediscovered (not assessed).





**Legend**

Study Area

Worksite and alignment (Base)

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Plant specimens of conservation significance

Recently Rediscovered

Critically Endangered

Endangered

Vulnerable

Not Assessed

N

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Rev.	Date	By	Description	Chk'd	App'd

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
**CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
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	Drawn JW	Date JUN 2022



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OF CONSERVATION SIGNIFICANCE IN  
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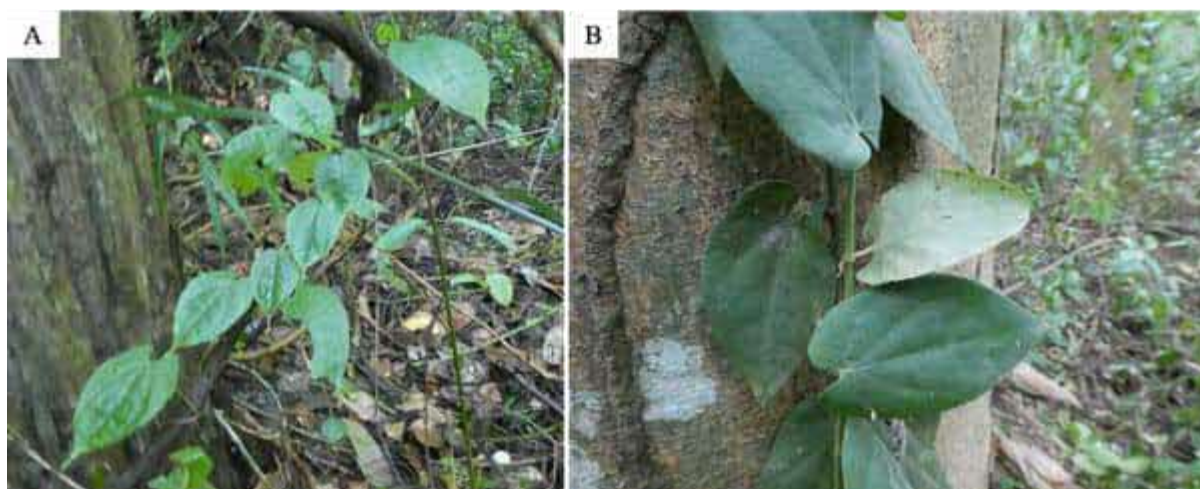
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The only species that is recently rediscovered (not assessed) in Eng Neo Avenue Forest is *Dioscorea orbiculata* var. *tenuifolia*, a climber species (Figure 7-28A). Two specimens were both found within the northern-most native-dominated patch in the Study Area. This species has been recorded in different forest types previously, ranging from disturbed abandoned-land forests to the least disturbed BTNR (Neo et al., 2013; Ho et al., 2019).



**Figure 7-28 (A) Recently Rediscovered (Not Assessed) *Dioscorea orbiculata* var. *tenuifolia*; (B) Nationally Critically Endangered *Piper pedicellosum***

Several specimens of *Piper pedicellosum* (Figure 7-28B), a nationally Critically Endangered species, were found throughout the Study Area. There is no obvious pattern of distribution and it was found growing across all three existing forest types, i.e., native-dominated secondary forest, abandoned-land forest, and waste woodland (Figure 7-27).

Altogether, 20 species listed as nationally Critically Endangered are considered of conservation significance in Eng Neo Avenue Forest. Some of the rarer species include *Aporosa lucida* var. *lucida*, *Ficus grandulifera*, *Memecylon floridum*, *Prunus arborea* var. *stipulacea*, *Anodendron candolleianum*, and *Uncaria longiflora* var. *pteropoda* (Figure 7-29). The three species known to be cultivated in some local nurseries according to Chong et al. (2009), but are considered of conservation significance are (1) *Centotheca lappacea*, (2) *Hoya diversifolia*, and (3) *Xanthophyllum ellipticum* (Appendix D1).

As with many other species, a cluster of *Prunus arborea* var. *stipulacea* seedlings and trees up to 0.2 m girth and one individual of *Anodendron candolleianum* were only recorded in a vegetation plot located within the northern-most native-dominated forest patch. *Prunus arborea* var. *stipulacea* is more often associated with more mature secondary forests. It was noted by taxonomic experts that this species is fairly rare and not commonly encountered even in the NSSf (pers. comms.).

In addition to native-dominated secondary patches, some of the rare species were also found beyond those areas, such as *Xanthophyllum ellipticum*. In this study, 16 specimens were found throughout the Study Area, both in and outside the native-dominated patches. Previous records of this species include the pristine forests NSSf, CCNR, and BTNR, as well as outside the protected areas (Ang Mo Kio and Tanglin Barracks) (Tan et al., 2016). Similarly, small- to medium-sized clusters of *Memecylon floridum* were distributed only within the northern half of the Study Area (Appendix D1). On the contrary, two specimens of *Aporosa lucida* var. *lucida* were encountered in the abandoned-land forest south of the Study Area, one of which is a fairly large tree of 0.4 m girth found inside one of the vegetation plots.





**Figure 7-29 Nationally Critically Endangered plant species recorded at Eng Neo Avenue Forest. (A) *Anodendron candolleanum*; (B) *Prunus arborea* var. *stipulacea*; (C) *Memecylon floridum*; (D) *Uncaria longiflora* var. *pteropoda***

Seventeen out of 18 species recorded as nationally Endangered are considered of conservation significance in this study (Appendix D1). With the exception of *Aphanamixis polystachya*, all other species are neither known to be cultivated in local nurseries nor sold commercially. All specimens are almost certainly from native genetic stocks. Some of the less frequently encountered species include *Artocarpus lacucha*, *Uncaria cordata*, *Canthiumeria robusta*, and *Koompassia malaccensis* (Figure 7-30).

One specimen each of *Koompassia malaccensis* and *Uncaria cordata* were both encountered in the northern-most native-dominated forest patch.

On the other hand, a cluster of about 20 *Artocarpus lacucha* specimens was found in one of the vegetation plots outside but in close proximity to the northern-most native dominated forest patch (Figure 7-27). The girth size ranges from < 0.05 m to 0.2 m. The forest type in which these specimens were found was classified as abandoned-land forest as several rubber trees form the canopy layer. However, the forested patch hosts a mix of native and crop plants species.

Two specimens of *Canthiumeria robusta* were also encountered outside the areas not demarcated as 'native-dominated'; they were within a waste woodland patch and at the border between a native-dominated patch and waste woodland, respectively (Appendix D1).





**Figure 7-30 Nationally Endangered Plant Species Recorded at Eng Neo Avenue Forest. (A) Young Leaf Stem of *Artocarpus lacucha* with Two Leaves that are Lobed; (B) Leaf Upperside of *Canthiumeria robusta*; (C) Underside of a Leafy Stem of *Uncaria cordata* Showing the Recurved Spines (Red Circle); (D) Leafy Stem of *Koompassia malaccensis*.**

There are 42 nationally Vulnerable species of conservation significance recorded from Eng Neo Avenue Forest, some of which are commonly encountered in some secondary forests in Singapore, such as *Bridelia stipularis*, *Cayratia trifolia*, *Lygodium longifolium*, and *Macaranga griffithiana*. The rarer and less commonly encountered species include *Flacourtia rukam*, *Hornstedtia scyphifera* var. *scyphifera*, *Psychotria ovoidea*, *Pternandra echinata*, *Lophopetalum wightianum*, and *Sterculia rubiginosa*, amongst others (Figure 7-31).

*Flacourtia rukam* and *Lophopetalum wightianum* were both found in the vegetation plot located within the northern-most native-dominated forest patch, from which the rare and nationally Critically Endangered *Prunus arborea* var. *stipulacea* and *Strophanthus caudatus* were also recorded.





Figure 7-31 Nationally Vulnerable Plant Species in Eng Neo Avenue Forest. (A) Trunk of *Flacourtia rukam* With Distinct Branched Thorns; (B) *Hornstedtia scyphifera* var. *scyphifera* Herb; (C) Leafy Stem of *Pternandra echinata*; (D) *Psychotria ovoidea*; (E) Canopy Leaves of *Lophopetalum wightianum*; (F) *Sterculia rubiginosa* Sapling.



### 7.3.2.3.3 Large Plant Specimens

Thirteen large plant specimens were recorded at Eng Neo Avenue Forest – six trees (3–3.7 m spread), two stranglers (5 m spread), and five bamboo clusters (3–15 m spread) (Figure 7-33; Appendix E1). None of these large plant specimens lie within the proposed worksites.

**Table 7-12 Number of Large Plant Specimens in Eng Neo Avenue Forest**

Habit	Species	No. of Specimens
Tree	<i>Alstonia angustiloba</i>	1
	<i>Cyrtophyllum fragrans</i>	4
	<i>Ficus variegata</i>	1
Strangler	<i>Ficus benjamina</i>	2
Shrub (Bamboo)	<i>Bambusa vulgaris</i>	5
<b>Total</b>		<b>13</b>





Study Area

Worksite and alignment (Base)

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Large plant specimens

Tree

Strangler

Bamboo

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
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Project Title :  
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ENVIRONMENTAL IMPACT STUDY  
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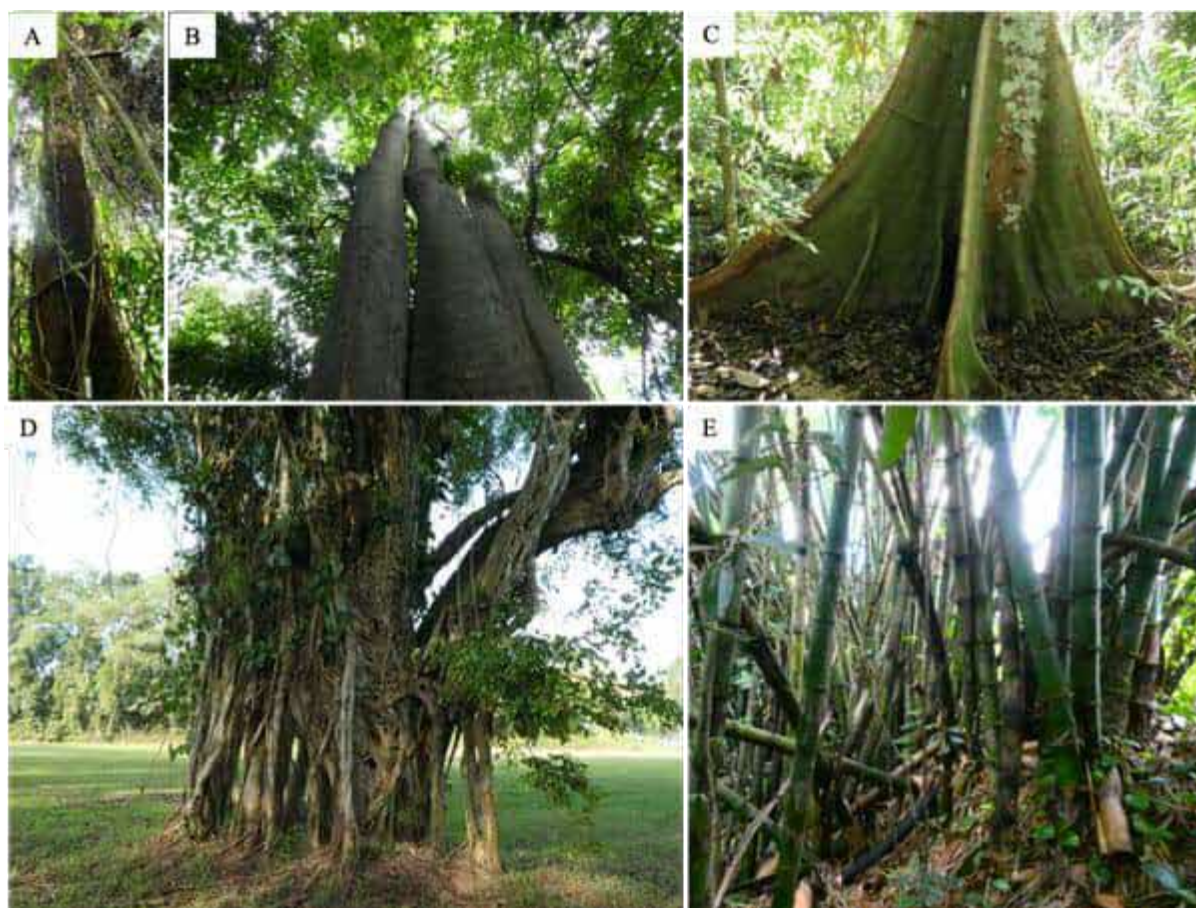
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**Figure 7-33 Large Plant Specimens Recorded at Eng Neo Avenue Forset. (A) Tembusu, *Cyrtophyllum fragrans*; (B) *Alstonia angustiloba*; (C) Large Root Flares of *Ficus variegata*; (D) Strangling Fig, *Ficus benjamina*; (E) Bamboo Cluster, *Bambusa vulgaris*.**

#### **7.3.2.3.4 Other Plant Specimens of Value**

Three other plant specimens of value were recorded at Eng Neo Avenue Forest (Appendix F1). All the specimens are *Falcataria moluccana* trees, which are exotic and naturalised, but were observed to each have one raptor nest and two active giant honeybee hives, respectively (Figure 7-34). As the observations were made from a distance, it was challenging to estimate tree girth. Locations of these trees were also taken from the position of the observer, which was approximately 50–100 m away. These points were then adjusted post-hoc to indicate the approximate locations on the map (Figure 7-35).

The giant honeybee hives were active on the days they were observed. A crested honey buzzard (*Pernis ptilorhynchus*) had also been observed feeding on one of the hives (Section 7.3.2.4.10). It is not known whether the raptor nest is being actively used, but a crested honey buzzard was observed in the vicinity of the nest during floristic surveys on the same day the nest was seen. This same species was repeatedly seen in the area over a few floristic surveys. In addition, raptors are known to nest all year round in Singapore, and existing nests may be reused given that it is comparatively more costly to build new nests (Yong, 2011; Jimenez-Franco et al., 2014). Even though the trees belong to exotic species, they are important refugia for fauna and hence are valuable to conserve.





Figure 7-34 Other Plant Specimens of Value at Eng Neo Avenue Forest. (A–B) A Raptor Nest on A *Falcataria moluccana* Tree; (C) A Crested Honey Buzzard (*Pernis ptilorhynchus*) Seen near the Raptor Nest on the Same Day of Observation; (D) An Active Giant Honeybee Hive on A *Falcataria moluccana* tree





**Legend**

Study Area

Worksite and alignment (Base)

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Other specimens of value

Raptor nest (exact)

Bee hive (approximate)

Bee hive (observer's)

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG
Rev.	Date	By	Description	Chk'd	App'd

Qualified Person Endorsement :  
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LTA Endorsement :  
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Consultant :  
**AECOM**

Project Title :  
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### 7.3.2.3.5 Arboricultural Survey Findings

A total of 963 specimens belonging to 48 species and one species group was tagged during this present study's arboricultural surveys (Appendix G1). One specimen could not be identified with certainty based on vegetative characters alone and was identified as *Khaya* cf. *nyasica*. These specimens belong to 24 families in total.

*Falcataria moluccana* tree specimens alone make up about 59.3% (571 specimens) of all the specimens assessed (Appendix G1). Following this, the two other species with relatively high counts are *Spathodea campanulata* (88 specimens) and *Ficus variegata* (82 specimens). There were fewer than 25 tagged specimens for the remaining 45 species. Altogether, thirty-two specimens belonging to six species of conservation significance were tagged and assessed. These species are *Archidendron jiringa*, *Calophyllum tetrapterum*, *Garcinia eugeniifolia*, *Lophopetalum wightianum*, *Oncosperma tigilarium*, and *Symplocos fasciculata*.

Note that there were more specimens assessed than tagged as some specimens occur in clusters, i.e., within 1–2 m of each other. All the specimens within clusters were assessed, but only one specimen was tagged (Section 7.2.4.4).

### 7.3.2.3.6 Forest Regeneration

The ten most abundant species for trees found in the vegetation plots in two broad girth-size classes— $\geq 0.5$  m girth and  $< 0.5$  m girth—are listed in descending order in Table 7-13. The girth-size classes were further divided and the trends in diameter frequency distribution are shown in Figure 7-36 and Figure 7-37.

Specimens of *Hevea brasiliensis*, commonly known as rubber, dominated both size classes; there are 14 stems of  $\geq 0.5$  m girth and 139 stems of  $< 0.5$  m girth. This is likely a reflection of the site's past land use history, which shows that the area was partially a rubber plantation. Floristic field observations noted that abandoned-land forest occupies the second largest area in Eng Neo Avenue Forest. Mature trees of large sizes are generally expected to exhibit high seedling recruitment given that they act as seed sources in the forest, which allows for the continual persistence of propagules. There is also a fairly large number of stems of *Falcataria moluccana* of  $\geq 0.5$  m girth, only second to *H. brasiliensis* with nine counts. This also corroborates field observations whereby waste woodland is the largest forest sub-type found in Eng Neo Avenue Forest, of which the dominant tree species is the naturalised *Falcataria moluccana*, a common wayside tree in the past.

There are generally very few trees in the larger size class ( $\geq 0.5$  m girth) and the maximum stem count for each species is fewer than fifteen. Besides *H. brasiliensis* and *F. moluccana*, the remaining species had fewer than eight stems. There is a mix of native pioneer species (*Macaranga gigantea*), other native species (*Cinnamomum iners*, *Claoxylon indicum*, and *Ficus variegata*), cultivated tree species (*Nephelium lappaceum* and *Cocos nucifera*), as well as fast-growing exotic tree species (*Falcataria moluccana* and *Spathodea campanulata*). Given their overall low stem counts, there is insufficient resolution for the detection of distinct trends.

On the contrary, there are numerous seedlings and saplings found in the lower forest strata. Approximately 75% (621 out of 836) of the total stems encountered measured  $\leq 0.05$  m in girth. Eight of the ten (and 15 of the 20) most abundant species of  $< 0.5$  m girth are native. All ten most abundant species of  $< 0.5$  m girth generally exhibit a typical reverse-J distribution pattern (Table 7-49), indicating that there is high recruitment of seedlings.

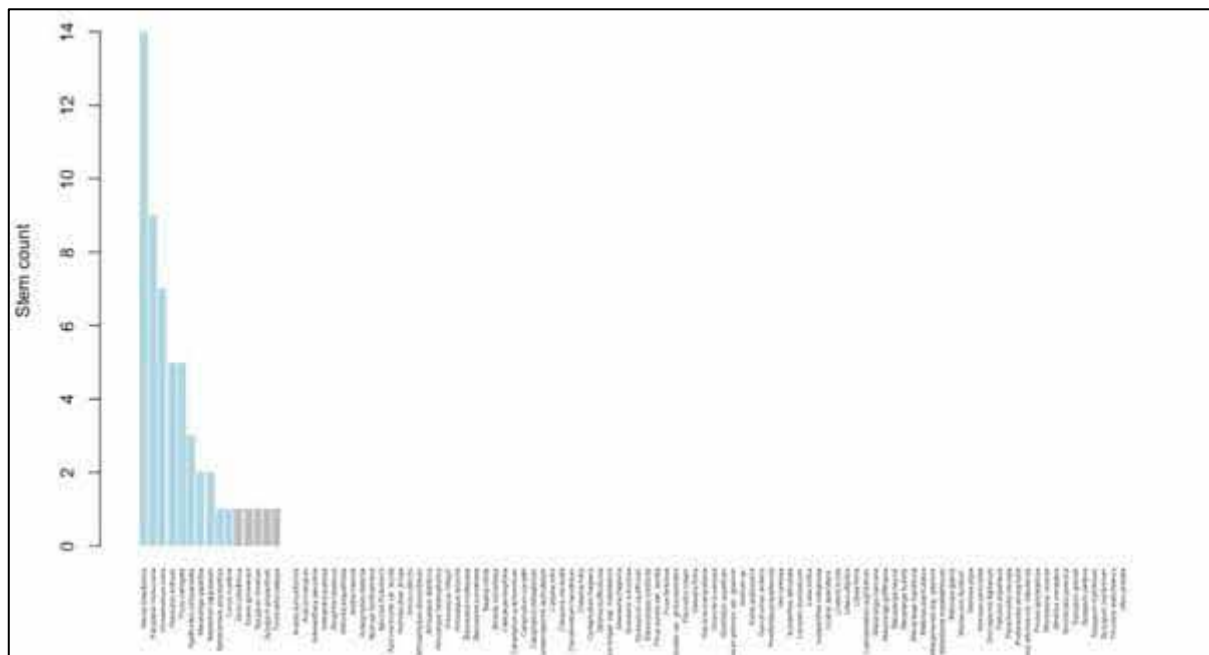
It is also interesting to note that the lower forest strata have a high proportion of native seedlings. In particular, *Prunus polystachya* and *Calophyllum tetrapterum* are two species that stand out in the list of top ten most abundant species of  $< 0.5$  m girth as they are typically found in abundance in the CCNR and not in most other secondary forests of Singapore. This distribution pattern could be partially explained by the proximity of the Study Area to the CCNR. Although fragmented by the PIE, the proximity of the forest patch to the CCNR provides a nearby source for the arrival of propagules. Continual dispersal is important in maintaining the amount of native seeds in the soil seed bank. Additionally, some specimens could also have persisted from the past before fragmentation occurred.

Nevertheless, its proximity to the old secondary native forests of the CCNR is advantageous, in that there are more opportunities for the continual dispersal of native propagules. It is possible that given time, and if left undisturbed, propagules in the existing native-dominated secondary forest already in Eng Neo Avenue Forest could continue to disperse into the neighbouring abandoned-land forest and waste woodland patches—which could serve as additional refugia for nationally threatened species or species with distributions restricted mainly to the CCNR—thereby allowing other parts of the forest to slowly recover into a native secondary forest. While this may take a long time, Eng Neo Avenue Forest possesses great potential for such forest succession to occur.



Table 7-13 The Ten Most Abundant Tree Species in Eng Neo Avenue Forest, Listed in Descending Order

S/N	Trees of $\geq 0.5$ m Girth	Trees of $< 0.5$ m Girth
1.	<i>Hevea brasiliensis</i>	<i>Hevea brasiliensis</i>
2.	<i>Falcataria moluccana</i>	<i>Cinnamomum iners</i>
3.	<i>Cinnamomum iners</i>	<i>Syzygium grande</i>
4.	<i>Claoxylon indicum</i>	<i>Leea indica</i>
5.	<i>Ficus variegata</i>	<i>Manihot carthagenesis</i>
6.	<i>Spathodea campanulata</i>	<i>Prunus polystachya</i>
7.	<i>Macaranga gigantea</i>	<i>Caryota mitis</i>
8.	<i>Nephelium lappaceum</i>	<i>Nephelium lappaceum</i>
9.	<i>Aphanamixis polystachya</i>	<i>Ficus fistulosa</i>
10.	<i>Cocos nucifera</i>	<i>Calophyllum tetrapterum</i>

Figure 7-36 Number of Stems (54 in Total) with  $\geq 0.5$  m Girth for All Species Across Vegetation Plots in Eng Neo Avenue Forest. Bars in Light Blue Belong to the Ten Most Abundant Species.



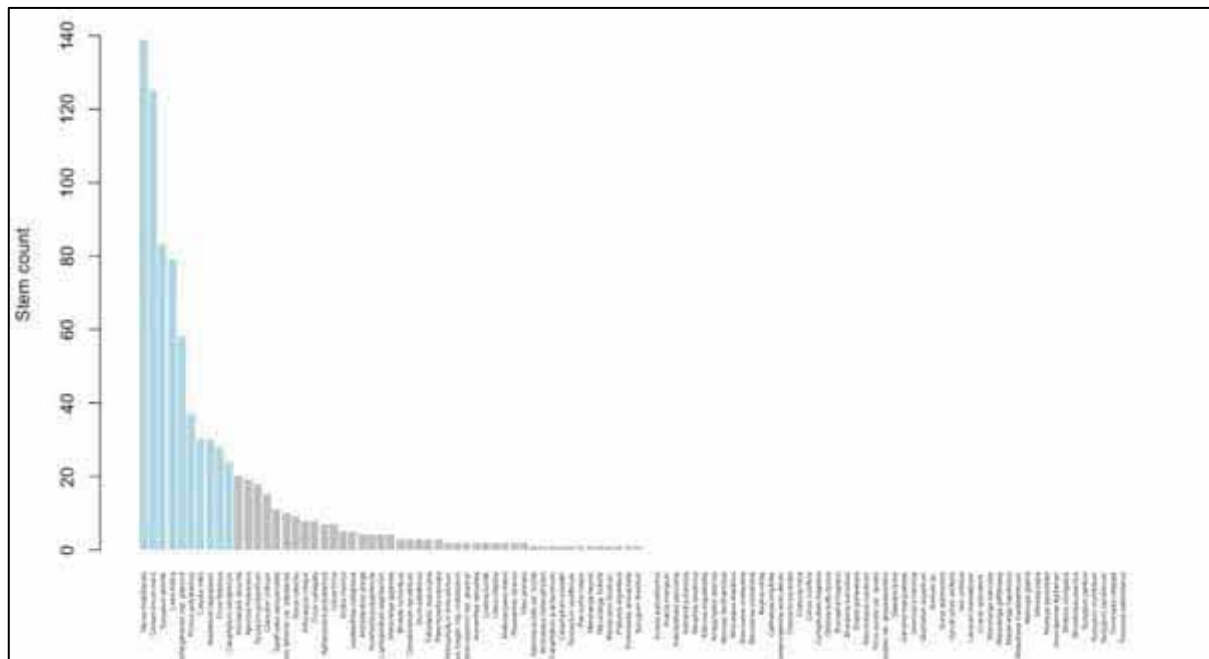


Figure 7-37 Number of Stems (836 in Total) with < 0.5 m Girth for All Species Across Vegetation Plots in Eng Neo Avenue Forest. Bars in Light Blue Belong to the Ten Most Abundant Species.

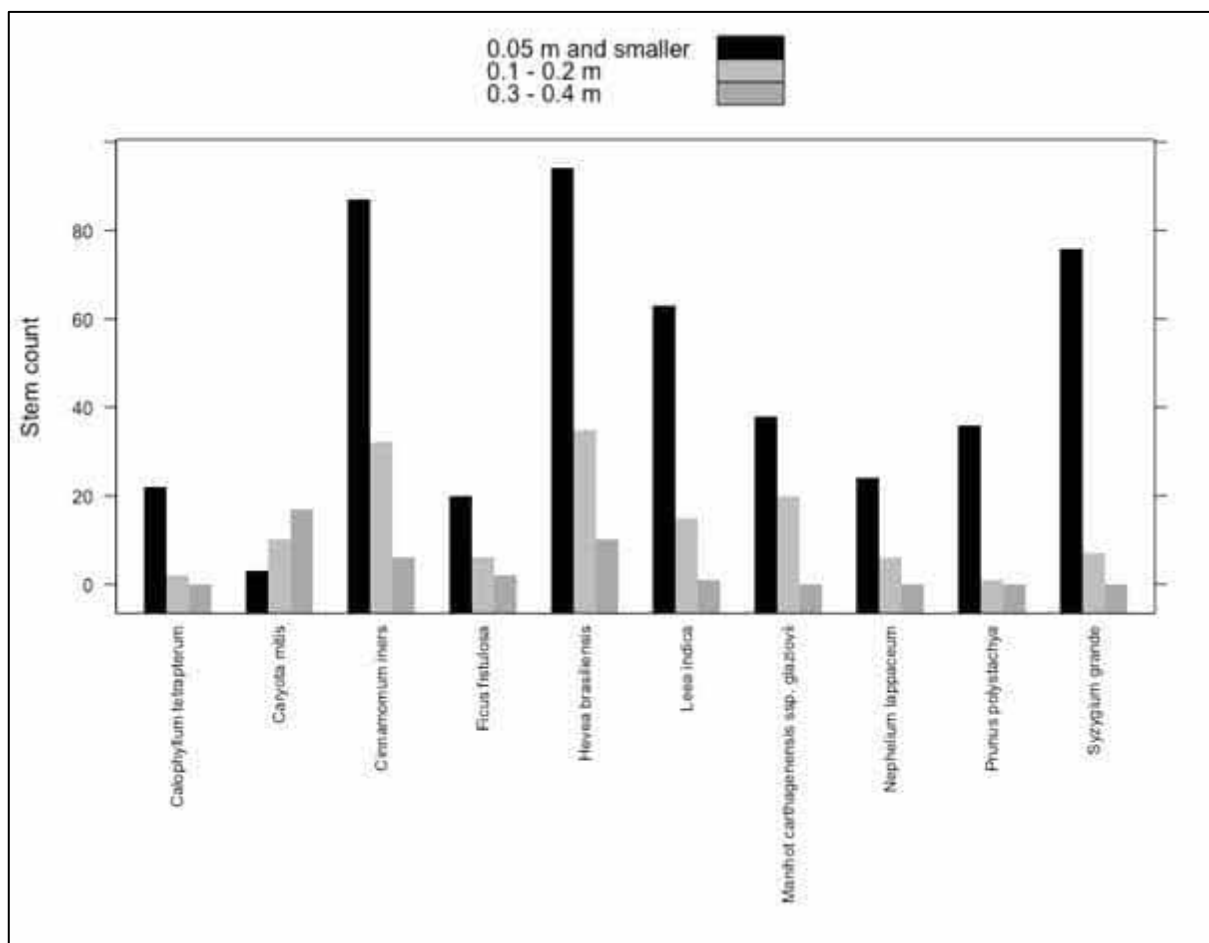


Figure 7-38 Girth-Size Distribution of the Ten Most Abundant Tree Species with < 0.5 m Girth in Eng Neo Avenue Forest



### 7.3.2.4 Faunistic Field Findings

#### 7.3.2.4.1 Overall

The desktop assessment identified 575 species of probable occurrence at Eng Neo Avenue Forest. The field assessment documented 233 species, dominated by birds (72 species) and butterflies (64 species). From these, 15 species of conservation significance were also recorded. Three species (one odonate, one reptile and one bird) were not listed as probable species. The findings for each faunal group are described in Sections 7.3.2.4.3 to 7.3.2.4.12 respectively. The list of probable and recorded species is available in Appendix H1, and summarised in Table 7-14. The list of faunal species of conservation significance and their conservation statuses is available in Table 7-15. The faunal survey and camera trap data are provided in Appendix I1 and Appendix J1 respectively.

**Table 7-14 Summary of Probable and Recorded Faunal Species at Eng Neo Avenue Forest**

Faunal Group	No. of Probable Species		No. of Recorded Species		No. of Recorded Species Not on Probable List (CS Species)
	All Species	CS Species	All Species	CS Species	
Aculeate hymenopterans	85	0	26	0	0
Bees	41	0	8	0	0
Stinging wasps	44	0	18	0	0
Odonates	70	15	29	0	1 (0)
Dragonflies	47	5	24	0	0
Damselflies	23	10	5	0	1 (0)
Butterflies	167	13	64	3	0
Freshwater decapod crustaceans	2	0	0	0	0
Freshwater fish	11	0	6	0	0
Herpetofauna	48	2	20	0	1 (0)
Amphibians	16	0	6	0	0
Reptiles	32	2	14	0	1 (0)
Birds	162	23	72	8	1 (0)
Mammals	30	8	16	4	0
Non-volant mammals	20	5	9	2	0
Bats	10	3	7	2	0
<b>Total</b>	<b>575</b>	<b>61</b>	<b>233</b>	<b>15</b>	<b>3 (0)</b>

Note: 'CS species' refers to species of conservation significance.

**Table 7-15 List of Faunal Species of Conservation Significance Recorded in Eng Neo Avenue Forest**

Taxon	Species	Common Name	Local Status	Global Status
Butterfly	<i>Telicota colon stinga</i>	Common palm dart	Nationally Extinct (Rediscovered)	Not Assessed
Butterfly	<i>Pachliopta aristolochiae asteris</i>	Common rose	Vulnerable	Not Assessed
Butterfly	<i>Troides helena cerberus</i>	Common birdwing	Vulnerable	Not assessed; CITES protected (Appendix II)
Bird	<i>Nisaetus cirrhatus</i>	Changeable hawk-eagle	Endangered	Least Concern
Bird	<i>Treron curvirostra</i>	Thick-billed green pigeon	Endangered	Least Concern
Bird	<i>Cacomantis sepulcralis</i>	Rusty-breasted cuckoo	Vulnerable	Least Concern
Bird	<i>Gallus gallus</i>	Red junglefowl	Endangered	Least Concern
Bird	<i>Loriculus galgulus</i>	Blue-crowned hanging-parrot	Endangered	Least Concern
Bird	<i>Psittacula longicauda</i>	Long-tailed parakeet	Not Assessed	Vulnerable



Taxon	Species	Common Name	Local Status	Global Status
<b>Bird</b>	<i>Pycnonotus zeylanicus</i>	Straw-headed bulbul	Endangered	Critically Endangered
<b>Bird</b>	<i>Rallina fasciata</i>	Red-legged crane	Vulnerable	Least Concern
<b>Mammal</b>	<i>Manis javanica</i>	Sunda pangolin	Critically Endangered	Critically Endangered
<b>Mammal</b>	<i>Macaca fascicularis</i>	Long-tailed macaque	Least Concern	Vulnerable
<b>Bat</b>	<i>Eonycteris spelaea</i>	Cave nectar bat	Vulnerable	Least Concern
<b>Bat</b>	<i>Tylonycteris</i> sp.	Bamboo bat	Vulnerable	Least Concern

While it is unlikely for non-volant species from the CCNR to cross the PIE and reach the Study Area, there remains a chance of expecting rare species here. This is evident from our records which were not expected to occur here since they were previously thought to be confined to CCNR. An example is the Wagler's pit viper (*Tropidolaemus wagleri*). It provides habitats for species of conservation significance which were distributed across the Study Area, including the globally threatened straw-headed bulbul (*Pycnonotus zeylanicus*) and Sunda pangolin (*Manis javanica*). Species of conservation significance appear to be distributed across the Study Area (Figure 7-39).







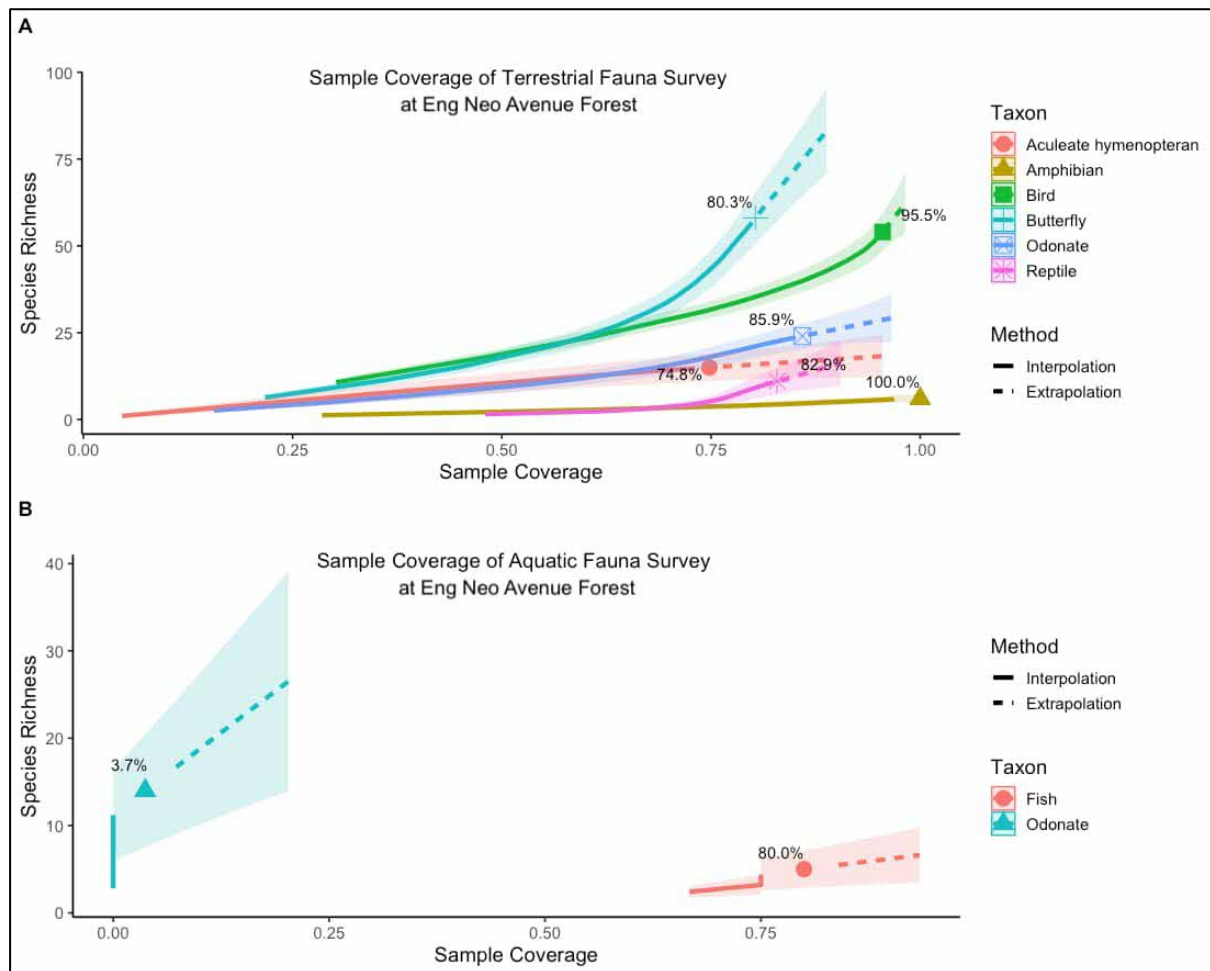
### 7.3.2.4.2 Sampling Coverage

Along the terrestrial sampling routes and at aquatic sampling points, the sample coverage for each taxon were all above 70%, with the exception of odonates from diurnal sampling points at only 3.7%. With doubled sampling effort, a marginal increase in richness is expected for most groups, but more than 15 species may be detected for odonates and butterflies. The sample coverage for odonates is expected to rise to 26.1% and an additional 16 species may be detected. However, this may be an overestimation of the species richness expected for odonates since only 70 odonate species were listed as probable for Eng Neo Avenue Forest. Sample coverage was not calculated for faunal groups with less than three species were recorded. Camera trapping obtained a coverage of 94.4%. The results are summarised in Table 7-16.

**Table 7-16 Result Summary of Taxon Sampling Analysis for Eng Neo Avenue Forest**

Faunal Group	Sample Coverage (%)	Observed Richness	Estimated Richness ( $\pm$ Standard Error)	95% Confidence Interval for Estimated Richness	Estimated Coverage with Doubled Effort (%)	Estimated Richness (and Additional Species) with Doubled Effort
<b>Terrestrial Sampling Routes</b>						
<b>Aculeate Hymenopteran</b>	74.8	15	18 $\pm$ 3.9	15.8–35.0	95.5	18 (+3)
<b>Odonate</b>	85.9	24	30 $\pm$ 5.7	25.6–52.4	96.6	29 (+5)
<b>Butterfly</b>	80.3	58	116 $\pm$ 29.1	81.1–204.7	88.8	82 (+25)
<b>Amphibian</b>	100.0	6	6 $\pm$ 0.6	6.0–7.7	100	6 (+0)
<b>Reptile</b>	82.9	11	22 $\pm$ 12.7	13.1–76.7	90.5	16 (+5)
<b>Bird</b>	95.5	54	67 $\pm$ 10.0	57.7–103.5	98.2	62 (+8)
<b>Non-Volant Mammal</b>	N.A.	2	N.A.	N.A.	N.A.	N.A.
<b>Bat</b>	N.A.	1	N.A.	N.A.	N.A.	N.A.
<b>Aquatic Sampling Points</b>						
<b>Odonate</b>	3.7	14	86 $\pm$ 40.4	40.3–215.1	26.1	30 (+16)
<b>Freshwater Fish</b>	80.0	5	7 $\pm$ 3.6	5.3–24.8	95.8	6 (+1)
<b>Amphibian</b>	N.A.	1	N.A.	N.A.	N.A.	N.A.
<b>Reptile</b>	N.A.	1	N.A.	N.A.	N.A.	N.A.
<b>Camera Trapping</b>						
<b>Non-Volant Mammal</b>	94.4	8	9 $\pm$ 3.2	8.1–26.8	98.1	9 (+1)





**Figure 7-40 Taxon Sampling Curves for Respective Faunal Groups (A) Terrestrial Sampling Routes and (B) Aquatic Sampling Points at Eng Neo Avenue Forest**



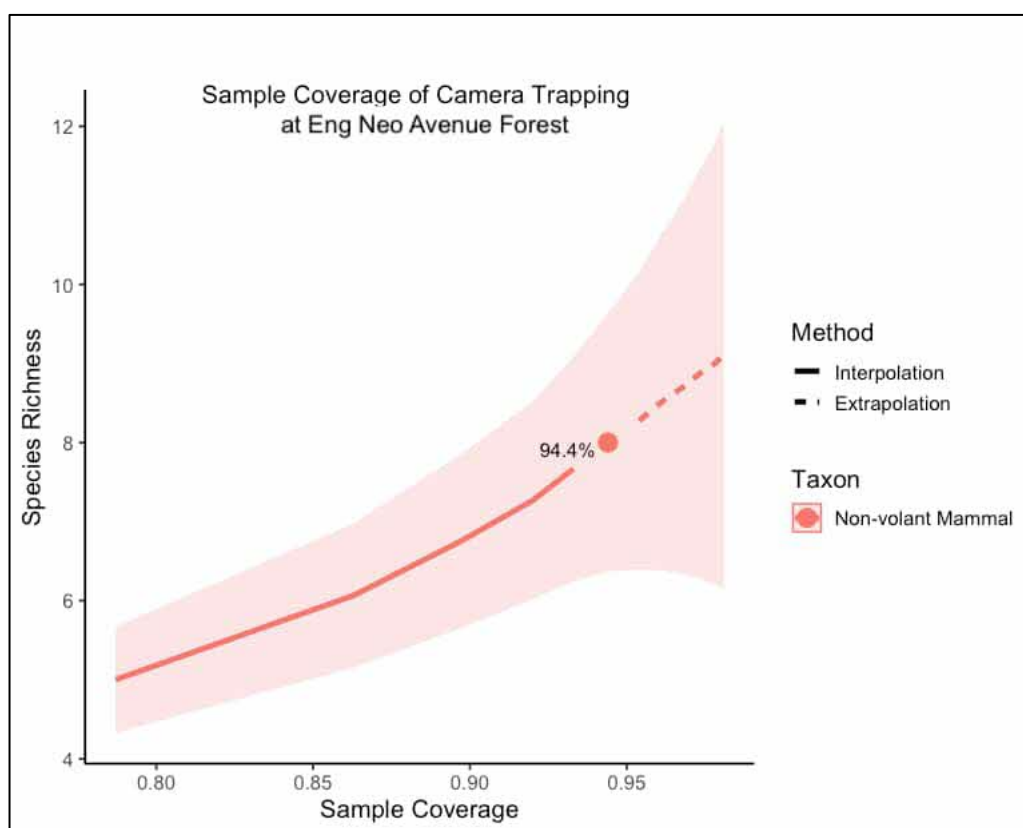


Figure 7-41 Taxon Sampling Curve for Camera Trapping at Eng Neo Avenue Forest

#### 7.3.2.4.3 Aculeate Hymenopterans

As the Study Area is in close proximity to the CCNR to its northeast, separated only by the PIE, it is thus a potential habitat for a wide variety of species, including forest specialists.

A total of 26 species of aculeate hymenopterans were recorded, from seven families – Apidae (6 species), Crabronidae (1 species), Halictidae (1 species), Megachilidae (1 species), Pompilidae (1 species), Sphecidae (5 species) and Vespidae (11 species). Many of the records were from open areas with wildflowers, which may be attractive for these species.

Three wasp species, *Sphex subtruncatus*, *Liostenogaster varipicta* and *Polistes stigma*, can be classified as Near Threatened following the criteria in Ascher et al. (in prep). These are forest-inclined species (not strictly forest-dependent) that are usually found in natural habitats. The most abundantly recorded species was the Eastern honeybee (*Apis cerana*) with 25 individuals recorded. This is followed by two potter wasp (Vespidae, Eumeninae) species, *Antepipona* sp. nr. *bipustulata* with 16 individuals recorded, and *Stenodyneriellus guttulatus* with 14 individuals recorded. Several species were recorded feeding on plant species within the site, suggesting that the site provides foraging opportunities for the species. For example, the Eastern honeybee (*Apis cerana*) was observed feeding on *Asystasia gangetica* ssp. *micrantha*, *Mimosa pudica* and *Muntingia calabura*. Nests were observed for five species, namely Eastern honeybee, *Sceliphron* sp., *Delta pyriforme*, *Eumenes* sp. and *Ropalidia stigma*, confirming the use of the site by these species. One non-native species, *Megachile disjuncta*, was found in the Study Area. This species is common throughout Singapore but is usually found in urban habitats.



#### 7.3.2.4.4 Odonates

A total of 70 species of odonates were determined of probable occurrence in Eng Neo Avenue Forest, including 15 of conservation significance (Table 7-14; Appendix H1).

The assemblage recorded in these areas includes both common and uncommon species. Sightings here may be contributed by the diversity of waterbodies present. Shallow puddles of water within the open country habitats along the old road provide habitats for common species such as the yellow-barred flutterer (*Rhyothemis phyllis*), and uncommon species such as the sapphire flutterer (*Rhyothemis triangularis*). Large ponds also attract species such as the emperor (*Anax guttatus*), where exuviae of this species was found at the anaerobic pond. The sultan (*Camacinia gigantea*) and common redbolt (*Rhodothermis rufa*) were also recorded at this pond. The stream (D/S14) also provides habitat for forest stream-associated species such as the yellow featherlegs (*Copera marginipes*) and shadowdancer (*Idionyx yolanda*). Along the stream, records of odonates were generally poor except for the northern part upstream.

All species were considered widespread, but some uncommon species were observed – the sultan (*Camacinia gigantea*), sapphire flutterer (*Rhyothemis triangularis*), dingy duskhawker (*Gynacantha subinterrupta*), and the non-probable fiery coraltail (*Ceriagrion chaoi*). The most notable sighting was the fiery coraltail (*Ceriagrion chaoi*). Though neither globally nor nationally threatened, this is a rare and uncommon species that was recorded once along terrestrial sampling route beside the stream, D/S14. This species inhabits ponds and slow-flowing streams with submerged water plants, which was observed mainly in the upstream of D/S14. The upstream habitat appears more favourable for the fiery coraltail, thus explaining the sighting here. This species was regarded as non-probable as it had only been recorded in Bishan Park, MacRitchie Reservoir and a pond in Commonwealth. As the population at Bishan Park no longer exists (Tang, pers comm.), the distribution records of this species have been reduced. The sighting of this species at Eng Neo Avenue Forest, is therefore, noteworthy. The sapphire flutterer (*Rhyothemis triangularis*); inhabits ponds and sluggish streams (Tang et al., 2010). It can be observed outside of CCNR, such as Marina East and Bishan Park. This species was frequently noted along the old gravel road, where shallow man-made waterways and large pond also lie. While not ideal habitats for this species, it is likely able to make use of such habitats. It was also seen once at the northern tip of the stream.



Figure 7-42 (A) Fiery Coraltail (*Ceriagrion chaoi*) and (B) Sapphire Flutterer (*Rhyothemis triangularis*) and (C) Dingy Duskhawker (*Gynacantha subinterrupta*)





**Figure 7-43 Favourable Habitat for the Fiery Coraltail (*Ceragrion chaoi*) due to Presence of Submerged Water Plants in the Upstream of Eng Neo Avenue Forest Stream D/S14**

#### **7.3.2.4.5 Butterflies**

A total of 167 butterfly species were deemed of probable occurrence within Eng Neo Avenue Forest and 13 are of conservation significance (Table 7-14; Appendix H1). The field assessment recorded 64 species of butterflies, including three only identified to the genus or family level – *Miletus* Sp., *Nacaduba* sp. and Theclinae. Butterfly traps recorded four species – common palmfly (*Elymnias hypermnestra agina*), dark brand bush brown (*Mycalesis mineus macromalayana*), and *Tanaecia* sp.

Three species of conservation significance were recorded. Among them, the nationally Vulnerable common rose (*Pachliopta aristolochiae asteris*) and common birdwing (*Troides helena cerberus*) are now considered moderately common as its host plant is frequently planted in the urban landscape. They share a host plant, *Aristolochia acuminata*, which was also observed in the Study Area. They were observed in multiple locations across the Study Area (Figure 7-44). Lastly, the nationally extinct common palm dart (*Telicota colon stinga*) is a rediscovered species which is now regarded as moderately common due to clarification in field identification. Two individuals were recorded once in the eastern part of the Study Area.

While not listed as threatened, the Malayan jester (*Symbrenthia hippoclus selangorana*) was observed once along the old road (Figure 7-44). It was first discovered in 2012 in the western part of Singapore and was regarded as a very rare seasonal migrant (Khew et al., 2019). Recent sightings in the northern (Admiralty Park) and central (Dairy Farm area; Bukit Timah Hill) parts of Singapore suggest a breeding population here (Khew et al. 2019). Therefore, the record of this species here is of significance.





Study Area

Worksite and alignment (Base)

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route 1

Terrestrial sampling route 2

Butterfly species of conservation significance

P. a. asteris

T. c. stinga

T. h. cerberus

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
**CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
(WINDSOR AND  
ENG NEO AVENUE FOREST)**

Designed JW	Checked JAG	Approved JAG
	Drawn JW	Date JUN 2022

Land Transport Authority  
We Keep Your World Moving

Figure Title :  
**LOCATIONS OF BUTTERFLY SPECIES  
OF CONSERVATION SIGNIFICANCE AT  
ENG NEO AVENUE FOREST**

Figure No. : 7 - 44	Rev. -	Sheet 1 of 1
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CAD File Name : NA

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Note: Source of basemap - Google Earth Map

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#### 7.3.2.4.6 **Freshwater Decapod Crustaceans**

Only two species, the native maculate freshwater crab (*Parathelphusa maculata*) and the non-native ghost shrimp (*Macrobrachium lanchesteri*), were considered of probable occurrence (Table 7-14; Appendix H1). Both species were not recorded, suggesting poor habitat suitability for these species.

#### 7.3.2.4.7 **Freshwater Fish**

The desktop assessment identified 11 species of probable occurrence at the Study Area, with six species being recorded (Table 7-14; Appendix H1). Four of these were native species while two are non-native. The two non-native species are the guppy (*Poecilia reticulata*) and Indochinese spotted barb (*Barbodes rhombeus*).

Richness of freshwater fish was generally low throughout the stream D/S14. The highest richness (4 species) was recorded in the middle of stream channel. These sampling points were similar; both were deeper sections of the stream and as such had sufficient volume to host larger-bodied, predatory species (common walking catfish, *Clarias* cf. *batrachus* and ghost shrimp, *Channa striata*). The most upstream location at the culvert also holds a larger volume of water and likely supports these species as well. However, the point is too deep to safely sample in and visual surveys were impaired by the cloudy water in the site.

While its local and global conservation statuses are yet to be assessed, the presence of the common walking catfish (*Clarias* cf. *batrachus*) is of significance. Though a previously widespread species in the non-forested waterways of Singapore, it has seen a marked decline in its populations outside of the central reserves due to competition and displacement from the invasive African sharp-tooth catfish (*Clarias gariepinus*) (Ng et al., 2014). It was recorded thrice in the D/S14 stream during visual surveys at night. The existing stream habitat thus has value in supporting the populations of the species in Singapore.

#### 7.3.2.4.8 **Amphibians**

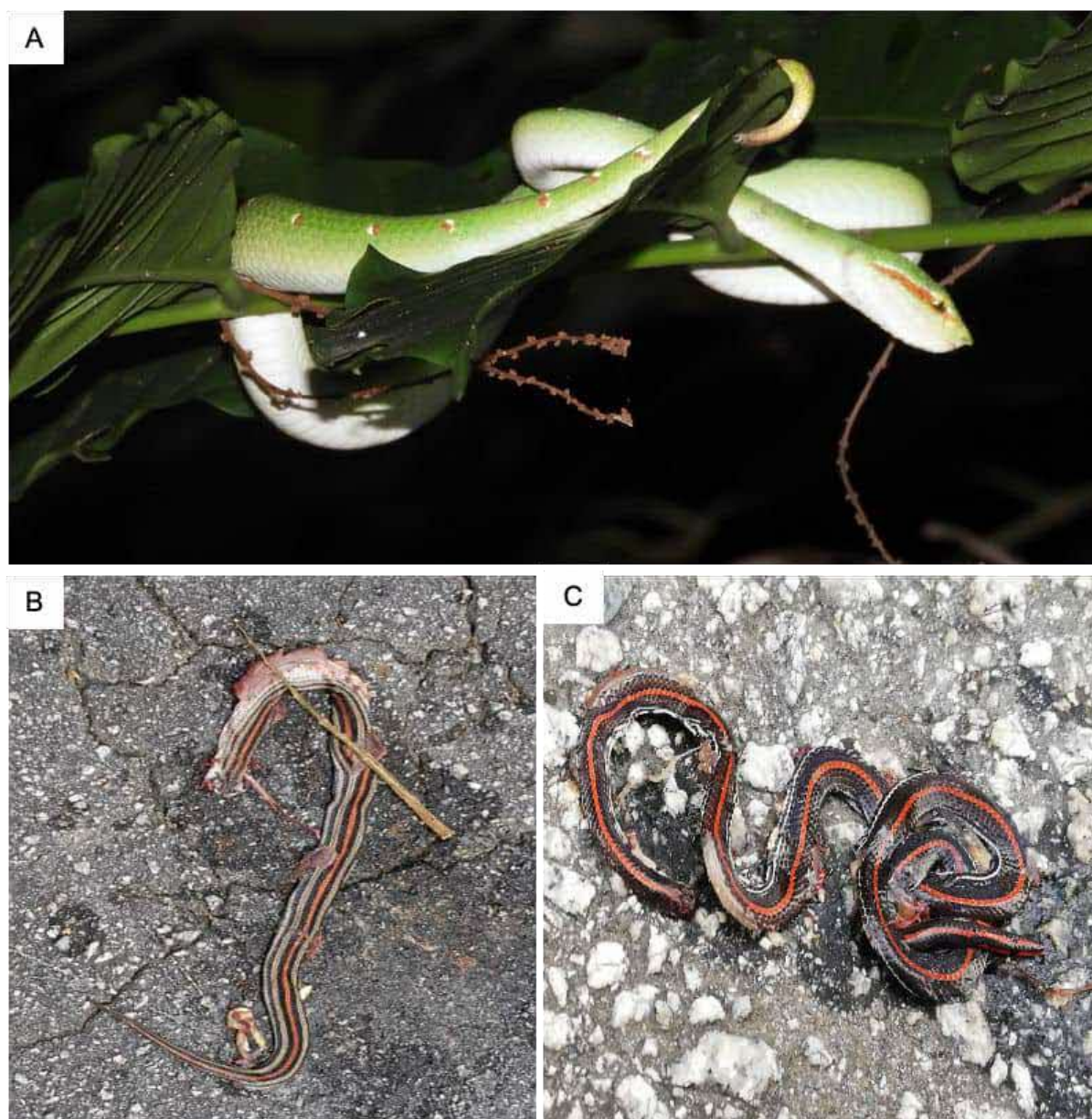
A total of 16 amphibians, none of conservation significance, were deemed of probable occurrence. The field assessment recorded six amphibian species (Table 7-14; Appendix H1). No species of conservation significance was recorded.

#### 7.3.2.4.9 **Reptiles**

The probable species list amounted to 32 reptiles comprising three terrapins, 12 lizards and 17 snakes. Of this, two species (one snake and one terrapin) were of conservation significance. The field assessment recorded 14 reptiles, which were mostly widespread and common (Table 7-14; Appendix H1). No species of conservation significance was recorded.

Two nationally Near Threatened snakes, namely the red-necked bronzeback (*Dendrelaphis kopsteini*) and the Wagler's pit viper (*Tropidolaemus wagleri*), were recorded in the central part of the Study Area. The red-necked bronzeback can be found in the CCNR, as well as suburban and rural areas. The Wagler's pit viper was not deemed of probable occurrence since it inhabits mature forests and was thought to be restricted to the CCNR (Baker & Lim, 2012). A male individual was recorded once within the forest in the northern part of the Study Area. Notably, the habitats located along the western terrestrial sampling route (T1) appears favourable for painted bronzebacks (*Dendrelaphis pictus*), with 53 individuals being recorded in one night. This may be attributed to the presence of waterbodies and grasslands that the bronzebacks prefer (Alex Figueroa, pers comm). Three species were recorded from roadkills along Fairways Drive, namely the striped kukri snake (*Oligodon octolineatus*), striped bronzeback (*Dendrelaphis caudolineatus*) and banded Malayan coral snake (*Calliophis intestinalis*) (Figure 7-45).





**Figure 7-45 Reptiles Sighted in Eng Neo Avenue Forest. (A) Wagler's Pit Viper (*Tropidolaemus wagleri*); (B) Striped Kukri Snake (*Oligodon octolineatus*); (C) Banded Malayan Coral Snake (*Calliophis intestinalis*).**

#### 7.3.2.4.10 Birds

A total of 162 species of birds were deemed of probable occurrence, of which 104 are resident (15 introduced), 1 is an introduced non-resident and 57 are migrant/visitor species (Table 7-14; Appendix H1). The contiguity of the Study Area to the larger CCNR in the east also means that rarer forest-dependent species were expected.

The field assessment recorded 72 species which comprised 54 resident (44 native and 10 introduced) and 15 migrant/visitor species (Table 7-14; Appendix H1). The remaining three species were recorded only to genus or family level, hence not classified by their native status. Three birds were only recorded from camera traps. Of note is the slaty-breasted rail (*Gallirallus striatus*) that was recorded once in the centre portion of the Study Area (CT\_03) where a large pond lies nearby.

Migratory species recorded comprise common and uncommon species, except for two rare species. Of note is the Sakhalin leaf warbler (*Phylloscopus borealoides*) that was heard once in the southern tip of the Study Area. This species is considered a rare accidental visitor, with the first wintering record confirmed in 2014 (Yap et al., 2014). It has since been sighted from the BTNR and MacRitchie Reservoir Park (NSS, 2018). The green-backed flycatcher (*Ficedula elisae*) was seen once in the northern tip of the Study Area. It has been sighted in CCNR (Yong et al., 2016). The uncommon crested honey buzzard (*Pernis ptilorhynchus*) was recorded incidentally feeding on the hive of giant honeybee (*Apis dorsata*) in the southern part of the Study Area (Figure 7-47). An unidentified raptor nest



was also observed nearby (Figure 7-46). While none are of conservation significance, these records show the value of the Study Area in providing habitats for some uncommon and rare migratory species.

Of the 23 probable conservation significant species, eight were recorded (Table 7-14; Appendix H1). Sightings were distributed across the Study Area. Most of these species were previously regarded as rare but have since increased in range and numbers such as the changeable hawk-eagle (*Nisaetus cirrhatus*) and the blue-crowned hanging-parrot (*Loriculus galgulus*). They are now regarded as common or uncommon locally (NSS, 2020; Singapore Birds Project, 2020). The nationally Endangered thick-billed green pigeon (*Treron curvirostra*) is a forest-dependent species with an estimated population of between 100 and 200 birds (NParks, 2019). This species is an indicator of the quality of the remaining forest in Singapore and a seed disperser that helps to maintain tree populations (NParks, 2019). It has been increasing in range and abundance (Lim & Yong, 2013). It was seen twice incidentally in the northern part of the Study Area (Figure 7-46). Similarly, the nationally Vulnerable rusty-breasted cuckoo (*Cacomantis sepulcralis*) was heard once here. Also, the globally and nationally threatened straw-headed bulbul (*Pycnonotus zeylanicus*) was heard several times across Eng Neo Avenue Forest, suggesting the value of the Study Area in supporting this species.









**Figure 7-47 Crested Honey Buzzard (*Pernis ptilorhynchus*) Feeding on the Hive of Giant Honeybee (*Apis dorsata*) in the South of Eng Neo Avenue Forest**

#### **7.3.2.4.11 Non-volant mammals**

Despite the barrier effect created by the PIE, some uncommon or rare forest-specialists were expected to occur due to proximity of the CCNR. Of note is the record of Sunda slow loris (*Nycticebus coucang*) to the east of the Study Area across the PIE (ERM, 2016), although it is unlikely for the existing population to cross the PIE to the Study Area. The nationally Critically Endangered Sunda pangolin (*Manis javanica*) was considered of probable occurrence as it has been recorded from the nature reserves and degraded forest fragments (Nash et al. 2020).

A total of 20 species of non-volant mammals were deemed of probable occurrence (Table 7-14; Appendix H1). Most species of probable occurrence are widespread, common, and tolerant of disturbance. More records were observed in the northern and southern part of the Study Area (Figure 7-48). Subsequently, the Sunda slow loris, Horsfield flying squirrels and lesser mousedeer were added as probable species, due to their presence in the Sime forest across the PIE (o'dempsey, pers comm.).

Visual surveys and camera trapping documented 9 species of non-volant mammals (Table 7-14; Appendix H1), including the Sunda colugo (*Galeopterus variegatus*) and Sunda pangolin (*Manis javanica*). Species not recorded include murids and feral cats and dogs. Most recorded species are known to occur in degraded secondary forests. Examples are the Oriental house rat (*Rattus tanezumi*), common treeshrew (*Tupaia glis*), wild pig (*Sus scrofa*) and common palm civet (*Paradoxurus musangus*). The slender squirrel (*Sundasciurus tenuis*), which is largely restricted to the CCNR was sighted once in the eastern part of the Study Area. A roadkill of the common palm civet (*Paradoxurus musangus*) was also noted along Eng Neo Avenue, located 150 m south of the Fairways Drive.

The forest-dependent Sunda colugo was observed six times. Sightings were distributed across the site but there were more records in the northern tip. They were recorded at heights between 6 to 12 m. Sightings in the north may be due to presence of tall trees and closed canopy as compared to relatively open woodland habitats in the rest of the site. The nationally Near Threatened Sunda colugo is a species of interest as it is largely restricted to the CCNR and its surrounding forests, although it has been sighted in discreet forest patches (Bromley et al., 2019). The globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*) was recorded by camera traps at three locations across the Study Area (CT01, CT03 and CT04).





**Legend**

Study Area

Worksite and alignment (Base)

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route 1

Terrestrial sampling route 2

Mammalian species of conservation significance or interest

M. javanica

M. fascicularis

G. variegatus

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
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Figure Title :  
**LOCATIONS OF MAMMALIAN SPECIES  
OF CONSERVATION SIGNIFICANCE  
OR INTEREST AT  
ENG NEO AVENUE FOREST**

Figure No. : 7 - 48	Rev. -	Sheet 1 of 1
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**Figure 7-49 An Individual of the Sunda colugo (*Galeopterus variegatus*) Sighted within Eng Neo Avenue Forest**

The 6 camera traps yielded 358 independent detections and 8 species of mammals over 435 trap-nights (Table 7-17; Table 7-18). The list of camera trap data is available in Appendix J1. The most commonly recorded was the plantain squirrel (*Callosciurus notatus*) with 111 independent detections. Notably, the Sunda pangolin (*Manis javanica*) was recorded over five occasions at four locations (CT01–CT04) across the Study Area. The highest mammal richness (7 species) was recorded at CT\_03 in the central part of the site. However, the highest mammal detection rate was recorded at CT\_05 (3.3 independent detections per trap-night).

**Table 7-17 Locations and Number of Independent Detections of Mammalian Species at Eng Neo Avenue Forest**

Species	Common Name	CT Location	No. of Independent Detections
<i>Callosciurus notatus</i>	Plantain squirrel	All (01–06)	111
<i>Macaca fascicularis</i>	Long-tailed macaque	03	1
<i>Manis javanica</i>	Sunda pangolin	01–04	5
<i>Paradoxurus musangus</i>	Common palm civet	04, 05	3
<i>Rattus</i> sp.	Rat	01–03, 05–06	45
<i>Sundasciurus tenuis</i>	Slender squirrel	02–05	6
<i>Sus scrofa</i>	Wild pig	01–06	43
<i>Tupaia glis</i>	Common treeshrew	All (01–06)	144
<b>Total</b>			<b>358</b>

**Table 7-18 Number of Species and Detection Rate of Mammals Recorded at Each Camera Trap within Eng Neo Avenue Forest**

Station	No. of Trap Nights	No. of Mammalian Species Recorded	Detection Rate of Mammals
CT_01	62	5	0.3
CT_02	109	6	1.1
CT_03	62	7	0.6
CT_04	62	6	0.4
CT_05	65	6	3.3
CT_06	75	4	0.3



#### 7.3.2.4.12 Bats

Ten bat species were deemed of probable occurrence within the Study Area (Table 7-14; Appendix H1). Of these, seven species were recorded via visual surveys and acoustic sampling (Table 7-14; Appendix H1).

Two species of bats recorded in Eng Neo Avenue Forest are known to be forest-specialists, namely the Vulnerable cave nectar bat (*Eonycteris spelaea*) and the unassessed glossy horseshoe bat (*Rhinolophus refulgens*) (Figure 7-51). One individual of the cave nectar bat was caught on mist net in the southern region of the Study Area amongst more common lesser dog-faced fruit bats (*Cynopterus brachyotis*). The glossy horseshoe bat was trapped in harp trap in the northern area of the Study Area, and documented once via acoustic sampling. It was thought to be confined to CCNR (Baker & Lim, 2012). Both these forest-specialised bat species feed on different resources – the cave nectar bat feeds on nectar and is a key pollinator for many tree species (Thavry et al., 2017) while the glossy horseshoe bat eats insects (Pottie et al., 2005). The presence of both these species at Eng Neo Avenue Forest indicates that the forests at the site are capable of supporting both habitat-specialists with different niches. The other two species recorded were the common Asiatic lesser yellow house bat (*Scotophilus kuhlii*) and whiskered myotis (*Myotis muricola*) which are known to utilise suburban and rural areas. They were recorded via acoustic sampling.

Two species of bamboo bats are found in Singapore: the lesser bamboo bat (*Tylonycteris fulvida*) and the greater bamboo bat (*T. malayana*). The acoustic signatures of the two species overlap, thus making it difficult to distinguish the species without handheld specimens. As both species are nationally Vulnerable, the bamboo bat species was considered a species of conservation significance. Out of five bamboo clusters were surveyed, visual roost emergence surveys detected roosting of bamboo bats in three clusters (BB\_01, BB\_03 and BB\_04). Bamboo bats were also detected acoustically at BB\_02 although roosting was not confirmed. Lastly, although presence of bamboo bat was not detected at BB\_05, it remains as a potential roosting site due to the presence of slits.





**Legend**

Study Area

Worksite and alignment (Base)

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route 1

Terrestrial sampling route 2

Bat species of conservation significance

enaf old cs

Tylonycteris sp.

E. spelaea

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG
Rev.	Date	By	Description	Chk'd	App'd

Qualified Person Endorsement :  
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LTA Endorsement :  
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**LOCATIONS OF BAT SPECIES  
OF CONSERVATION SIGNIFICANCE AT  
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**Figure 7-51 Bats Recorded from Bat Trapping in Eng Neo Avenue Forest: (Left) Glossy Horseshoe Bat (*Rhinolophus refulgens*), and (Right) Cave Nectar Bat (*Eonycteris spelaea*)**

### 7.3.3 Sites I and II

#### 7.3.3.1 Habitat and Vegetation Types

Sites I and II comprise two vegetated zones located east and west of an unnamed road, collectively comprising eight habitat and vegetation types (Table 7-19; Figure 7-52). Mixed forest is the largest at 5.1 ha, which is approximately one-third of the Study Area. It occupies the southern half of the western zone and majority of the eastern zone, both of which are bordered by roads and other infrastructure. The native-dominated secondary forest, abandoned-land forest, as well as scrubland and herbaceous vegetation are roughly 3 ha each. There are three patches of native forest, where the largest occupies the northern half of the western zone. Abandoned-land forest is mostly in the southern half of the eastern zone. Scrubland and herbaceous vegetation occur in several small patches throughout the Study Area, where they were found along forest edges and within the forest interior. Managed vegetation is the next largest habitat type, where two patches located in the northern half of the eastern zone take up about 8% of the total area. The combined area of the remaining habitat types makes up 10% of the Study Area, namely, in descending order, infrastructure and two waterbodies.

**Table 7-19 Absolute (Ha) and Relative (%) Sizes of Each Habitat and Vegetation Type in Sites I and II**

	Absolute size (ha)	Relative size (%)
Native-dominated Secondary Forest	2.9	17.1
Abandoned-land Forest	3.0	18.1
Mixed Forest	5.1	30.5
Scrubland and Herbaceous Vegetation	2.7	16.2
Managed Vegetation	1.4	8.4
Others (Infrastructure)	1.3	7.5
Waterbody*	0.4	2.5
<b>Total Area*</b>	<b>16.8</b>	<b>100.0</b>

Note: The waterbodies in the Study Area partially overlap with the study boundary but were drawn as complete units beyond the arbitrary study boundary to accurately assess their ecological values. Hence the total area reported here is slightly larger (by about 0.1 ha) than the original size of the Study Area.





**Legend**

- Study Area
- Worksites, access roads and alignment (Mitigated)
- Vegetation
  - Native-dominated secondary forest
  - Mixed forest
  - Abandoned-land forest
  - Scrubland and herbaceous vegetation
  - Managed vegetation
  - Waterbody
  - Others (infrastructure)

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

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NA

Consultant :  
**AECOM**

Project Title :  
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(WINDSOR AND  
ENG NEO AVENUE FOREST)**

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Figure Title :  
**VEGETATION DISTRIBUTION OF FORESTED  
AREA ADJACENT TO FAIRWAYS QUARTERS**

Figure No. : 7 - 52	Rev. -	Sheet 1 of 1
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### 7.3.3.1.1 *Native-dominated Secondary Forest*

Native-dominated secondary forest is the third-largest habitat type in the Study Area (Table 7-19). It is made up of three separate patches, which together add up to 2.9 ha. The features of the native patches here are similar to those in the Eng Neo Avenue Forest in that they are hotspots with a diverse pool of common and rare native species more typically found in old secondary forests.

Unique to the largest patch in the western zone is the presence of fairly large trees of rare native species. For example, at least one *Ficus glandulifera* and two *Actinodaphne macrophylla* trees of at least 1 m girth were recorded during floristic surveys. The former is a nationally Critically Endangered species, and the tree was observed to be producing figs at the time of survey (Figure 7-61D), while the latter was thought to be nationally Extinct but has been rediscovered in recent years. These mature specimens play an important role in ensuring constant supplies of native propagules for the continued survival of the threatened species. Such forested patches may, as a result, serve as additional refuge for rare species such that they are also able to persist elsewhere in Singapore outside the CCNR.

Also present in this area of hotspot are common native species in the understory, such as *Gironniera nervosa*, *Xylopia malayana*, *Elaeocarpus ferrugineus*, and *Morella esculenta* (Figure 7-53A–D). Although listed as nationally Common, these species are not typically found in the young and disturbed secondary forests of Singapore. Instead, their presence tends to be characteristic of more mature native secondary forests. Additionally, a few *Rhodamnia cinerea* trees still persist in the area; this tree species—as well as other species belonging to other genera—typically characterises forests in the post-adinandra belukar successional stage (Gilliland, 1958; Yee et al., 2016).

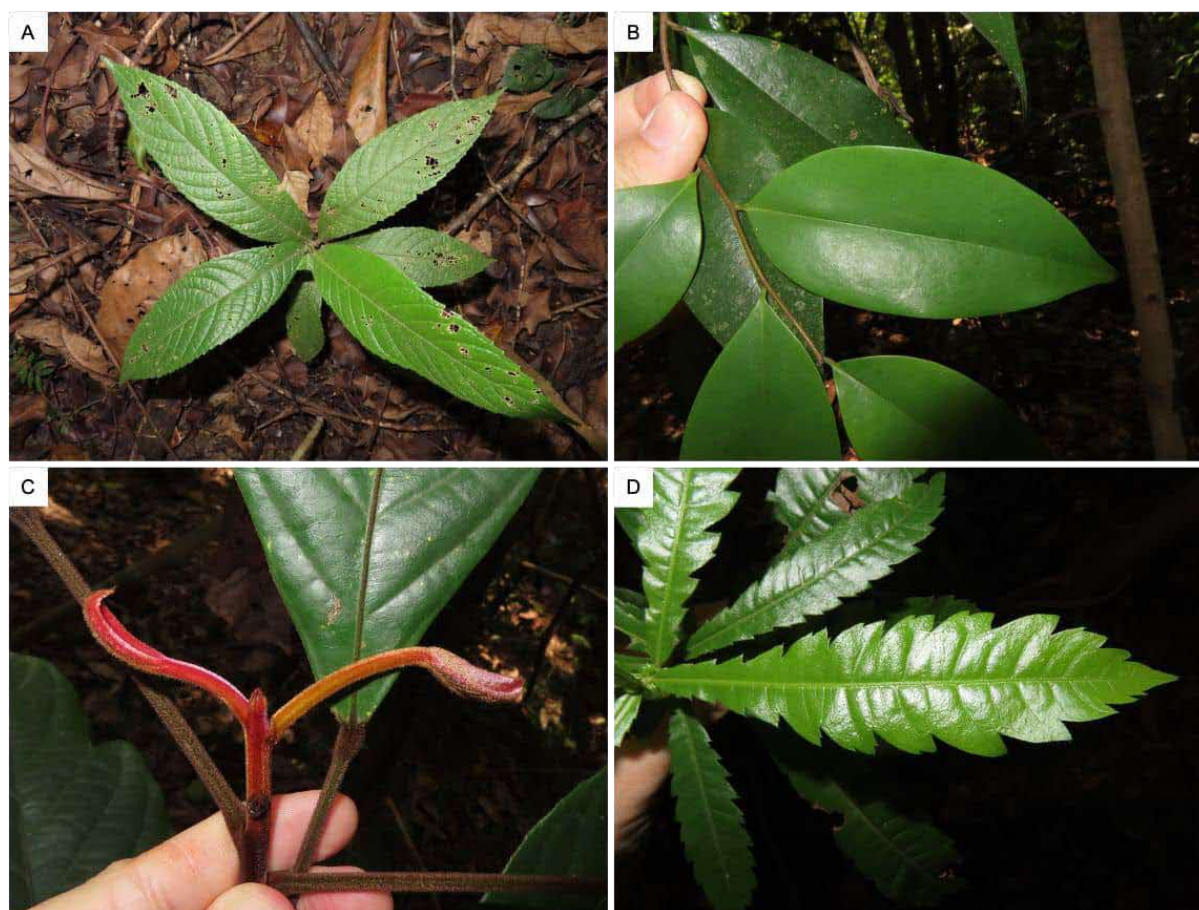
The corroboration of the aforementioned observations suggests that this native patch could be the remnant of what was initially a continuous native-dominated secondary forest connected to the larger fragment of the CCNR and is in the later stages of forest succession. Another feature that distinguishes this patch from the other native patches in the Study Area is the fairly large population of the nationally Vulnerable *Alsophila latebrosa* at the wetter areas of the northern portion. This tree fern species has often been observed to grow near streams and in areas with wet/poor-draining soils. All in all, this patch of native forest in the western zone hosts a relatively rich and diverse group of native species, which was a surprising find considering the extent of disturbance and fragmentation it had undergone.

The second largest patch of native forest is within the circular horse track in the middle of the eastern zone (Figure 7-52). This patch is mostly surrounded by mixed forest, where planted exotic trees have grown to very large sizes, hosting a wide diversity of epiphytes and climbers (see Section 7.3.3.1.3 for the habitat description of the mixed forest). One of the epiphytic plants found to be widespread in the area is the nationally Endangered orchid species *Bulbophyllum vaginatum* (Figure 7-62B). The orchids were found to be widespread and abundant throughout the area; many were growing on the exotic trees alongside other epiphytes. Outside this central patch, the orchids were neither observed nor recorded in the Study Area. In addition, of particular interest in this native area is the presence of large nationally Critically Endangered *Ficus kerkhovenii* stranglers. One spanned at least a staggering 14 m in width (Figure 7-65A–B). The specimen was observed to be strangling two large exotic rain trees (*Samanea saman*). This rare strangler species is more commonly associated with coastal areas. Nevertheless, even in its more commonly-associated coastal habitats, such large specimens are exceedingly rare in Singapore. As such, records of such specimens in the Study Area, which are much further inland, are very valuable and noteworthy. Other surprising finds in this patch are the exceedingly rare *Baccaurea pyriformis* (Figure 7-61C) and *Aporosa nigricans* (Figure 7-62A) (refer to Section 7.3.3.2.2 for the description of these species of conservation significance).

The third and smallest native patch is located north of the eastern zone, surrounded by scrubland and herbaceous vegetation, managed vegetation, a road, and mixed forest. Although small fragmented and surrounded by areas with human disturbances, some species more commonly found in old growth secondary forests seem to still be persisting here, such as *Gironniera nervosa* (Figure 7-53A). Large tembusu trees (*Cyrtophyllum fragrans*) were also recorded here, as well as throughout the Study Area. This slow-growing species, although planted in streetscapes, would take a long time to attain their present-day large sizes, before which they were not sold in commercial markets for streetscape planting. This implies that the specimens are most likely of native stock and belong to the native forest that was present before there were human disturbances.

The close proximity of the CCNR and Eng Neo Avenue Forest allows for constant and steady dispersal rates of propagules among the native patches. If left undisturbed, the entire area may eventually regenerate into a late-stage successional forest.





**Figure 7-53 Nationally Common Native Plant Species in the Native-dominated Secondary Forest of Sites I and II. (A) *Gironniera nervosa*; (B) *Xylopia malayana*; (C) *Elaeocarpus ferrugineus*; (D) *Morella esculenta*.**

#### 7.3.3.1.2 Abandoned-land Forest

Abandoned-land forest (3.0 ha; 18.1%) is the second largest habitat type, located at the southern half of the eastern zone and middle portion of the western zone. For the former, old topographical maps dating between 1974 and 1983 show that the area was “sundry tree cultivation”, which is a term previously used to refer to abandoned-land forest (Yee et al., 2016). Remnant trees from past plantations occupy the canopy layer, mostly by the African tulip (*Spathodea campanulata*), mango (*Mangifera* sp.; Figure 7-54C), rambutan (*Nephelium lappaceum*; Figure 7-54A), and durian (*Durio zibethinus*; Figure 7-54B). The understorey is largely dominated by wild cinnamon (*Cinnamomum iners*), *Aphanamixis polystachya*, rambutan saplings (*N. lappaceum*), with African oil palms (*Elaeis guineensis*; Figure 7-54D) scattered across this habitat type. Findings of threatened native plant species, such as the nationally Vulnerable *Horsfieldia polyspherula* and *Litsea firma*, Endangered orchid *Bulbophyllum vaginatum*; Critically Endangered *Calophyllum inophyllum* and *Piper pedicellosum* were occasionally recorded in this habitat type as well.

In the middle section of the Study Area, majority of the canopy layer was dominated by the African tulip trees. The understorey is also made up of diverse plant species, such as the wild cinnamon, rambutan, *Claoxylon indicum*, and fishtail palm (*Caryota mitis*). Some specimens belonging to species of conservation significance, like the nationally Endangered *Calophyllum rubiginosum* and *Ficus globosa*, and nationally Vulnerable *Guioa pubescens* and *Planchonella obovata*, were also found in this area.





**Figure 7-54 Common Crop Plant Species in the Abandoned-Land Forest of Sites I and II. (A) Rambutan; (B) Durian; (C) Mango; (D) Oil Palm.**

#### 7.3.3.1.3 Mixed Forest

Mixed forest is the largest habitat type found in the Study Area, taking up 5.1 ha (30.5%) (Table 10-21). This habitat type, as defined in this study, is overgrown past streetscape and urban plantings with native recruits that are likely propagules from the nearby native patches. With the previous urban plantings abandoned and left to regenerate, this forest type is characterised by a mix of large exotic trees with native epiphytes growing on them, as well as young native saplings and treelets in the understory. Most of the exotic trees, which are relics from past urban plantings in the Study Area, are rain trees (*Samanea saman*) (Figure 7-55B; Table 7-23; Appendix E2). Not only do they naturally host epiphytic plants, they also provide a diverse range of microhabitats for fauna and other organisms.

Besides supporting exotic trees, the mixed forest is also interspersed by dense and overgrown *Baphia nitida*, a shrub species commonly planted as hedges in streetscapes (Figure 7-56D). Left unmanicured and unmaintained, the shrubs were observed to have grown vigorously and formed extensive patches of scrubland. These areas were mostly species-poor, perhaps owing to the strong species dominance that suppress the growth of other plants.

Based on the vegetation map by Gaw et al. (2009), the area here used to be “Vegetation with structure dominated by human management” with and without tree canopy. While an area as such is expected to be exotic-dominated and species-poor, it shows surprising signs of recruitment of native propagules, some of which are rare and nationally threatened. Several native species were recorded in the mixed forest habitat during floristic surveys. This includes the nationally Endangered epiphytic orchid species, *Bulbophyllum vaginatum*, which was found to be widespread and abundant in this habitat type. Other rare native species recorded here include the fern species, *Asplenium nitidum* (thought to be national Extinct but has been rediscovered in recent years), the nationally Endangered tree species *Calophyllum tetrapterum*, and nationally Vulnerable *Litsea firma*. Some native stranglers, such as *Ficus microcarpa*, were also seen growing over the abandoned infrastructure, such as concrete walls (Figure 7-55A).

A small fragment of what is categorised as mixed forest in this study has been partially cleared and maintained by humans (Figure 7-55A–B). This is a thin stretch of vegetation along Turf Club Road, opposite the Bukit Timah Junkyard and Turf Club Antique Shop. The area, although partially cleared and possibly maintained by humans,



the tree canopy is still occupied by exotic tree species. The canopy layer is a mix of recently-planted trees and those from past cultivation. The understory, however, has mostly been cleared with little to no vegetation; man-made items such as swings, jugs, etc. are placed there, presumably from the nearby junkyards.

These forested areas surrounding the native patches are also important habitats with several specimens of conservation significance, albeit in lower concentrations. If left to regenerate, they may eventually succeed into a native-dominated forest as a result of natural ecological processes.



**Figure 7-55 Mixed Forest in Sites I and II. (A) A large *Ficus microcarpa* Strangler Growing Over a Concrete Wall (Arrowed); (B) A large Rain Tree (*Samanea saman*) of 4.6 m Girth.**

#### 7.3.3.1.4 Scrubland and Herbaceous Vegetation

Scrubland and herbaceous vegetation occupy up to 16.2% (2.7 ha) of Sites I and II. Numerous random patches of scrubland are scattered across the forested area, and various different sub-types of this vegetation were observed. Among the sub-types, one is existing scrublands that seem to have remained as semi-open canopy patches within the forested area for a long period of time (Figure 7-56A). Based on satellite images dating the early 2000s, these scrubland patches most likely formed from the time of vegetation clearance in the past but still persist today even though the area was most likely left untouched since. These scrublands are dominated by the broad sword fern (*Nephrolepis biserrata*) and *Ottochloa nodosa*, which thrive best in environments with open canopy and high incidence of sunlight.

The other sub-type is mostly located at the northern half of the western zone, within the native dominated forest. These patches of scrubland are dominated by the resam fern (*Dicranopteris linearis*; Figure 7-56B), mostly in open canopy areas. As a sun-loving species, the ferns most likely established themselves when the areas are fairly open and receive high light levels; they, however, would most likely be shaded out by the canopy as the surrounding trees grow, such as those of the pioneer species nearer towards the forest edge. Scrublands can also form when there are tree falls which create gaps in the canopy. Following tree fall events, sun-loving ferns and herbaceous vegetation tend to occupy the spaces and collectively form patches of scrubland in the open-canopy areas (Figure 7-56C).

In addition, scrubland covered with a dense layer of camwood (*Baphia nitida*) shrub (Figure 7-56D) were also found. This sub-type was recorded in the southern side of the eastern zone, in proximity to the Eng Neo Avenue.



*B. nitida* is a shrub species commonly planted as hedges along the streetscapes, including the nearby Eng Neo Avenue Forest. If not maintained and pruned regularly, as in the case in the Study Area, this species is able to overgrow and encroach into adjacent forested areas. This would result in extensive patches of scrubland dominated by the single species, which was recorded in the present study.



**Figure 7-56 Scrubland and Herbaceous Vegetation In Sites I and II. (A) Scrubland Within a Forested Patch; (B) Dominant Species in This Scrubland, *Dicranopteris linearis*, Getting Shaded Out by Larger Trees; (C) Open Canopy Formed by Tree Falls; (D) Dense *Baphia nitida* Shrubs.**

#### 7.3.3.1.5 *Managed Vegetation*

There are two main patches of managed vegetation in the Study Area. The larger patch is located at the northern half of the eastern zone. It consists of managed turf and scattered trees, bordering the premises north of the Bukit Timah Saddle Club where equestrian training is often being held (Figure 7-57A). Some of the common trees recorded here are the angkana (*Pterocarpus indicus*; Figure 7-57B), rain trees (*Samanea saman*), and tembusu (*Cryptophyllum fragrans*). These trees are periodically pruned and maintained as they are located in close proximity to the training areas and other amenities, such as carparks. *Syzygium myrtifolium* is also planted in these areas as hedges which are regularly maintained as well (Figure 7-57B).

The second patch of managed vegetation is located south of the Bukit Timah Saddle Club. Here, clusters of *Syzygium grande* trees with few specimens of exotic trees, such as *Acacia auriculiformis*, saga (*Adenanthera pavonina*) and African tulip (*Spathodea campanulata*) were planted on turf (Figure 7-57C). A Sunda colugo (*Galeopterus variegatus*; Figure 7-57D) was also opportunistically sighted on one of the *Syzygium grande* trees during floristic surveys.



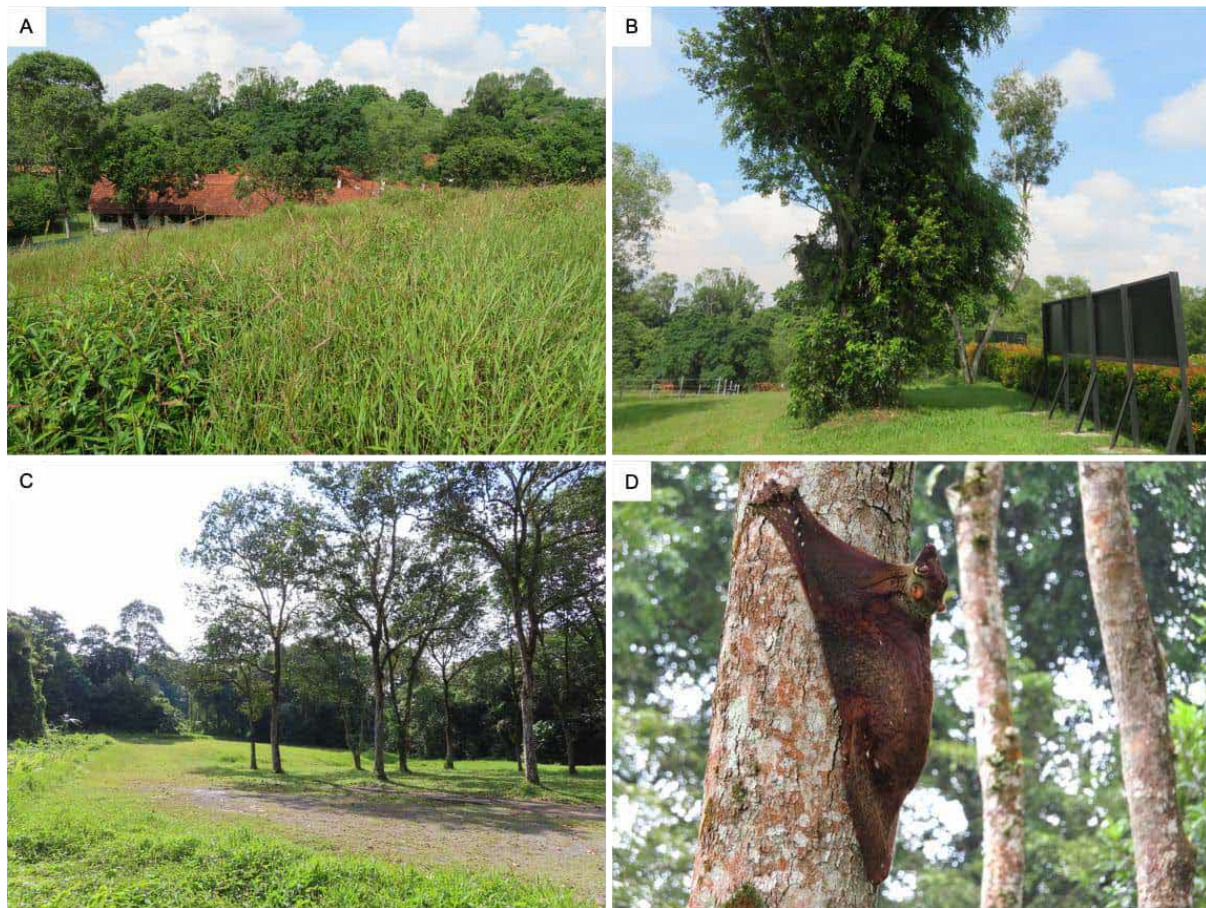


Figure 7-57 Managed Vegetation in Sites I and II. (A–B) near the Bukit Timah Saddle Club; (C–D) South of the Bukit Timah Saddle Club, Where A Sunda colugo was Opportunistically Sighted.

#### 7.3.3.1.6 Others (Infrastructure)

Infrastructure within the Study Area includes concrete roads and sand pathways that are now used by horses (Figure 7-58A-B). There are also abandoned infrastructure as well as water pump rooms (Figure 7-58C). These buildings are located within the forested areas, some of which were enclosed within dilapidated green chain-linked fences (Figure 7-58D). Multiple concrete culverts and drains were also present within the Study Area (Figure 7-58E).





**Figure 7-58 Infrastructure in Sites I and II. (A–B) Concrete and Sand Pathways for Horses; (C–D) Abandoned Buildings within Green Chain-Linked Fences and with Overgrown Vegetation; (E) A Culvert; (F) Abandoned Amenities.**

#### 7.3.3.1.7 *Waterbodies*

Within Sites I and II, naturalised and concretised ponds and streams are present (Figure 7-59). The locations and alignment of the waterbodies is shown in Figure 7-2.

There is a single stream system that runs from north to south on the western edge of Site I (Figure 7-59A–D). The waterway flowing through the site encompasses narrower, slow flowing streams where parts of the old concrete drain has been filled with soil and leaf debris, naturalising these areas while other sections of the stream remained concrete-bottomed. Some parts of the stream flow were overland.

In addition, parts of the old concrete drain system within the forested area remain inundated and form shallow streams within the eastern part of Site II (Figure 7-59E–F). This is located within a horse track oval found in the middle of Site II within the forest habitat.



**Figure 7-59 Waterbodies in Sites I and II. (A–D) Waterbody D/S16 with Different Microhabitats from Upstream (A) To Downstream (D); (E–F) Waterbody D/S15**



### 7.3.3.2 Floristic Field Findings

#### 7.3.3.2.1 Overall

A total of 270 plant species and species groups (i.e., plants that could not be identified with certainty), belonging to 89 families were recorded from the Study Area (Table 7-20; Appendix C2). There are 13 species groups, namely (1) *Aglaonema* cultivar, (2) *Araucaria* cf. *columnaris*, (3) *Dillenia* sp., (4) *Heliconia* cultivar, (5) *Musa* cultivar, (6) cf. *Asplenium nitidum*, (7) cf. *Dibridsonia conferta*, (8) cf. *Psydrax* sp. 10, (9) *Dacryodes* cf. *rostrata*, (10) *Endospermum* sp., (11) *Nephrolepis* cf. *acutifolia*, (12) *Syzygium* cf. *fastigiatum*, and (13) *Syzygium* cf. *pustulatum*. The first five species groups are exotic planted species, some of which have several cultivars which are difficult to identify to species or the specific variety. The other nine species are native.

Of the 270 species and species groups recorded, more than half are native (139; 51.5%), while 109 (40.4%) are exotic, and 21 (7.8%) are cryptogenic (i.e., of unknown or uncertain origin despite being a known species). One species has not been assessed (Table 7-20).

Native threatened species comprise species that have been accorded the following statuses: Vulnerable, Endangered, Critically Endangered, Presumed Extinct, and those that were recently rediscovered and not yet assessed. For overall findings, however, a distinction was not made as to whether threatened species are from native wild populations or are cultivated locally and/or relics from past cultivation. Species belonging to the latter category are not of conservation significance even though they have been accorded with a threatened status. This is discussed in greater detail in Sections 7.2.2.3 and 7.3.3.2.2.

**Table 7-20 Number and Percentage of Species Belonging to Each Status Category in Sites I and II**

Origin	Status	Number of Species	Percentage
<b>Native</b>		<b>139</b>	<b>51.5</b>
	Common	75	27.8
	Vulnerable	27	10.0
	Endangered	13	4.8
	Critically Endangered	16	5.9
	Presumed Extinct	6	2.2
	Not assessed	1	0.4
	Unidentified species	1	0.4
<b>Exotic</b>		<b>109</b>	<b>40.4</b>
	Cultivated Only	36	13.3
	Casual	25	9.3
	Naturalised	40	14.8
	Not assessed	7	2.6
	Unidentified species	1	0.4
<b>Cryptogenic</b>		<b>21</b>	<b>7.8</b>
<b>Not assessed</b>		<b>1</b>	<b>0.4</b>
<b>Total</b>		<b>270</b>	<b>100.0</b>

#### 7.3.3.2.2 Plant Species of Conservation Significance

A total of 54 plant species are considered of conservation significance. Some species, though listed as nationally threatened, were not considered of conservation significance in this study because they are most likely escapees from present-day cultivation or relics that has persisted from past cultivation. The assessment of whether a threatened plant species is of conservation significance was carried out based on the criteria detailed in Section 7.2.4.3.1.

The number of species of conservation significance in Sites I and II is comparable to that at the Eng Neo Avenue Forest, where 80 species of conservation significance were recorded (Section 7.3.2.3.2). This is in view of the relative sizes of both forested patches – the Sites I and II are less than half the size of the Eng Neo Avenue Forest, yet it hosts more than 50% of the number of species of conservation significance than its larger counterpart.

Altogether, 300 specimens and/or clusters of specimens belonging to these species of conservation significance were recorded in the Study Area. Majority of the specimens are concentrated within the native-dominated secondary forest, followed by the mixed forest (Table 7-22). The distribution of plant specimens of conservation significance is in Figure 7-60. The findings suggest that while the mixed forest and abandoned-land forest are predominantly occupied by exotic tree species, they are also recruiting natives.

Four specimens of conservation significance (i.e. two *Bridelia stipularis*, one *Litsea firma*, and one *Guioa pleuropteris*) lie within the worksites.



**Table 7-21 Number of Threatened Plant Species in Sites I and II**

	VU	EN	CR	EX	UN	Total
Non-Cultivated Threatened Species, i.e., CS Species	24	12	13	4	1	54
Cultivated Threatened Species	3	1	3	2	0	9
<b>Total Number of Threatened Species</b>	<b>27</b>	<b>13</b>	<b>16</b>	<b>6</b>	<b>1</b>	<b>63</b>

Note: VU – Vulnerable; EN – Endangered; CR– Critically Endangered; EX – Presumed Extinct; UN – Not assessed

**Table 7-22 Number of Plant Specimens and Species of Conservation Significance in Each Vegetation Type in Sites I and II**

	Number of Individuals and Clusters						Number of Species					
	VU	EN	CR	EX	UN	Total	VU	EN	CR	EX	UN	Total
Native-Dominated Secondary Forest	121	9	40	5	0	175	19	6	9	2	0	35
Abandoned-Land Forest	23	4	9	0	1	37	8	4	4	0	1	17
Mixed Forest	39	7	16	1	0	63	14	3	7	1	0	25
Scrubland and Herbaceous Vegetation	10	1	2	0	0	13	5	1	1	0	0	7
Managed Vegetation	0	0	0	0	0	0	0	0	0	0	0	0





**Legend**

Study Area

Worksites, access roads and alignment (Mitigated)

Native-dominated secondary forest

Mixed forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Plant specimens of conservation significance

Recently Rediscovered

Critically Endangered

Endangered

Vulnerable

Others (not assessed, unidentified)

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
**CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
(WINDSOR AND  
ENG NEO AVENUE FOREST)**

<div><div>Designed JW</div></div>	<div><div>Checked JAG</div></div>	<div><div>Approved JAG</div></div>
	<div><div>Drawn JW</div></div>	<div><div>Date JUN 2022</div></div>

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Figure Title :  
**DISTRIBUTION OF PLANT SPECIMENS OF  
CONSERVATION SIGNIFICANCE IN FORESTED  
AREA ADJACENT TO FAIRWAYS QUARTERS**

<div>Figure No. : 7 - 60</div>	<div>Rev. -</div>	<div>Sheet 1 of 1</div>
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Several nationally threatened species were found in the Study Area. A key species of interest is the fern ally *Phlegmariurus carinatus* (Figure 7-61A). Two small clusters of this fern ally were spotted on a rain tree (*Samanea saman*) near the Rider's Café carpark in Oct 2021. Based on the distinct morphological feature of the cord-like shoots and assuming the specimens are native, *P. carinatus* is the only plausible species of this genus in the region (Lindsay S., pers. comms). This species is classified as Extinct in the Singapore Red Data Book (Davison et al., 2008) and by Chong et al. (2009). The most recent specimen catalogued in the Singapore Botanic Gardens' Herbarium (SING) was collected from the Petaling stream at MacRitchie in 2010. Besides this, there are only two other specimens from mainland Singapore vouchered in the 18<sup>th</sup> and 19<sup>th</sup> century, respectively. The recent collection at MacRitchie as well as this finding from the present study could indicate a rediscovery of this rare species. Although the specimens are not located within the boundaries of the Study Area (Appendix D2), there is a possibility that more of them occur in the forested areas nearby but were undetected during floristic surveys. Therefore, a more conservative approach was adopted by including the species as part of the findings from the present study.

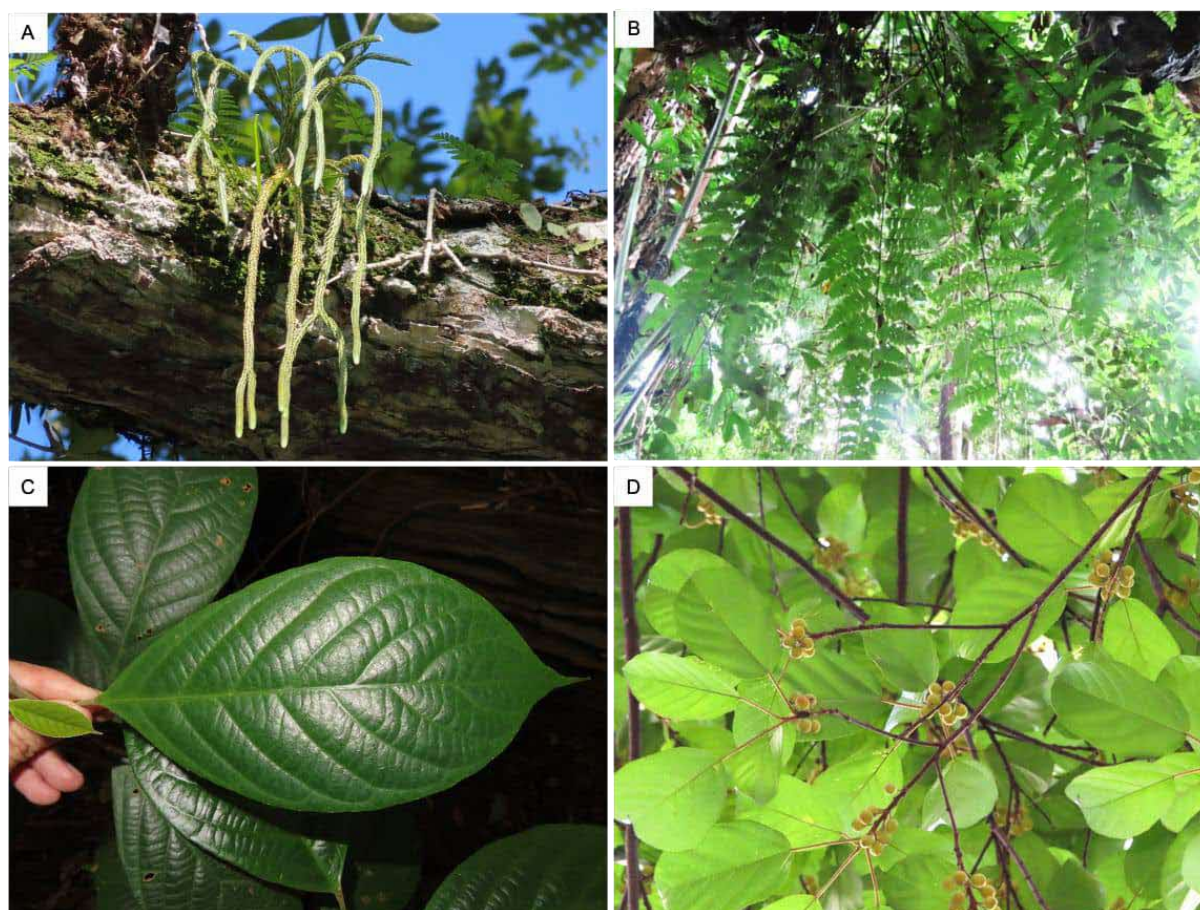
Another noteworthy species is the fern, *Asplenium nitidum* (Figure 7-61B). One specimen was encountered on 11 Nov 2021. It was growing on a rain tree, near Fairways Drive (Appendix D2). The specimen was relatively large with fronds measuring up to 50 cm long. As the specimen was too high to reach, photographs were taken and used to match against identification keys and books. Characters observed in the photographs match those in Piggott (1996). No spores were observed during surveys. This species is listed as nationally Extinct in Davison et al. (2008), Chong et al. (2009), and Ho et al. (2019). Three specimens catalogued in the SING date all the way back to the 19<sup>th</sup> century, where the specimens were collected between 1906 and 1907. Thereafter, no voucher specimens were collected until about a century later, in 2012, where one specimen was collected from Jalan Jelutong at Pulau Ubin. This species may have been under-detected and thus thought to be nationally extinct. Findings from this study as well as previous surveys in other forested patches of Singapore (Camphora, unpublished data) is evidence that the population may still be persisting on mainland Singapore. More studies on this species are needed to assess and determine its national conservation status as well as to put in place measures to conserve it as part of our natural heritage.

A total of three findings of *Baccaurea pyriformis* were recorded. Their locations are restricted to the native-dominated forest patches. This species is characterised by the visible marginal glands on both leaf surfaces, which with covered with hairs, especially on the venations on the abaxial side of the leaves. It was previously thought to be nationally extinct, as listed in Davison et al. (2008) and Chong et al. (2009). Most of the voucher specimens' collection catalogued in the SING date back to 1984, except for the latest one which was collected in 2015 at MacRitchie Reservoir. This species could be very exceedingly rare, as noted by a taxonomic expert that it was only recently re-discovered in the Nee Soon Swamp Forest (NSSF) and another individual observed in an old secondary patch in MacRitchie (Lam W.N., pers. comms.). Apart from these, there is very little information to-date on the distribution and habitats of *B. pyriformis* in Singapore.

*Calophyllum inophyllum*, listed as Critically Endangered in Chong et al. (2009), is a native coastal species. Currently, the only known area in Singapore where mature individuals of this species still persist is the natural coastal forest southwest of St. John's Island, where a population was found to be widespread (Hung et al., 2017). This species is also commonly planted in local streetscapes; as such it is likely that propagules from cultivated stocks have spread into some secondary forests in Singapore. However, one large *Calophyllum inophyllum* tree of 3.3 m girth was recorded from the present floristic surveys (Table 7-23; Appendix E2). Given that it would take a long time for the slow-growing species to attain the present size, it is almost certain the large specimen has been at the site for a long time. The individual is likely a remnant of the original native population there before human disturbance and could still be persisting in spite of the surrounding human developments and forest fragmentation.

A few nationally threatened species of relatively large girth were also documented in this present study. For example, one specimen of the fig tree species *Ficus glandulifera* was at least 1.1 m girth (Appendix D2). It was also producing figs at the time of observation (Figure 7-61D). Two *Actinodaphne macrophylla* trees of at least 1 m girth were also recorded in close proximity to the large *Ficus glandulifera* tree. These were recorded in the largest native-dominated secondary forest patch in the western zone. Other nationally Presumed Extinct, Critically Endangered, and/or recently rediscovered species recorded in the Study Area include *Psychotria sarmentosa*, *Aporosa lucida* var. *lucida*, *Gymnacranthera farquhariana* var. *farquhariana*, and *Strophanthus caudatus* (Appendix D2). As some plants are climbers or epiphytes by nature, it is equally important to preserve them and the trees on which they grow. Although exotic, the value of these trees increases as they get nativized by more and more rare climbers and epiphytes overtime.





**Figure 7-61 (A) Nationally Presumed Extinct *Phlegmariurus carinatus*, (B) cf. *Asplenium nitidum*; and (C) *Baccarea pyriformis* and Nationally Critically Endangered (D) *Ficus glandulifera*.**

Other findings of non-widespread species of conservation significance include a single sapling of nationally Endangered *Aporosa nigricans* that was encountered within the native-dominated forest surrounded by the circular horse track, located beside a drain outlet. This species is characterised by the prominent glands at the base of the leaves, with whitish twig colour and leaf tends to dry with a distinct blackish colour. This species was a surprising find at the Study Area as it is exceedingly rare. There have only been three records of this species in the recent years – one voucher specimen collected from the Macritchie Reservoir in 2014 at the SING, and recorded from the Bukit Timah Nature Reserve (BTNR) by Ho et al. (2019) and the NSSF (Lam et al., 2022). Similar to *B. pyriformis*, *A. nigricans* is uncommon even in the NSSF and other nature reserves, with low densities of population found only in undisturbed and old forest patches (Lam et al., 2022). Therefore, the forest should be retained so that these species can continue to grow and flourish in Singapore.

There were a few rare epiphyte species found as well, including *Bulbophyllum vaginatum*, a nationally Endangered orchid. According to Yam and Thame (2005), this is an “unusual species” that is able to grow naturally on the branches of rain trees (*Samanea saman*) and sea apple (*Syzygium grande*), and in areas that are fairly exposed. This is consistent with the observations of *B. vaginatum* from the present study, where this orchid was observed to be abundant and growing extensively on the branches of the rain trees. This species was recorded in both mixed forest and abandoned-land forest. Although there was no obvious pattern of distribution, this species appears to be well established within the forested areas of the Study Area.

Other nationally threatened species recorded in this study had only a few specimens, such as the Endangered *Calophyllum rubiginosum* with only one specimen (Figure 7-62D) and the Vulnerable *Symplocos fasciculata* with two specimens in the Study Area (Figure 7-63C). Others had slightly different distribution pattern; for example, the Vulnerable *Agelaea borneensis* (Figure 7-63A) and *Aporosa benthamiana* (Figure 7-63B) were found in small clusters within the same area, whereas specimens of *Amphineuron opulentum* (Figure 7-62C) and *Guioa pleuropteris* (Figure 7-63D) were recorded in small numbers and scattered across the site.





Figure 7-62 Nationally Endangered (A) *Aporosa nigricans*; (B) *Bulbophyllum vaginatum*; (C) *Amphineuron opulentum*; (D) *Calophyllum rubiginosum* (leaf underside).





Figure 7-63 Nationally Vulnerable (A) *Agelaea borneensis*; (B) *Aporosa benthamiana* (large stipules); (C) *Symplocos fasciculata*; (D) *Guioa pleuropteris* (stem underside).

#### 7.3.3.2.3 Large Plant Specimens

A total of 128 large plant specimens were recorded during floristic surveys, of which 58 specimens (45.3%) are exotic, 55 (43.0%) are native and the remaining 15 (11.7%) cryptogenic (i.e., of unknown origin) (Appendix E2). The distribution of all large plant specimens is shown in Figure 7-64.

Of 128 large plant specimens, 78 are trees belonging to 16 species. Majority of them (24 specimens) are rain trees (*Samanea saman*) (Table 7-23). Forty-four large specimens are stranglers comprising four *Ficus* species. The Malayan banyan (*F. microcarpa*) is the most abundant, with 26 specimens. The remaining six specimens are shrubs comprising two bamboo species, of which four specimens belong to the species *Thyrsostachys siamensis*.

The largest specimen recorded within the Study Area was a nationally Critically Endangered strangler, *Ficus kerkhovenii*, with a spread of up to 14 m (Figure 7-65A). At the point of encounter, this specimen was also producing figs (Figure 7-61B). The largest tree specimen recorded was a rain tree (*S. saman*) with a girth of 7.8 m, while the largest bamboo specimen, *Bambusa vulgaris*, had a spread of 4 m (Figure 7-65D).

Table 7-23 Number of Large Plant Specimens in Sites I and II

Habit	Species	No. of Specimens
Tree	<i>Acacia auriculiformis</i>	1
	<i>Calophyllum inophyllum</i>	1
	<i>Cinnamomum iners</i>	1
	<i>Cocos nucifera</i>	1
	<i>Cyrtophyllum fragrans</i>	18
	<i>Elaeis guineensis</i>	1
	<i>Elaeocarpus angustifolius</i>	1
	<i>Erythrophleum suaveolens</i>	8
	<i>Ficus barteri</i>	1
	<i>Ficus variegata</i>	1
	<i>Nephelium lappaceum</i>	1
	<i>Peltophorum pterocarpum</i>	2



Habit	Species	No. of Specimens
	<i>Pterocarpus indicus</i>	6
	<i>Samanea saman</i>	24
	<i>Spathodea campanulata</i>	8
	<i>Syzygium grande</i>	3
Strangler	<i>Ficus benjamina</i>	15
	<i>Ficus kerkhovenii</i>	2
	<i>Ficus microcarpa</i>	26
	<i>Ficus religiosa</i>	1
Shrub (Bamboo)	<i>Bambusa vulgaris</i>	2
	<i>Thyrsostachys siamensis</i>	4
<b>Total</b>		<b>128</b>





**Legend**

Study Area

Worksites, access roads and alignment (Mitigated)

Native-dominated secondary forest

Mixed forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Large plant specimens

Tree

Strangler

Bamboo

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
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ENG NEO AVENUE FOREST)

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	Drawn JW	Date JUN 2022

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Figure Title :  
DISTRIBUTION OF LARGE PLANT SPECIMENS  
IN FORESTED AREA ADJACENT TO  
FAIRWAYS QUARTERS

Figure No. : 7 - 64	Rev. -	Sheet 1 of 1
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Figure 7-65 Large Specimens at Sites I and II. (A–B) *Ficus kerkhovenii* of 14 m spread; (C) *Samanea saman* of 7 m girth; (D) *Bambusa vulgaris* of 4 m spread.

#### 7.3.3.2.4 Other Plant Specimens of Value

Three other plant specimens of value were recorded within the Study Area (Appendix F2; Figure 7-66). They are two trees and one bamboo cluster. The tree specimens, namely Indonesian bayleaf (*Syzygium polyanthum*) and an unidentified tree species, each with a bird nest. The bamboo specimen, *Bambusa vulgaris*, was small with only a 0.5-m spread (Figure 7-67A-B). It is located among a larger cluster of bamboos, which were found to be the roost sites of bamboo bats (*Tylonycteris* sp.) during roost emergence surveys (refer to Section 7.3.3.3.12).





**Legend**

- Study Area
- Worksites, access roads and alignment (Mitigated)
- Vegetation
  - Native-dominated secondary forest
  - Mixed forest
  - Abandoned-land forest
  - Scrubland and herbaceous vegetation
  - Managed vegetation
  - Waterbody
  - Others (infrastructure)
- Other specimens of value
  - Bamboo
  - Bird nest (exact)
  - Wasp nest (exact)

**N**

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG
Rev.	Date	By	Description	Chk'd	App'd

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
**CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
(WINDSOR AND  
ENG NEO AVENUE FOREST)**

<b>Designed</b> JW	<b>Checked</b> JAG	<b>Approved</b> JAG
	<b>Drawn</b> JW	<b>Date</b> JUN 2022

Figure Title :  
**DISTRIBUTION OF OTHER SPECIMENS  
OF VALUE IN FORESTED AREA  
ADJACENT TO FAIRWAYS QUARTERS**

<b>Figure No. :</b> 7 - 66	<b>Rev.</b> -	<b>Sheet</b> 1 of 1
<b>CAD File Name :</b> NA		<b>A3</b>





Figure 7-67 Other Specimens of Value at Sites I and II. (A–B) *Bambusa Vulgaris* of 0.5 M Spread.

#### 7.3.3.2.5 Tree Mapping Findings

A total of 137 trees were tagged during the tree mapping surveys, of which, more than half (72 trees; 52.6%) are native, 58 (42.3%) exotic and 7 (5.1%) cryptogenic (Appendix G2; Figure 7-68).

The tree species with highest count is *Syzygium grande* (22 specimens) followed by *Cinnamomum iners* (18 specimens), *Samanea saman* (17 specimens), *Acacia auriculiformis* (12 specimens) and tembusu (*Cryptophyllum fragrans*; 11 specimens). Altogether, 80 specimens from these five species make up about more than half (58.8%) of the total number of trees. Only two specimens belonging to two species of conservation significance, i.e., the nationally Vulnerable *Endospermum* sp., and *Planchonella obovata*, were tagged and mapped.

Note that there were more specimens assessed than tagged as some specimens occur in clusters, i.e., within 1–2 m of each other. All the specimens within clusters were assessed, but only one specimen was tagged (Section 7.2.4.5).





**Legend**

Study Area

Worksites, access roads and alignment (Mitigated)

Vegetation

Native-dominated secondary forest

Mixed forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Tree assessed

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
**CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
(WINDSOR AND  
ENG NEO AVENUE FOREST)**

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Figure Title :  
**DISTRIBUTION OF MAPPED TREES AT  
FORESTED AREA ADJACENT TO  
FAIRWAYS QUARTERS**

Figure No. : 7 - 68	Rev. -	Sheet 1 of 1
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CAD File Name : NA

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### 7.3.3.3 Faunistic Field Findings

#### 7.3.3.3.1 Overall

The field assessment documented 165 species, dominated by birds (59 species) and butterflies (26 species). From these, 13 species of conservation significance were also recorded. Two species (one bird and one bat) were not listed as probable species. The findings for each faunal group are described in Sections 7.3.3.3.3 to 7.3.3.3.12, respectively. The list of probable and recorded species is available in Appendix H2 and summarised in Table 7-24. The list of faunal species of conservation significance and their conservation statuses is available in Table 7-25. The faunal survey and camera trap data are provided in Appendix I2 and Appendix J2 respectively.

**Table 7-24 Summary of Probable and Recorded Faunal Species at Sites I and II**

Faunal Group	No. of Probable Species		No. of Recorded Species		No. of Recorded Species Not on Probable List (CS Species)
	All Species	CS Species	All Species	CS Species	
Aculeate hymenopterans	92	0	17	0	0
Bees	45	0	9	0	0
Stinging wasps	47	0	8	0	0
Odonates	70	13	22	0	0
Dragonflies	46	3	17	0	0
Damselflies	24	10	5	0	0
Butterflies	171	13	26	3	0
Freshwater decapod crustaceans	2	0	0	0	0
Freshwater fish	13	0	6	0	0
Herpetofauna	51	2	18	0	0
Amphibians	16	0	9	0	0
Reptiles	35	2	9	0	0
Birds	162	23	59	7	1 (0)
Mammals	30	8	17	3	1 (0)
Non-volant mammals	20	5	9	2	0
Bats	10	3	8	1	1 (0)
<b>Total</b>	<b>591</b>	<b>59</b>	<b>165</b>	<b>13</b>	<b>2 (0)</b>

Note: 'CS species' refers to species of conservation significance.

**Table 7-25 List of Faunal Species of Conservation Significance Recorded in Sites I and II**

Taxon	Species	Common Name	Local Status	Global Status
Butterfly	<i>Borbo cinnara</i>	Formosan swift	Endangered	Not Assessed
Butterfly	<i>Arhopala amphimuta amphimuta</i>	NA	Nationally Extinct (Rediscovered)	Not Assessed
Butterfly	<i>Troides helena cerberus</i>	Common birdwing	Vulnerable	Not Assessed; CITES protected (Appendix II)
Fish	<i>Clarias cf. batrachus</i>	Common walking catfish	Not Assessed	Not Assessed
Bird	<i>Accipiter trivirgatus</i>	Crested goshawk	Critically Endangered	Least Concern
Bird	<i>Gallus gallus</i>	Red junglefowl	Endangered	Least Concern
Bird	<i>Loriculus galgulus</i>	Blue-crowned hanging-parrot	Endangered	Least Concern
Bird	<i>Psittacula longicauda</i>	Long-tailed parakeet	Not Assessed	Vulnerable



Taxon	Species	Common Name	Local Status	Global Status
Bird	<i>Pycnonotus zeylanicus</i>	Straw-headed bulbul	Endangered	Critically Endangered
Bird	<i>Rallina fasciata</i>	Red-legged crane	Vulnerable	Least Concern
Bird	<i>Strix seloputo</i>	Spotted wood owl	Critically Endangered	Least Concern
Mammal	<i>Macaca fascicularis</i>	Long-tailed macaque	Least Concern	Vulnerable
Mammal	<i>Manis javanica</i>	Sunda pangolin	Critically Endangered	Critically Endangered
Bat	<i>Tylonycteris</i> sp.	Bamboo bat	Vulnerable	Least Concern

Given the site's proximity to Eng Neo Avenue Forest, rare species that could be expected at Eng Neo Avenue Forest also have a chance of being found here. Species of conservation significance appear to be distributed across the Study Area, including the globally threatened straw-headed bulbul (*Pycnonotus zeylanicus*) and Sunda pangolin (*Manis javanica*) with six independent detections (Figure 7-69).





**Legend**

Study Area

Worksites, access roads and alignment (Mitigated)

Native-dominated secondary forest

Mixed forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route

Faunal species of conservation significance

Non-volant mammal and bat

Bird

Butterfly

● Critically Endangered

● Endangered

● Vulnerable

● Nationally Extinct

▲

▲

NA

LTA Endorsement :  
NA

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Figure Title :  
**LOCATIONS OF FAUNAL SPECIES OF  
CONSERVATION SIGNIFICANCE FROM  
SURVEYS AND CAMERA TRAPPING  
CONDUCTED AT FORESTED AREA  
ADJACENT TO FAIRWAYS QUARTERS**

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### 7.3.3.3.2 Sampling Coverage

Along the terrestrial sampling routes, the sample coverage for each taxon were above 70%, with the exception of invertebrates: aculeate hymenopterans, odonates and butterflies. With doubled sampling effort, a marginal increase in richness is expected for some groups, and more than 10 species may be detected for odonates and birds. Sample coverage was not calculated for faunal groups with three or less species recorded. Especially for taxa detected only during terrestrial sampling routes, more species may hence be expected. Along aquatic sampling points, the sample coverage for all taxa were above 70%. Camera trapping obtained a coverage of 98.1%.

**Table 7-26 Result Summary of Taxon Sampling Analysis for Sites I and II**

Faunal Group	Sample Coverage (%)	Observed Richness	Estimated Richness ( $\pm$ Standard Error)	95% Confidence Interval for Estimated Richness	Estimated Coverage with Doubled Effort (%)	Estimated Richness (and Additional Species) with Doubled Effort
<b>Terrestrial Sampling Routes</b>						
Aculeate Hymenopteran	67.1	17	34 $\pm$ 15.3	21.1–93.7	86.6	27 (+10)
Odonate	50.7	20	135 $\pm$ 129.2	39.6–695.8	57.0	34 (+14)
Butterfly	66.7	23	40 $\pm$ 13.0	27.9–87.1	84.5	32 (+9)
Amphibian	94.4	9	10 $\pm$ 3.4	9.2–28.9	98.5	10 (+1)
Reptile	78.3	6	11 $\pm$ 6.3	6.9–39.3	91.0	9 (+3)
Bird	88.7	55	91 $\pm$ 22.3	67.0–164.9	93.7	71 (+16)
Non-Volant Mammal	N.A.	3	N.A.	N.A.	N.A.	N.A.
Bat	100.0	5	5 $\pm$ 0.3	5–5.6	100.0	5 (+0)
<b>Aquatic Sampling Points</b>						
Odonate	70.6	5	8 $\pm$ 6.0	5.4–39.5	89.2	7 (+2)
Freshwater Fish	86.7	6	8 $\pm$ 3.6	6.3–26.1	98.2	8 (+2)
Amphibian	94.6	4	4 $\pm$ 1.2	4.0–11.4	99.3	4 (+0)
Reptile	N.A.	1	N.A.	N.A.	N.A.	N.A.
<b>Camera Trapping</b>						
Non-Volant Mammal	98.1	8	10 $\pm$ 4.4	8.4–32.7	100.0	10 (+2)



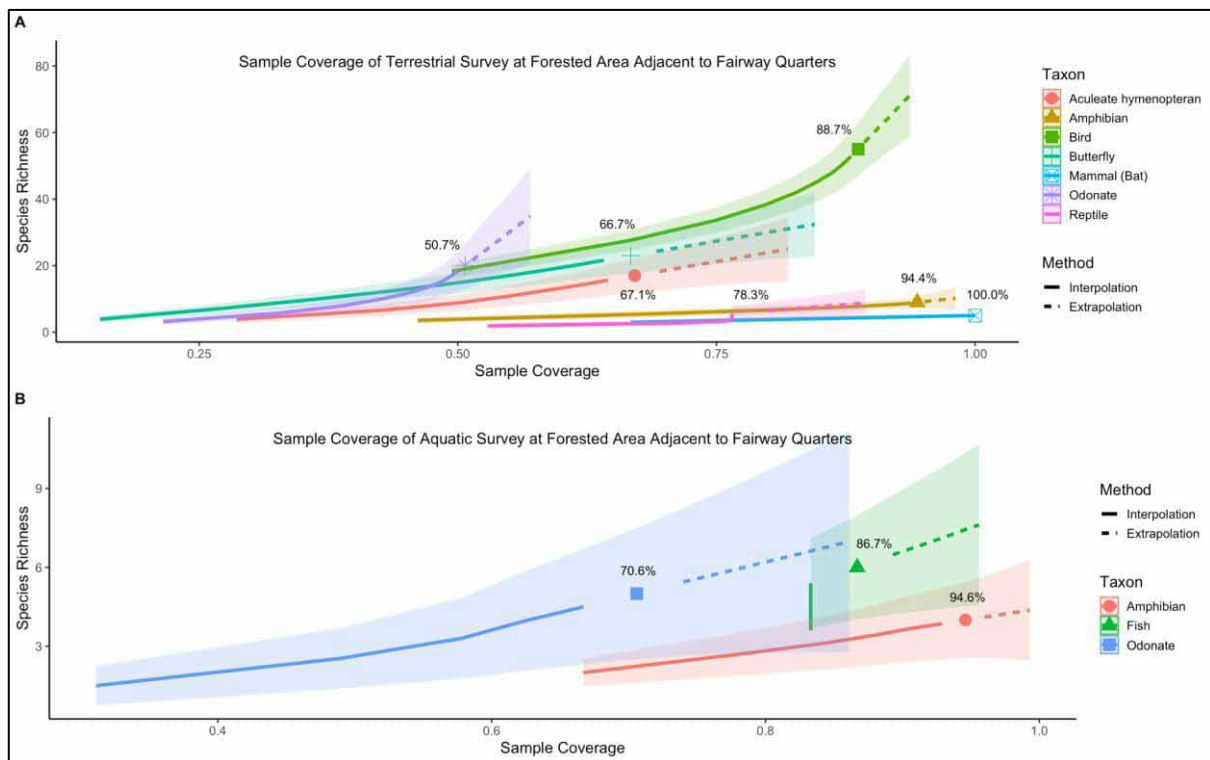


Figure 7-70 Taxon Sampling Curves for Respective Faunal Groups (A) Terrestrial Sampling Routes and (B) at Aquatic Sampling Points at Sites I and II.

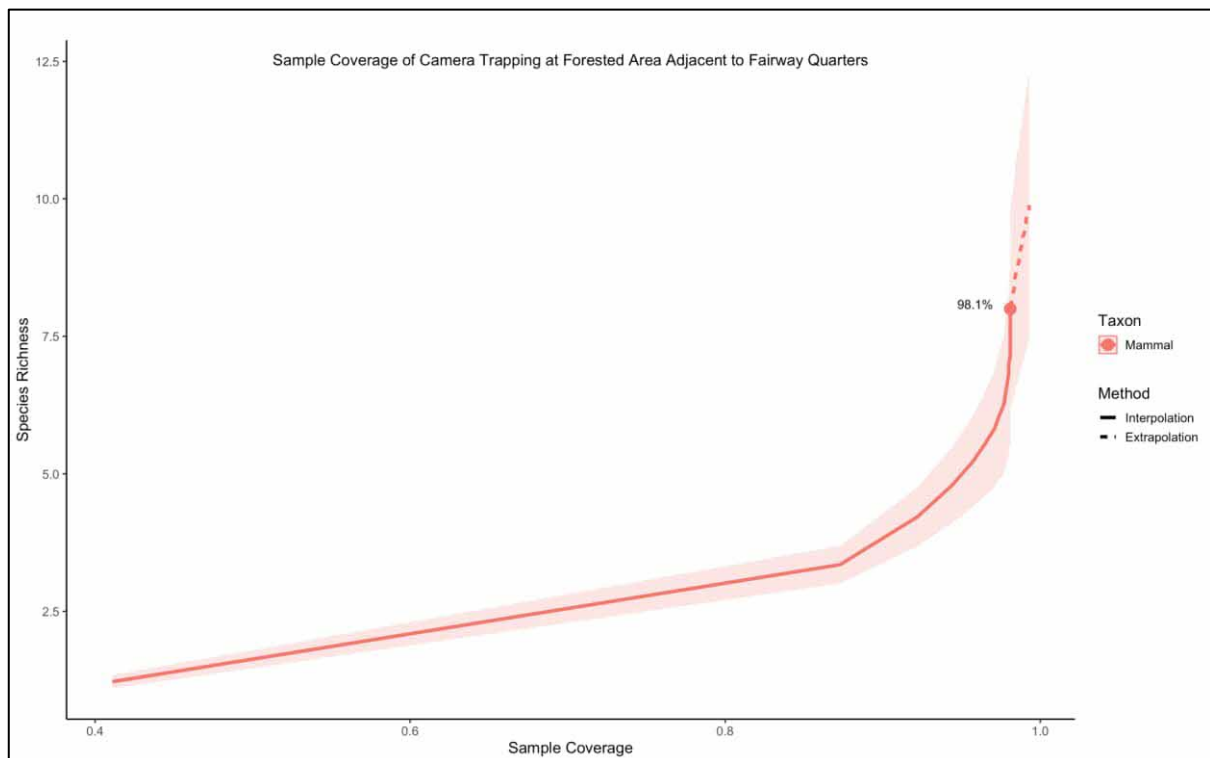


Figure 7-71 Taxon Sampling Curve for Camera Trapping at Sites I and II.



### 7.3.3.3.3 Aculeate Hymenopterans

Aculeate hymenoptera is a taxonomic group containing bees, stinging wasps and ants. They are defined mainly by their stingers – modified ovipositors, in females for self-defence, and in wasps for subduing and paralysing prey (Tan et al., 2015). In this Study, only bees and wasps were assessed.

Bees and wasps play vital ecological roles, notably as pollinators and in some cases, as predators of other insects to naturally control populations. As pollinators, these flower-visiting insects help sustain plant populations, which are particularly important in Singapore as most native flowering plant species are currently threatened (Soh & Ngiam, 2013; Chong et al., 2009). Stable plant populations, in turn, provide food for and support other animals such as birds and bats in the area (Black et al., 2009), as well as humans. A good diversity of aculeate hymenopterans is hence essential for and indicative of a healthy ecosystem.

While 92 species were expected due to proximity to CCNR and BTNR (Table 7-24; Appendix H2), a total of 17 species were recorded within Sites I and II: nine bees and eight stinging wasps, from five families. All species found were native, but none of conservation significance. Of which, one can be classified as Near Threatened – *Liostenogaster varipicta*, due to its inclination for (but not strictly dependent on) forest habitats (Ascher et al., in prep). Apart from nests, the most abundantly recorded species was the eastern honey bee (*Apis cerana*), amounting to a total of 33 individuals. The bees and wasps were clustered mostly around open pockets of scrubland with wildflowers and flowering trees in forested areas.

Sites I and II provide abundant foraging opportunities for numerous species such as the eastern honey bee (*A. cerana*), Andrew's blue-banded digger bee (*Amegilla andrewsi*) and *Sphex subtruncatus* (Figure 7-72). They were often found feeding on flowering plants such as *Leea indica* and *Asystasia gangetica*. Active nests of *R. jacobsoni*, *Tetragonula valdezi* and *R. sumatrae* were also found, with the latter on a large Critically Endangered strangler, *Ficus kerkhovenii*, specimen (Figure 7-72) thereby confirming the use of the Study Area by these species.



**Figure 7-72 Aculeate Hymenopterans found in the Study Area, Include (A) *Sphex subtruncatus* feeding on *Leea indica*; (B) *Ropalidia sumatrae* nesting in a large Critically Endangered *Ficus kerkhovenii* specimen**

### 7.3.3.3.4 Odonates

Dragonflies and damselflies serve as good biological indicators for the assessment of aquatic environments, as they are highly sensitive to environmental changes and are taxonomically well known. Odonates are mostly encountered near their freshwater breeding sites, of which can be many habitats, ranging from suburban drains to streams.

A total of 70 species of odonates were determined of probable occurrence in the Study Area, including 13 of conservation significance (Table 7-24; Appendix H2). At Sites I and II, 22 species of odonates were recorded, of which many can be considered widespread and common. No species of conservation significance were recorded. Unlike at Eng Neo Avenue Forest, the waterbodies in Site I (D/S15 and D/S16) are mainly naturalised lined drains, which may explain the assemblage of odonate sightings. Nonetheless, both the uncommon sultan (*C. gigantea*) and dingy duskhawker (*G. subinterrupta*), were recorded. Moreover, forest-associated damselflies like the crescent threadtail (*P. notostigma*) and orange-striped threadtail (*P. humeralis*) were also found, with the latter observed mating, thereby suggesting the suitability of the habitat for the species to breed.



### 7.3.3.3.5 Butterflies

A total of 171 butterfly species were deemed of probable occurrence within Sites I and II and 13 are of conservation significance (Table 7-24; Appendix H2). The field assessment recorded a total of 26 species including 3 species of conservation significance: the nationally Endangered Formosan swift (*Borbo cinnara cinnara*), the nationally Extinct (Rediscovered) *Arhopala amphimuta amphimuta* and the nationally Vulnerable common birdwing (*Troides helena cerberus*) (Figure 7-74A; Figure 7-74B). The common birdwing was encountered as an incidental finding during the night transect survey.

The open country and forest edge habitats found within parts of the Study Area may attract many butterfly species to gather for foraging and basking, although it may not apply to strict forest specialists. The open habitats may allow for easier detection of species as well. Due to the presence of scrubland and herbaceous vegetation, grassland-associated species such as the bush browns (*Mycalesis* sp.) were frequently recorded.

As butterflies are host specific, the retention of host plants is critical to maintaining butterfly populations. In the case of the common birdwing, its presence in the Study Area is solely dependent on the Dutch's pipe (*Aristolochia acuminata*), which is a non-native cultivated plant identified during the floristic assessment of the Study Area. The common birdwing shares this host plant with the nationally Vulnerable common rose (*Pachliopta aristolochiae asteris*) which is an expected species found in the Study Area although it was not encountered.

The nationally Endangered Formosan swift shares extensive morphological similarities with other species in the Hesperiidae family and is thus, viewed as a cryptic species. Multiple species of grasses in the Poaceae family serve as host plants of the Formosan swift. Considering the difficulty in identifying this species in the field and the variety of host plants it can utilise, the Formosan swift could be encountered more often than recorded in literature, making it a moderately common species in Singapore. It is worth noting that amongst the known host plants of the Formosan swift, only the critically endangered *Centotheca lappacea* was found in the Study Area during the floristic assessment. This finding suggests that the Formosan swift population in the Study Area is sustained solely by this cultivated grass.



**Figure 7-73 Butterfly Species of Conservation Significance Observed on Site at Sites I and II (A) Common birdwing (*Troides helena cerberus*), (B) Formosan swift (*Borbo cinnara cinnara*), and (C) *Arhopala amphimuta amphimuta***





**Legend**

Study Area

Worksites, access roads and alignment (Mitigated)

Vegetation

Native-dominated secondary forest

Mixed forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route

Butterfly species of conservation significance

B. cinnara

T. h. cerberus

A. a. amphimuta

N

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### 7.3.3.3.6 **Freshwater Decapod Crustaceans**

Only two species, the native maculate freshwater crab (*Parathelphusa maculata*) and the non-native ghost shrimp (*Macrobrachium lanchesteri*), were considered of probable occurrence (Table 7-24; Appendix H2). Both species were not recorded, suggesting poor habitat suitability for these species.

### 7.3.3.3.7 **Freshwater Fish**

The desktop assessment identified 13 species of probable occurrence at the Study Area, with six species being recorded (Table 7-24; Appendix H2). Four of these were native species while two are non-native. The two non-native species are the guppy (*Poecilia reticulata*) and Indochinese spotted barb (*Barbodes rhombeus*).

Richness of freshwater fish was generally low throughout the stream. The highest richness (4 species) was recorded in the middle of main stream channel. These sampling points were similar; both were deeper sections of the stream and as such had sufficient volume to host larger-bodied, predatory species (common walking catfish, *Clarias* cf. *batrachus* and ghost shrimp, *Channa striata*). The most upstream location at the culvert also holds a larger volume of water and likely supports these species as well. However, the point is too deep to safely sample in and visual surveys were impaired by the cloudy water in the site.

The waterbodies were dominated by three non-native species including the guppy (*Poecilia reticulata*), Indochinese spotted barb (*Barbodes rhombeus*) and pearl danio (*Brachydanio albolineata*). While not listed to be threatened nationally or globally, the presence of the common walking catfish (*Clarias* cf. *batrachus*) is a species of significance. Though a previously widespread species in the non-forested waterways of Singapore, it has seen a marked decline in its populations outside of the central reserves due to competition and displacement from the invasive African sharptooth catfish (*Clarias gariepinus*) (Ng et al., 2014). It was recorded as an incidental record in in D/S16 during nocturnal transect and once during visual surveys, The existing stream habitat thus has value in supporting the populations of the species in Singapore



### 7.3.3.3.8 **Amphibians**

A total of 16 amphibians, none of conservation significance, were deemed of probable occurrence. The field assessment recorded nine amphibian species (Table 7-24; Appendix H2). Richness of amphibians was generally low across all terrestrial sampling routes and aquatic sampling points, with higher richness found at aquatic sampling point FW2\_03, a deep pool downstream. No species of conservation significance was recorded.

### 7.3.3.3.9 **Reptiles**

The probable species list amounted to 35 reptiles comprising three terrapins, 12 lizards and 18 snakes (Table 7-24; Appendix H2). Of this, two species (one snake and one terrapin) were of conservation significance, both of which were not recorded during field assessment. The field assessment recorded 9 reptiles, which were mostly widespread and common (Table 7-24; Appendix H2).

Although not sighted within the Study Area during the field assessment, the nationally Vulnerable Wagler's pit viper (*Tropidolaemus wagleri*) was deemed of probable occurrence even though it was previously thought to be restricted to the CCNR (Baker & Lim, 2012) since it had been recorded in earlier field assessments at Eng Neo Avenue Forest, which is adjacent to the Study Area.

### 7.3.3.3.10 **Birds**

A total of 162 species of birds were deemed of probable occurrence, of which 104 are resident (15 introduced), 1 is an introduced non-resident and 57 are migrant/visitor species (Table 7-24; Appendix H2). The contiguity of the Study Area to the larger CCNR in the east also means that rarer forest-dependent species were expected.

The field assessment recorded 59 species which comprised 51 resident (41 native and 10 introduced) and 7 migrant/visitor species (Table 7-24; Appendix H2). The remaining one species was recorded only to genus or family level, hence not classified by their native status.

Seven species of conservation significance were found in Sites I and II: the nationally Vulnerable red-legged crane (*Rallina fasciata*), Endangered red junglefowl (*Gallus gallus*) and blue-crowned hanging parrot (*Loriculus galgulus*) that were recorded during targeted surveys, as well as the nationally Critically Endangered spotted wood owl (*Strix seloputo*) and crested goshawk (*Accipiter trivirgatus*) that were incidental observations. The remaining two species, the long-tailed parakeet (*Psittacula longicauda*) and straw-headed bulbul (*Pycnonotus zeylanicus*) are globally Vulnerable and Critically Endangered respectively, with the straw-headed bulbul being Endangered locally.

The oriental magpie-robin (*Copsychus saularis*) and blue-crowned hanging parrot (*Loriculus galgulus*), although listed as Endangered in the Singapore Red Data Book (Davison et al., 2008), have increased in range and abundance and can now easily be seen in urban parks and gardens (Lim & Yong, 2013). The long-tailed parakeet (*Psittacula longicauda*) is globally vulnerable, and its population is threatened mainly by pet bird trade (BirdLife International, 2022). It is currently protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as an Appendix II species with international trade of the species controlled. Locally, this bird is relatively common, but faces competition from the introduced, red-breasted parakeet (*Psittacula alexandri*) as they both nest in tree holes (Collar et al., 2020). The straw-headed bulbul (*Pycnonotus zeylanicus*) is globally Critically Endangered as a result of rampant poaching for the songbird trade. In Singapore, although it is listed as Endangered in the Singapore Red Data Book (Davison et al., 2008), its population shows a rising trend (Lim & Yong, 2013) with Singapore now acting as a global stronghold for this species. Thus, all habitats in Singapore that support this species play a critical role in its global conservation. Similarly, the locally Vulnerable red-legged crane (*Rallina fasciata*) can be found in many forested areas around Singapore, but loss of forest habitat has contributed to its decline in population over the years (Lim & Yong, 2013).

Uncommon migratory species encountered in Sites I and II include the forest wagtail (*Dendronanthus indicus*) and tiger shrike (*Lanius tigrinus*).





Figure 7-75 Bird Species Encountered at Sites I and II. (A) Common tailorbird (*Orthotomus sutorius*); (B) Grey-rumped tree swift (*Hemiprocne longipennis*); and (C) Red-legged crane (*Rallina fasciata*)





**Legend**

Study Area

Worksites, access roads and alignment (Mitigated)

Vegetation

Native-dominated secondary forest

Mixed forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route

Bird species of conservation significance

A. trivirgatus

G. gallus

L. galgulus

P. longicauda

P. zeylanicus

R. fasciata

S. seloputo

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LOCATIONS OF BIRD SPECIES OF  
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#### 7.3.3.3.11 *Non-volant mammals*

A total of 20 species of non-volant mammals were deemed of probable occurrence (Table 7-24; Appendix H2). Most species of probable occurrence are widespread, common, and tolerant of disturbance. Subsequently, the Sunda slow loris, Horsfield's flying squirrel and lesser mousedeer were added as probable species, due to their presence in the Sime forest across the PIE (O'Dempsey, pers comm.).

Visual surveys and camera trapping documented 9 species of non-volant mammals (Table 7-24; Appendix H2), including the Sunda colugo (*Galeopterus variegatus*) and Sunda pangolin (*Manis javanica*). Most recorded species are known to occur in degraded secondary forests. Examples are the rat (family Muridae), common treeshrew (*Tupaia glis*), wild pig (*Sus scrofa*) and common palm civet (*Paradoxurus musangus*). The slender squirrel (*Sundasciurus tenuis*), which is largely restricted to the CCNR was also sighted.

The forest-dependent Sunda colugo was observed once close to the mixed forest during a floral survey in Site II. This may be due to the presence of tall trees and closed canopy in the eastern part of the Study Area as compared to relatively open woodland habitats in other parts of the site. The nationally Near Threatened Sunda colugo is a species of interest as it is largely restricted to the CCNR and its surrounding forests, although it has been sighted in discreet forest patches (Bromley et al., 2019). The globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*) was recorded on camera traps at four locations across the Study Area (CT11–13, CT23), indicating the species' use of the entire extent of the Study Area. The Sunda pangolin was also sighted on camera trap carrying a juvenile at CT13. These sightings may indicate the presence of a mobile and breeding population of Sunda pangolins within the Study Area.





**Legend**

- Study Area
- Worksites, access roads and alignment (Mitigated)
- Vegetation
  - Native-dominated secondary forest
  - Mixed forest
  - Abandoned-land forest
  - Scrubland and herbaceous vegetation
  - Managed vegetation
  - Waterbody
  - Others (infrastructure)
- Terrestrial sampling route
- Mammalian species of conservation significance or interest
  - M. javanica
  - M. fascicularis
  - G. variegatus

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**LOCATIONS OF MAMMALIAN SPECIES OF  
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**Figure 7-78 Mammalian Species Sighted in the Study Area: (A) Long-tailed macaque (*Macaca fascicularis*); (B) Sunda colugo (*Galeopterus variegatus*); (C) Sunda pangolin (*Manis javanica*) mother and young captured on camera trap**

The 5 camera traps yielded 250 independent detections and 8 species of mammals over 306 trap-nights (Table 7-27; Table 7-28). The list of camera trap data is available in Appendix J2. The most commonly recorded was the common treeshrew (*Tupaia glis*) with 123 independent detections. Notably, the Sunda pangolin (*Manis javanica*) was recorded on six occasions at four locations (CT11–CT13, CT23) across the Study Area. The highest mammal detection rate was recorded at CT23 (1.4 independent detections per trap-night).

**Table 7-27 Locations and Number of Independent Detections of Mammalian Species at Sites I and II**

Species	Common Name	CT Location	No. Of Independent Detections
<i>Callosciurus notatus</i>	Plantain squirrel	12–13, 23	86
<i>Macaca fascicularis</i>	Long-tailed macaque	11–12, 23	15
<i>Manis javanica</i>	Sunda pangolin	11–13, 23	6
<i>Paradoxurus musangus</i>	Common palm civet	11	1
Family Muridae	Rat	11–13	17
<i>Sundasciurus tenuis</i>	Slender squirrel	11	1
<i>Sus scrofa</i>	Wild pig	11	1
<i>Tupaia glis</i>	Common treeshrew	11–13, 23	123
<b>Total</b>			<b>250</b>

**Table 7-28 Number of Species and Detection Rate of Mammals Recorded within Sites I and II**

Station	No. of Trap Nights	No. of Mammalian Species Recorded	Detection Rate of Mammals
CT11	63	7	0.7
CT12	60	5	0.4
CT13	60	4	1.1
CT19	60	0	0
CT23	63	6	1.4

#### 7.3.3.3.12 Bats

Ten bat species were deemed of probable occurrence within the Study Area (Table 7-24; Appendix H2). Of these, eight species were recorded via visual surveys and acoustic sampling (Table 7-24; Appendix H2).

The frugivorous lesser short-nosed fruit bat (*Cynopterus brachyotis*) was detected visually. The remaining bats were insectivorous bats and were detected acoustically. They are the Asian whiskered myotis (*Myotis muricola*), black-bearded tomb bat (*Taphozous melanopogon*), glossy horseshoe bat (*Rhinolophus refulgens*), Horsfield's myotis (*Myotis horsfieldii*), lesser Asian house bat (*Scotophilus kuhlii*), pouched tomb bat (*Saccolaimus saccolaimus*), and an unidentified bamboo bat species (*Tylonycteris* sp.). The bamboo bat was the only species of conservation significance detected during the field assessment. Two species of bamboo bats are found in Singapore: the lesser bamboo bat (*T. fulvida*) and the greater bamboo bat (*T. malayana*). The acoustic signatures of the two species overlap, thus making it difficult to distinguish the species without handheld specimens. As both species are nationally Vulnerable, the bamboo bat species was considered a species of conservation significance.



Bamboo bats were recorded from Site II only. Six bamboo clusters were identified in both Sites I and II, and they were examined for its use by bamboo bats, as the species roosts in bamboo internodes. Bamboo bat activity was detected acoustically around two of the bamboo clusters (BB2\_03b and BB2\_03c) during roost emergence survey, indicating that these clusters are likely a roosting site for the species.

Areas adjacent to the Study Area have been converted for anthropogenic use, and in keeping with this, the majority of species recorded are highly adaptable species capable of utilising urban as well as forested habitats. However, the Study Area is still able to support forest-specialists such as the glossy horseshoe bat. Highly adapted to hunting in cluttered environments, the glossy horseshoe bat has been recorded CCNR and BTNR, and has been recorded hunting in forest canopies (Teo & Thomas, 2019). Acoustic recordings of the glossy horseshoe bat were recorded from native-dominated secondary forests and abandoned-land forests within the Study Area. Given that the species is volant and was recorded throughout the site, the glossy horseshoe bats detected during field assessment is most likely part of the larger population with CCNR, rather than an isolated population, and the species utilises the landscape as a contiguous habitat for its survival.





**Legend**

- Study Area
- Worksites, access roads and alignment (Mitigated)
- Vegetation**
  - Native-dominated secondary forest
  - Mixed forest
  - Abandoned-land forest
  - Scrubland and herbaceous vegetation
  - Managed vegetation
  - Waterbody
  - Others (infrastructure)
- Terrestrial sampling route
- Bat species of conservation significance**
  - Tylonycteris sp.

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### 7.3.4 Windsor

#### 7.3.4.1 Habitat and Vegetation Types

Windsor Nature Park alone occupies more than half the Study Area in Windsor, standing at 16.4 ha (55.2%) (Table 7-29). Beyond the nature park, the remaining area is largely fragmented into two forested patches by Island Club Road that abuts the northern boundary of Windsor Nature Park and forks in the Singapore Island Country Club (SICC) (Figure 7-80). These two patches are largely abandoned-land forest (7.7 ha; 26.1%) and managed vegetation (2.8 ha; 9.4%). Two patches of native-dominated secondary forest (0.9 ha; 3.0%) and small areas of scrubland and herbaceous vegetation (0.9 ha; 3.0%) occupy the rest of the Study Area.

Only two randomly-generated vegetation plots were sampled in the Northern Forest Fragment – one in native-dominated secondary forest and one in abandoned-land forest. From vegetation plot data, total species richness per plot is higher in the native than abandoned-land forest. The same trend can also be observed for native species richness, where 80% of all species recorded in the native plot belong to native species and only 64% in the abandoned-land plot belong to native species.

**Table 7-29 Absolute (ha) and Relative (%) Sizes, Number of Vegetation Plots, and Species Richness of Each Vegetation Type in Windsor**

	ha	%	Plots	Species Richness Per Vegetation Type		
				Total*	Native	Exotic and Cryptogenic
Native-Dominated Secondary Forest	0.9	3.0	1	40	32	8
Abandoned-Land Forest	7.7	26.1	1	36	24	12
Scrubland And Herbaceous Vegetation	0.9	3.0	0	–	–	–
Managed Vegetation	2.8	9.4	N.A.	–	–	–
Others (Infrastructure)	1.0	3.3	N.A.	–	–	–
Windsor Nature Park	16.4	55.2	N.A.	–	–	–
<b>Total Spontaneous Vegetation</b>	<b>9.5</b>	<b>32.1</b>	<b>2</b>	–	–	–
<b>Total Area</b>	<b>29.7</b>	<b>100.0</b>	–	–	–	–

Note: \*refers to the total number of species recorded across all plots in each vegetation type





**Legend**

Study Area

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Others (infrastructure)

Windsor Nature Park

Waterbody

Worksite and alignment

Boardwalk

Vegetation plot

N

							Qualified Person Endorsement : NA
							LTA Endorsement : NA
Rev.	Date	By	Description	Chk'd	App'd		
-	JUN 2022	SHMX	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG		

Consultant :  
**AECOM**

Project Title :  
**CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
(WINDSOR AND  
ENG NEO AVENUE FOREST)**

Designed  
SHMX

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JAG

Approved  
JAG

Drawn  
SHMX

Date  
JUN 2022

Land Transport Authority  
We Keep Your World Moving

Figure Title :  
**VEGETATION DISTRIBUTION AND  
LOCATION OF VEGETATION PLOTS  
IN WINDSOR**

Figure No. :  
7 - 80

Rev.  
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Sheet  
1 of 1

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### 7.3.4.1.1 *Native-dominated Secondary Forest*

There are two native-dominated secondary forest patches in the Northern Forest Fragment (Figure 7-80). One is located within SICC, west of the Study Area (thereby termed as the “western native patch”). The other patch, which is approximately twice as large as the first, is located north of the Study Area (thereby termed as the “northern native patch”).

Both patches are different in floristic make up. The western native patch is where several large native trees were found. This includes three *Camposperma auriculatum* trees of up to 2.4 m girth (Figure 7-81A–B). This native species is listed as Common and is usually present in native forests in the late-successional stage (Yee et al., 2016). Although the areas surrounding this patch are managed vegetation to its north and south, and abandoned-land forest to its east and west, there are also other common native species in these surrounding vegetation that are noteworthy. This includes an *Ilex cymosa* tree of 1.4 m girth next to some old facility buildings (indicated as “Others (infrastructure)” on the map), as well as a large *Cryptophyllum fragrans* tree of 3.1 m girth. The latter was found on the forest edge, where most spontaneous vegetation has been cleared and planted up with turf and ornamental shrubs along Island Club Road. Nonetheless, *Cryptophyllum fragrans* trees are known to be slow-growing and it would take a long time for specimens to attain large sizes. Thus, the large specimen of 3.1 m girth found at the area must have almost certainly been growing there over an extended period of time, way before this species was planted and sold locally in commercial markets. This, together with evidence of other large native trees present in the area, supports the conjecture that this forested area could have previously been a late-successional native-dominated secondary forest before there were human disturbances that destroyed and fragmented majority of the forested landscape. It is likely that the area formed a single continuous forested patch with the fragments south of the Upper and Lower Peirce reservoirs. The large trees we observe today are likely remnants that have persisted through the periods of disturbance.

The northern native patch, on the other hand, is comparatively more species-rich in both the canopy and understorey layers. Several native specimens—both common and nationally threatened—occur in high concentrations within this patch. For example, numerous seedlings and saplings of the nationally Vulnerable *Strombosia javanica* (Figure 7-81C–D) were found to be widespread. Two large parent trees of 0.6 m and 0.9 m girth of this species within this patch possibly explain the large propagule numbers. A large tree of 0.7 m girth of *Aporosa nervosa*, also a nationally Vulnerable tree species, and another of 0.8 m girth of the nationally Endangered *Carallia brachiata*, were also encountered here. Most of the rare native species recorded in Windsor were found only within this patch, including the nationally Critically Endangered *Enkleia malaccensis* and *Elaeocarpus rugosus*. Some of these rare species are discussed in Section 7.3.4.2.2. Other common native species that occur in high numbers here are *Xylopiya malayana* (Figure 7-81E), *Aporosa frutescens* (Figure 7-81F), *Calophyllum ferrugineum*, *Elaeocarpus petiolatus*, and *Timonius wallichianus*.

The floristic assemblage of the northern native patch largely overlaps with that of the CCNR, barring some casual and naturalised exotic species that have opportunistically grown in pockets of area. Although this patch is near the forest edge with golf course to its north, where abiotic conditions such as light and humidity levels are vastly different from the forest interior and exotic species are planted, the proximity to the CCNR provides a nearby source for the arrival of propagules. In addition, many native species propagated by the NParks and planted in the Windsor Nature Park as part of reforestation efforts may also disperse into the adjacent forest. With constant and steady rates dispersal of propagules from the nearby CCNR and Windsor Nature Park, together with successful seedling recruitment, this forested area in the Northern Forest Fragment may eventually develop into primary forest overtime if left undisturbed.





**Figure 7-81 Native-dominated Secondary Forest in the Windsor Northern Forest (Excluding Windsor Nature Park). (A–B) Native Common *Campnosperma auriculatum* Tree of 2.4 m Girth; (C–D) Nationally Vulnerable *Strombosia javanica* Aaplings and Tree of 0.9 m Girth; (D) A Leafy Twig of the Native Common *Xylopia malayana*; (E) A Fruiting Twig of the Native Common *Aporosa frutescens*.**

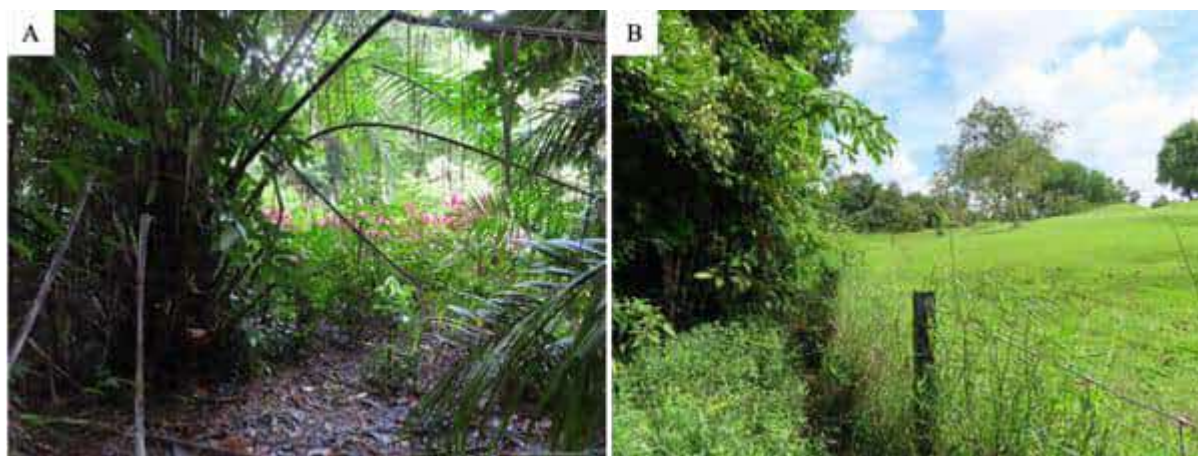
#### **7.3.4.1.2 Abandoned-land Forest**

Majority of the Northern Forest Fragment is occupied by abandoned-land forest (Figure 7-80). Floristic composition here generally consists of a mix of fruit tree species—such as rambutan (*Nephelium lappaceum*) and mata kuching (*Dimocarpus longan* ssp. *malesianus*)—and oil palms (*Elaeis guineensis*). While the abandoned-land forest patch within the SICC flanked by Island Club Road on both sides is dominated by the exotic tree and palm species, there are also one *Ixonanthes reticulata* and several *Macaranga gigantea* trees growing along the forest edges. *Ixonanthes reticulata* is a native common species usually found in old secondary and primary forests, while



*Macaranga gigantea* is a native pioneer species often associated with high disturbances and light conditions. The presence of light-demanding species is usually characteristic of early-successional forests, which may, overtime, develop into late successional forests where pioneer species are replaced (Corlett, 1991; Yee et al., 2016). During floristic surveys in this present study, however, several of these trees were observed to be previously pollarded. This suggests that the forest patch could be maintained by humans who directly restrict the growth of trees. Consequently, such maintenance works impede forest succession in the long run.

Elsewhere in the Study Area, the abandoned-land forest appears to be highly disturbed, with ornamental shrubs and hedges, the golf course, and/or road infrastructures abutting the entire forest boundary (Figure 7-82). Some native species are also found inside this forest type, though they are mainly fig trees and stranglers such as *Ficus microcarpa*, *Ficus variegata*, and *Ficus fistulosa*. Fig stranglers were not felled in the past when lands were cleared for cultivation owing to superstitious beliefs (Lok et al., 2013). As such, several fig specimens remain in forests that have gone through series of disturbances from cultivation and land conversions. In this study, most of the large strangling figs were found in the eastern-most end of the Northern Forest Fragment, adjacent to Upper Thomson Road.



**Figure 7-82 Abandoned-Land Forest in the Northern Forest Fragment (A) Oil Palm *Elaeis guineensis* in the Foreground and Ornamental Shrubs Planted along Island Club Road within the Singapore Island Country Club; (B) Abandoned-Land Forest adjacent to the Golf Course**

#### **7.3.4.1.3 Scrubland and Herbaceous Vegetation**

Scrubland and herbaceous vegetation occur in small random patches that are interspersed throughout the Study Area (Figure 7-80). This vegetation type is characterised by short vegetation with a single relatively uniform stratum and open canopy. The floristic composition of most patches is a mix of exotic and native woody shrubs, herbaceous climbers/creepers, and grasses. A few scrubland sub-types can be observed in the Study Area. For example, one of the scrubland patches is largely dominated by an exotic casual shrub species, *Clerodendrum paniculatum*, with its distinctive orange-red inflorescences (Figure 7-83A), while some other areas are solely occupied by short herbaceous plants and grasses, such as *Isachne globosa* and *Ischaemum muticum* (Figure 7-83D). There are yet other areas that have open canopy as a result of tree falls, after which sun-loving shrub species have opportunistically grown over and are not yet shaded out by trees which take a longer time to establish themselves (Figure 7-83C)). Finally, some areas appear to have encroached by the growth of shrubs, yet still have open canopy (Figure 7-83B). This could be because trees fail to establish themselves there, perhaps owing to the lack of seed sources, amongst other reasons.





**Figure 7-83 Scrubland and Herbaceous Vegetation in the Northern Forest Fragment (A) Scrubland Dominated by *Clerodendrum paniculatum*; (B) Area with Open Canopy Interspersed within A Larger Forested Patch; (C) Scrubland Caused by Previous Tree Falls; (D) A Small Patch Largely Occupied by Herbaceous Plants.**

#### **7.3.4.1.4 Managed Vegetation**

Managed vegetation occupies the second largest area in the Northern Forest Fragment (Figure 7-80). A big portion of this vegetation type is within the SICC and along Island Club Road (Figure 7-84). As most areas in the country club are heavily planted with exotic ornamental shrubs and trees, this has partly contributed to the high percentage of exotic species composition in the Study Area. Some cultivated plants, though, are native species and few are even listed as nationally threatened, such as the Critically Endangered *Crinum asiaticum*. These species, however, are almost certainly cultivated and unlikely to belong to the native genetic stock. Beyond SICC, most other managed vegetation is turf found along Island Club Road with planted trees and palms (Figure 7-84).





**Figure 7-84 Managed Vegetation in the Northern Forest Fragment (A–B) Largest Patch of Managed Vegetation at the Intersection Between Island Club Road and Upper Thomson Road; (C) Managed Turf with Planted Trees and Palms along Island Club Road; (D) Ornamental Shrubs and Hedges inside the Singapore Island Country Club.**

#### **7.3.4.1.5 Others (infrastructure)**

The two main infrastructures that occupy 1.0 ha (3.3%) of the Study Area are the Island Club Road and a few old facility buildings adjacent to the golf course northwest of the Northern Forest Fragment (Figure 7-85). Island Club Road stretches for approximately 700 m from west of Upper Thomson Road, before it forks inside SICC into two shorter roads of about 200 m and 300 m, respectively, until it reaches the western-most end of the study boundary. This two-land road divides the Study Area into three separate fragments.



**Figure 7-85 Infrastructures in the Northern Forest Fragment. (A) Island Club Road That Separates the Northern Forest Fragment (Right) from Windsor Nature Park (Left); (B) Old Facility Buildings adjacent to the Golf Course Northwest of the Northern Forest Fragment**



### 7.3.4.1.6 Windsor Nature Park

Windsor Nature Park occupies the largest area in Windsor (Figure 7-80). It consists of a mix of manicured park spaces, natural forested areas, as well as forested areas with enhancement plantings (Figure 7-86). Under the NParks Nature Conservation Masterplan, there have been habitat enhancement and restoration programmes put in place since 2015 (NParks, 2019). Specifically, the Forest Restoration Action Plan aims to “regenerate the secondary forests in Nature Parks buffering the two Nature Reserves” over ten years, and Windsor Nature Park is one of the nature parks of interest. While native species are actively introduced and planted, exotic species are concurrently weeded out and removed. With active forest restoration efforts, the vegetated landscape of Windsor Nature Park is thus, expectedly, a mix of managed and natural vegetation, as was observed during the present study’s floristic surveys.



**Figure 7-86 Windsor Nature Park. (A) Planted Up Area at the Intersection between Venus Drive and Island Club Road; (B) *Bentinckia nicobarica* Palms Planted on Managed Turf; (C) Boardwalk in the Park; (D) Shrubs and Treelets adjacent to the Boardwalk**

### 7.3.4.1.7 Waterbodies

Waterbodies and waterlogged areas are present within Windsor. Locations and alignment of the waterbodies are in Figure 7-9. Within the Northern Forest Fragment, two streams were observed and may be connected via underground waterflow. It enters from under the road culvert of Upper Thomson Road, and runs parallel to the road for approximately 130 m before draining in south-westerly direction towards the Island Club Road (D/S26). It may be connected to the shorter western stream which also drains in a southerly direction towards a road culvert along Island Club Road (D/S27). This likely connects to the main stream system located within Windsor Nature Park.

Within the Windsor Nature Park, a single stream system runs from west to east of the Study Area (D/S13). The waterway flowing through the site encompasses both forest streams characterised by higher canopy cover, lower temperatures and higher accumulations of leaf litter, and open-country streams or ponds characterised by lower canopy cover, higher temperatures and smaller leaf litter accumulations. Some swampy sections were also observed around the stream.





**Figure 7-87 Waterbodies in Windsor: (A) Stream Draining out from Road Culvert in Upper Fragment (D/S26); (B) Forested Stream in Upper Fragment (D/S27); (C) Forested Stream within Windsor Nature Park (D/S13); (D) Open Country Pond within Windsor Nature Park**

#### 7.3.4.2 Floristic Field Findings

##### 7.3.4.2.1 Overall

A total of 329 plant species and species groups, i.e., plants that could not be identified to species with certainty, belonging to 103 families were recorded at Windsor (Appendix C2). Thirteen are listed as species groups – (1) *Anaxagorea* cf. *javanica*, (2) *Cryptocarya* cf. *nitens*, (3) *Daemonorops* cf. *angustifolia*, (4) *Gnetum* species, (5) *Gymnacranthera* cf. *forbesii*, (6) *Ipomoea* species, (7) *Knema* species, (8) *Psychotria* cf. *ovoidea*, (9) *Salacia* cf. *korthalsiana*, (10) *Salacia* cf. *viminea*, (11) *Salvinia* species, and two unknowns.

Of these 13 species groups, seven (items 1, 2, 3, 5, 8, 9, and 10 in the list above) bear vegetative characters closely similar to the proposed species, barring some features atypical of the latter. Nonetheless, they were included in the tabulation in Table 7-30.

The *Gnetum* species (item 4) and *Knema* species (item 7) were assumed to be native species. As all native *Gnetum* climbers are listed as Critically Endangered in Singapore (Chong et al., 2009), the single specimen encountered in the northern native patch is likely to belong to one of the nationally threatened *Gnetum* species. On the other hand, the *Knema* specimen could not be identified with certainty without fertile specimens. It is, though, unlikely to be *Knema malayana*, the only other species of this genus recorded at Windsor. Both the *Gnetum* and *Knema* were included in Table 7-30.

The remaining four species groups (item 6, 11, and the two unknowns) were all encountered in Windsor Nature Park. Some could be exotic species planted in the manicured park spaces, or native species intentionally introduced as part of reforestation efforts. This, however, could not be determined with certainty. As such, these species are listed as “Unidentified species” in Table 7-30 below.



Of the total species count, 197 (59.9%) are native, 111 (33.7%) exotic, and 21 (6.4%) cryptogenic or unidentified species. Up to 30.4% (100 species) are nationally threatened a figure that is also comparable to that of Eng Neo Avenue Forest with 31.7% (90 species).

**Table 7-30 Number and Percentage of Species belonging to Each Status Category in Windsor (Including Windsor Nature Park)**

Origin		Status	Number of species	Percentage
<b>Native</b>			<b>197</b>	<b>59.9</b>
	Common		87	26.4
	Vulnerable		48	14.6
	Endangered		16	4.9
	Critically Endangered		36	10.9
	Presumed Extinct		7	2.2
	Not assessed		2	0.6
	– ( <i>Knema</i> sp.)		1	0.3
<b>Exotic</b>			<b>111</b>	<b>33.7</b>
	Cultivated Only		37	11.2
	Casual		28	8.5
	Naturalised		35	10.6
	Not assessed		11	3.3
<b>Cryptogenic</b>			<b>17</b>	<b>5.2</b>
<b>Unidentified species</b>			<b>4</b>	<b>1.2</b>
<b>Total</b>			<b>329</b>	<b>100.0</b>

#### 7.3.4.2.2 Plant Species of Conservation Significance

Of the 100 plant species listed as nationally threatened, only 49 are considered of conservation significance in this study (Appendix D3). More than half the species, though listed as nationally threatened, are not considered of conservation significance in this study because they are most likely escapees from present-day cultivation, relics that had persisted from past cultivation, or were found only in Windsor Nature Park. It was challenging to determine whether threatened specimens found along the boardwalks in Windsor Nature Park were planted and belong to the cultivated genetic stock, or if they have grown spontaneously from native propagules arriving from local populations elsewhere. There is also another likelihood that the specimens were propagated from local stocks and subsequently planted in the nature park. Considering the multifaceted circumstance, all threatened species found exclusively in Windsor Nature Park were hence excluded from the list of species of conservation significance.

In the list of 49 species of conservation significance in Windsor, 39 are not known to be cultivated locally while the remaining ten are. The approach on determining whether a nationally threatened species is of conservation significance is detailed in Section 7.2.2.3.

At least 200 individuals and clusters of specimens of conservation significance were recorded at the Northern Forest Fragment. Majority (193 specimens and clusters) were found within the larger continuous forested patch north of Windsor Nature Park. The specimens are mostly concentrated within the two native-dominated patches, but are also scattered throughout the abandoned-land forest between the two native patches. Beyond these areas, specimens of conservation significance occur at low concentrations.

Within the original worksite, there are 41 individuals and clusters of specimens of conservation significance (19 in native-dominated secondary forest, 19 in abandoned-land forest, two in scrubland and herbaceous vegetation, and one in managed vegetation).

Within the optimised worksite, there are 20 individuals and clusters of specimens of conservation significance (19 in native-dominated secondary forest and one in abandoned-land forest).



**Table 7-31 Number of Plant Species of Conservation Significance in the Northern Forest Fragment**

	VU	EN	CR
<b>Non-Cultivated Threatened Species</b>	17	8	14
<b>Cultivated Threatened Species</b>	8	0	2
<b>Total Number of Species of Conservation Significance</b>	<b>25</b>	<b>8</b>	<b>16</b>

Note: VU – Vulnerable; EN – Endangered; CR– Critically Endangered

**Table 7-32 Number of Plant Specimens and Species of Conservation Significance in Each Vegetation Type in the Northern Forest Fragment**

Area	Forest Type	Number of Individuals and Clusters				Number of Species			
		VU	EN	CR	Total	VU	EN	CR	Total
<b>Entire Study Area</b>	Native-Dominated Secondary Forest	53	14	28	<b>95</b>	22	6	10	<b>38</b>
	Abandoned-Land Forest	59	6	31	<b>96</b>	17	4	9	<b>28</b>
	Scrubland and Herbaceous Vegetation	4	1	3	<b>8</b>	3	1	2	<b>6</b>
	Managed Vegetation	2	0	0	<b>2</b>	2	0	0	<b>2</b>
<b>Option 1 (Original) Worksite</b>	Native-Dominated Secondary Forest	12	1	6	<b>19</b>	8	1	1	<b>10</b>
	Abandoned-Land Forest	14	1	4	<b>19</b>	6	1	2	<b>9</b>
	Scrubland And Herbaceous Vegetation	2	0	0	<b>2</b>	1	0	0	<b>1</b>
	Managed Vegetation	1	0	0	<b>1</b>	1	0	0	<b>1</b>
<b>Option 2 (Optimised) Worksite</b>	Native-Dominated Secondary Forest	12	1	6	<b>19</b>	8	1	2	<b>11</b>
	Abandoned-Land Forest	1	0	0	<b>1</b>	1	0	0	<b>1</b>

Note: Total species richness of the Study Area is not the sum of species richness per vegetation type as some species occur in more than one vegetation type. VU – Vulnerable; EN – Endangered; CR – Critically Endangered.





**Legend**

Study Area

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Others (infrastructure)

Windsor Nature Park (area not surveyed)

Waterbody

Worksite and alignment

Boardwalk

Plant Specimens

Critically Endangered

Endangered

Vulnerable

N

							Qualified Person Endorsement : NA	Consultant : <b>AECOM</b>	Land Transport Authority <i>We Keep Your World Moving</i>			
							LTA Endorsement : NA	Project Title : <b>CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (WINDSOR AND ENG NEO AVENUE FOREST)</b>	Figure Title : <b>DISTRIBUTION OF PLANT SPECIMENS OF CONSERVATION SIGNIFICANCE IN THE NORTHERN FOREST FRAGMENT (EXCLUDING WINDSOR NATURE PARK)</b>			
									Designed SHMX	Checked JAG	Approved JAG	Figure No. : 7 - 88
Rev.	Date	By	Description	Chk'd	App'd			Drawn SHMX	Date JUN 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

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Many species were observed to be restricted to the northern native patch in Windsor, some of which with only records of one specimen. For example, *Enkleia malaccensis* is a species from the family Thymelaeaceae seldom encountered in the secondary forests of Singapore. Within the CCNR and old growth forests, however, this species occurs at higher frequency and can be found in greater abundance. In this present study, only one specimen of this species was found in the northern native forest. A single *Elaeocarpus rugosus* tree of 0.15 m girth was also the only specimen recorded for this species within the same native patch.

Some of the rarer species of conservation significance include *Rourea asplenifolia* (Figure 7-89B), *Gironniera subaequalis* (Figure 7-90C), *Rourea fulgens* (Figure 7-91A), and *Baccaurea sumatrana* (Figure 7-91C). Both *R. asplenifolia* and *R. fulgens* were found in close proximity to each other in the northern native patch. This is an interesting and important find as there are only four extant *Rourea* species in Singapore, the other two being *R. minor* and *R. mimosoides*, which are nationally Endangered and Critically Endangered, respectively. As such, the area where two of the four extant *Rourea* species were found could serve as a refuge for species of this genus, in addition to the old growth forests of the CCNR.

As with many other species, the distribution of *Rinorea anguifera* within the Study Area was also restricted to the northern native patch. The only specimen of this species encountered in the present study's floristic surveys was a fallen tree with young shoots resprouting (Figure 7-89D). The area where the tree was found had low canopy cover and appeared to have been recently disturbed, presumably from tree falls. Small fragmented forest patches tend to experience greater forest edge effects where microclimatic conditions such as light, temperature, wind, and humidity have greater fluctuations. The Windsor northern forest is likely to experience these microclimatic conditions given that it is situated in the midst of a highly urbanised landscape and is fragmented by developments abutting its borders. With natural disturbances such as storm events, it could trigger treefalls within small forested fragments. While such periodic disturbances is a natural mechanism that helps maintain community equilibrium within forest patches, such as the one investigated by Yee et al. (2019), the cost of losing species from tree falls and failures in a forested landscape as that in the Windsor northern forest could be high. This is attributed to the fact that most threatened specimens are few and far between and the native patch is surrounded by exotic-dominated forest. Compared to many old secondary and primary forest native tree species, exotic trees such as *Spathodea campanulata* are able to quickly establish themselves in areas with open canopy. Smaller native trees and saplings in the lower forest strata that are unable to outcompete the exotic counterparts would eventually be shaded out. In such scenarios, the forest would slowly be taken over and dominated by exotic species.

Aside from the aforementioned observations, some nationally threatened species were found to be widespread throughout the site, such as *Strombosia javanica*, *Artabotrys suaveolens* (Figure 7-89D), and *Connarus semidecandrus*.



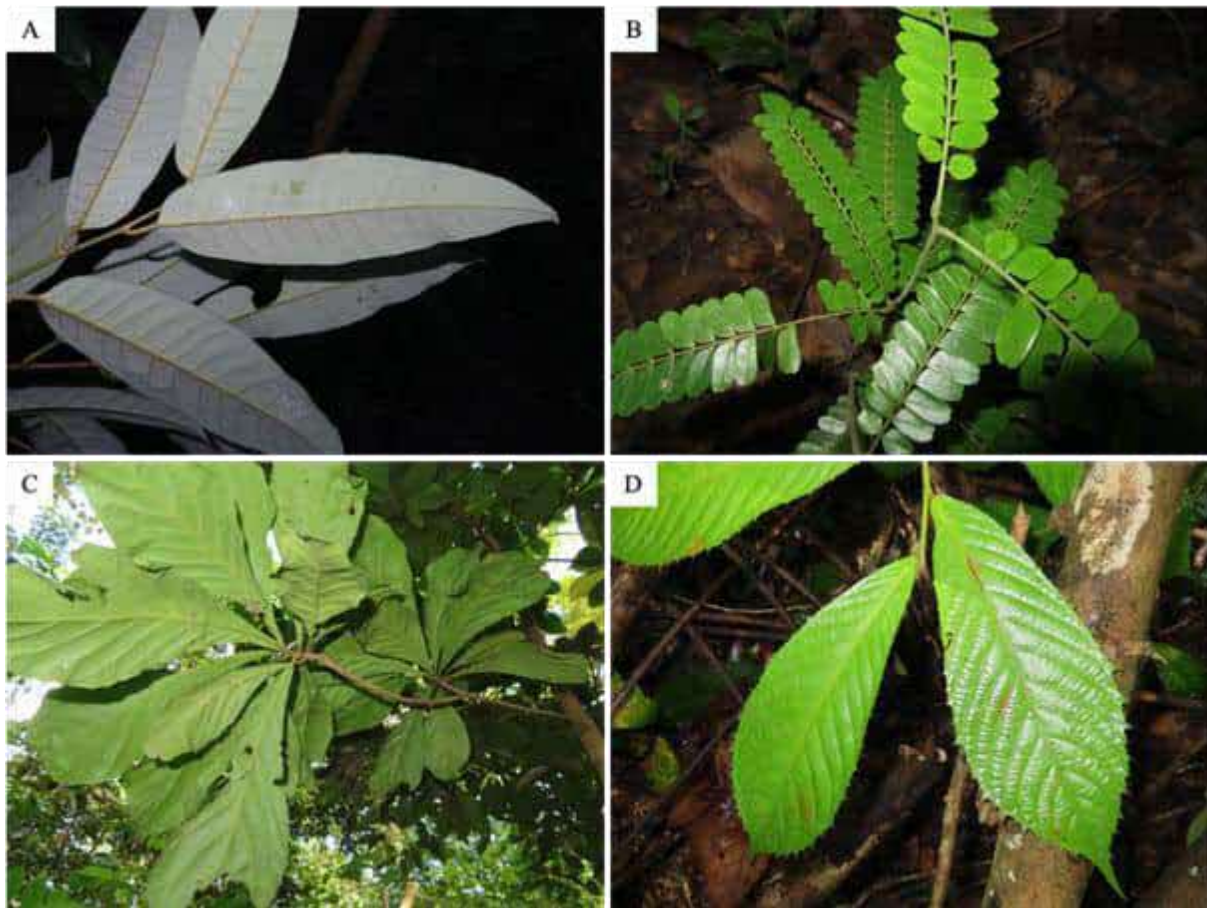


Figure 7-89 Nationally Critically Endangered Plant Species Recorded at the Northern Forest Fragment. (A) Leaf Underside of *Gymnacranthera cf. forbesii*; (B) *Rourea asplenifolia*; (C) *Elaeocarpus rugosus*; (D) *Rinorea anguifera*.



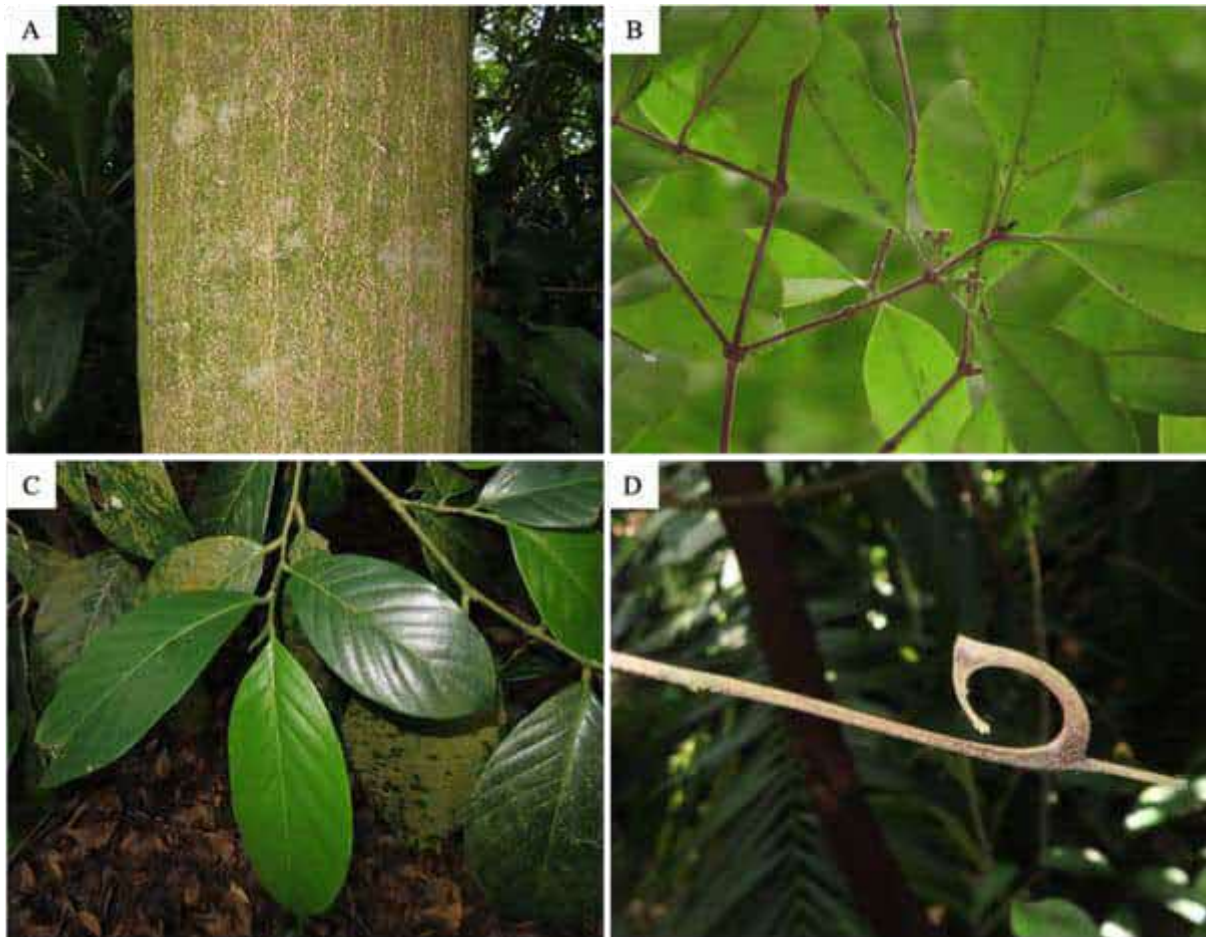
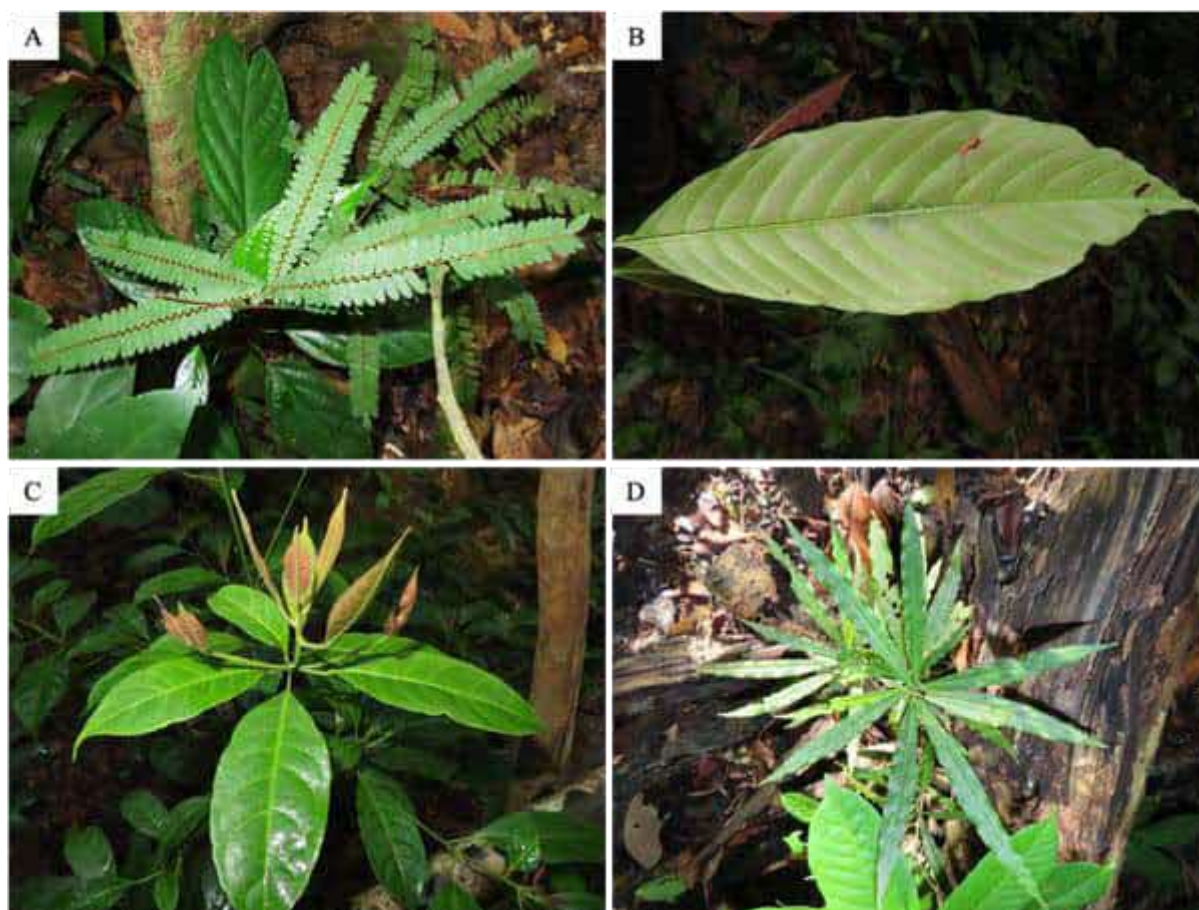


Figure 7-90 Nationally Endangered Plant Species Recorded at the Northern Forest Fragment. (A–B) *Carallia brachiata* Tree of 0.8 m Girth with Flower Buds; (C) A Leafy Twig of *Gironniera subaequalis*; (D) The Distinctive Hook of The Woody Climber *Artabotrys suaveolens*.





**Figure 7-91 Nationally Vulnerable Plant Species Recorded at the Northern Forest Fragment. (A) *Rourea fulgens*; (B) Leaf Underside of *Tetracera fragifolia*; (C) *Baccaurea sumatrana*; (D) *Elaeocarpus nitidus*.**

#### 7.3.4.2.3 Large Plant Specimens

Forty-three large plant specimens were recorded at Windsor – 27 in the Northern Forest Fragment and 16 along the boardwalks in Windsor Nature Park (Appendix E3).

Of the 27 large plant specimens in the Northern Forest Fragment, ten are trees of 3.0–4.5 m girth, ten are *Ficus microcarpa* stranglers of 3–15 m spread, five are *Bambusa vulgaris* clusters of 3–10 m spread, and two are *Oncosperma tigilarium* clusters both of which are of 3 m spread.

Of the 16 large plant specimens along the boardwalks in Windsor Nature Park, two are trees of 4 m (*Ficus variegata*) and 3.2 m (*Samanea saman*) girth, respectively, eight are stranglers of 3–20 m spread, and six are *Bambusa vulgaris* clusters of 4–12 m spread.

There are four large plant specimens that lie directly within the original worksite (Figure 7-92). These specimens are one *Pterocarpus indicus* tree of 3 m girth, two *Ficus microcarpa* stranglers of 3 m and 4 m spread, respectively, and one *Bambusa vulgaris* cluster of 3 m spread. There were no bamboo bats recorded at this bamboo cluster during roost emergence surveys.

Three other large plant specimens are located in very close proximity to the boundary of the original worksite at Windsor. They are two *Pterocarpus indicus* trees, both of which have 4.5 m girth, and one *Ficus microcarpa* strangler of 10 m spread. Although the locations of these specimens are represented as points on the distribution map and appear to be outside the worksite boundary, these specimens have large basal areas owing to their sizes. Hence, a portion of the basal areas may overlap with the worksite.

None of the large plant specimens appear to lie within the optimised worksite. There is, however, one *Cyrtophyllum fragrans* tree of 3.1 m girth situated in very close proximity to the western-most tip of the optimised worksite and may partially be within the worksite given its large basal area.



Table 7-33 Number of Large Plant Specimens in Windsor (Including Windsor Nature Park)

Area	Habit	Species	No. of Specimens
Northern Forest Fragment	Tree	<i>Alstonia angustiloba</i>	1
		<i>Cyrtophyllum fragrans</i>	1
		<i>Khaya senegalensis</i>	1
		<i>Pterocarpus indicus</i>	4
		<i>Samanea saman</i>	3
	Strangler	<i>Ficus microcarpa</i>	10
	Shrub (Bamboo)	<i>Bambusa vulgaris</i>	5
Windsor Nature Park	Shrub (Palm)	<i>Oncosperma tigilarium</i>	2
	Tree	<i>Ficus variegata</i>	1
		<i>Samanea saman</i>	1
	Strangler	<i>Ficus benjamina</i>	2
		<i>Ficus microcarpa</i>	6
	Shrub (Bamboo)	<i>Bambusa vulgaris</i>	6
Total			43





**Legend**

Study Area

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Others (infrastructure)

Windsor Nature Park

Waterbody

Worksite and alignment

Boardwalk

Large Specimens

Tree

Strangler

Bamboo

Palm

N

							Qualified Person Endorsement : NA	Consultant : <b>AECOM</b>	Land Transport Authority <i>We Keep Your World Moving</i>			
							LTA Endorsement : NA	Project Title : <b>CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (WINDSOR AND ENG NEO AVENUE FOREST)</b>	Figure Title : <b>DISTRIBUTION OF LARGE PLANT SPECIMENS IN WINDSOR (INCLUDING WINDSOR NATURE PARK)</b>			
									Designed SHMX	Checked JAG	Approved JAG	Figure No. : 7 - 92
Rev.	Date	By	Description	Chk'd	App'd			Drawn SHMX	Date JUN 2022	CAD File Name : NA		A3

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**Figure 7-93 Large specimens in Windsor (Including Windsor Nature Park). (A) *Alstonia angustiloba* of 3.3 m Girth; (B) *Oncosperma tigilarium* of 3 m Spread; (C) *Ficus macrocarpa* of 10 m Spread; (D) *Bambusa vulgaris* of 12 m Spread.**

#### **7.3.4.2.4 Other Plant Specimens of Value**

Seven other plant specimens of value were recorded at Windsor, all of which are bamboo clusters of 1–2 m spread (Appendix F3). Of these, six are in the Northern Forest Fragment and one along the boundary of Windsor Nature Park adjacent to Island Club Road. These bamboo clusters, albeit small in size, could be potential roost sites for nationally threatened bamboo bats. Bamboo bats enter bamboo internodes via small slits caused by leaf beetle larvae (Figure 7-95) and spend most of the day roosting inside (Chan & D'Rozario, 2013).

Two of these small bamboo clusters are situated within the worksite. There were no bamboo bats recorded at these clusters during roost emergence surveys..









**Figure 7-95 *Bambusa heterostachya*. (A) Specimen of 1 m Spread; (B) A Small Slit that could be Utilised by Bamboo Bats to Enter and Exit the Bamboo Internode.**

#### 7.3.4.2.5 Arboricultural Survey Findings

A total of 320 specimens belonging to 39 species and 20 families were tagged in the Northern Forest Fragment. The five tree species that make up majority (> 50%) of all specimens assessed during arboricultural surveys are, in descending order, *Nephelium lappaceum*, *Hevea brasiliensis*, *Cocos nucifera*, *Elaeis guineensis*, and *Cinnamomum iners* (Appendix G3). Only one specimen of conservation significance, *Palaquium obovatum*, of 0.3 m girth was encountered in the western native patch.

Note that there were more specimens assessed than tagged as some specimens occur in clusters, i.e., within 1–2 m of each other. All the specimens within clusters were assessed, but only one specimen was tagged (Section 7.2.4.4).

#### 7.3.4.2.6 Forest Regeneration

The top ten most abundant tree species occurring in the vegetation plots, from each broad girth-size class (i.e.  $\geq 0.5$ -m girth and < 0.5-m girth), were ranked in descending order (Figure 7-34). For the  $\geq 0.5$ -m girth-size class, however, the 33 specimens in total are only represented by six species (Figure 7-96). The < 0.5 m girth-size class, with 224 specimens altogether (Figure 7-97), was further divided to reveal any trends (Figure 7-98).

Further division was omitted for the  $\geq 0.5$  m girth-size class, where only stem counts of oil palm (*Elaeis guineensis*) and rubber (*Hevea brasiliensis*) exceeded ten each, while that of the remaining species were fewer than five each (Figure 7-96). The six species in this girth-size class comprise a mix of light-demanding native species (*Macaranga gigantea*), other native species (*Aporosa frutescens*, *Prunus polystachya*, and *Strombosia javanica*) as well as exotic species (*Elaeis guineensis* and *Hevea brasiliensis*). Given their overall low stem counts, there is insufficient resolution for the detection of distinct trends.

On the other hand, there are numerous seedlings and saplings found in the lower forest strata. Overall, the girth-size classes of 0.05 m and smaller, and 0.1–0.2 m, contribute to 50.4% and 86.7% of the total stem count, respectively (Figure 7-97). The total stem count of specimens < 0.5 m girth generally exhibits a reverse-J distribution pattern (Figure 7-98), indicating that abundance is unevenly distributed across species. This means that there is high recruitment of seedlings for several species, resulting in their disproportionate representation at the Northern Forest Fragment.

In particular, there is an overrepresentation of rubber (*Hevea brasiliensis*), comprising 34.5% of all specimens < 0.5 m girth, and far outstripping even the second-most abundant species, *Aporosa frutescens* (78 versus 43 stems) (Figure 7-97; Figure 7-98). This corroborates with the categorisation of the vegetation type here as abandoned-land forest (as per vegetation mapping carried out for this study; and in previous surveys e.g., Neo et al., 2014). Given that the area was a former rubber plantation that was subsequently abandoned with mature trees intact (Yee et al., 2006), these would have acted as seed sources, accounting for the persistence of rubber (*H. brasiliensis*) at the Northern Forest Fragment through continual recruitment.

Additionally, there is evidence of past cultivation of fruit trees, indicated by the presence of seedlings and saplings of the rambutan (*Nephelium lappaceum*), durian (*Durio zibethinus*) and langsat (*Lansium domesticum*). There are also several native, non-fruit-tree species that contribute to the top ten most abundant species in the < 0.5 m girth-



size class. They are, in descending abundance, *Aporosa frutescens*, *Cinnamomum iners*, *Strombosia javanica*, *Macaranga bancana*, *Prunus polystachya*, and *Leea indica*.

For species that are reflected in the top ten for the < 0.5 m girth-size class but are absent in the ≥ 0.5 m girth-size class (i.e., *C. iners*, *N. lappaceum*, *M. bancana*, *D. zibethinus*, *L. domesticum*, and *L. indica*), it is likely that mature specimens of these fruit and non-fruit trees still persist elsewhere in the vicinity, and act as seed sources in the forest. Although these species were not encountered in the vegetation plots, they were encountered in the other parts of the forest during floristic surveys in this study.

The high saturation of seedlings belonging to both native and fruit tree species occupying the same forest strata is indicative that there could be inter- and intra-specific competition for space, nutrients, light, and other resources. Should the native seedling species successfully outcompete the exotic seedling species when there are forest canopy openings, e.g., from natural tree falls, the forest may slowly recover into a native secondary forest over a long period of time if left undisturbed. However, if the exotic seedlings persist, seedling competition between the exotic and native species is likely to continue. Native species that are unable to outcompete the exotic counterparts would eventually be shaded out. In such scenarios, the forest would continue to be dominated by exotic species.

In the case of the Northern Forest Fragment, its proximity to native-dominated forest (i.e., that of the CCNR and more specifically, Windsor Nature Park) is advantageous, in that there are more opportunities for the dispersal of native propagules. Hence, it is not far-fetched to expect the Northern Forest Fragment to shift to a native-dominated forest over time. Nevertheless, considering that most areas in Singapore have been developed and the remaining areas covered with spontaneous vegetation are secondary forests, these forest patches are valuable and should be considered in conservation efforts (Yee et al., 2016).

**Table 7-34 The Ten Most Abundant Tree Species in the Northern Forest Fragment, Listed in Descending Order**

S/N	Trees of ≥ 0.5 m Girth	Trees of < 0.5 m Girth
1.	<i>Elaeis guineensis</i>	<i>Hevea brasiliensis</i>
2.	<i>Hevea brasiliensis</i>	<i>Aporosa frutescens</i>
3.	<i>Macaranga gigantea</i>	<i>Cinnamomum iners</i>
4.	<i>Strombosia javanica</i>	<i>Nephelium lappaceum</i>
5.	<i>Aporosa frutescens</i>	<i>Strombosia javanica</i>
6.	<i>Prunus polystachya</i>	<i>Macaranga bancana</i>
7.	N.A.	<i>Durio zibethinus</i>
8.	N.A.	<i>Lansium domesticum</i>
9.	N.A.	<i>Prunus polystachya</i>
10.	N.A.	<i>Leea indica</i>



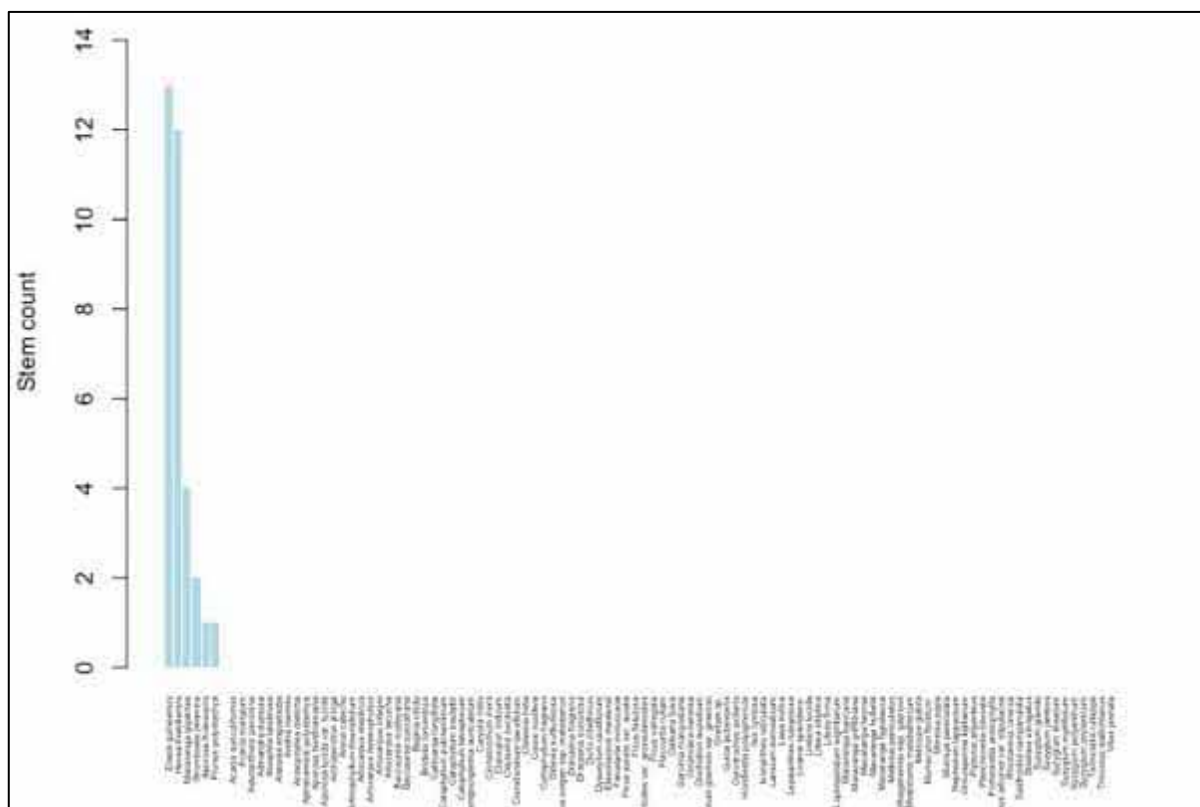
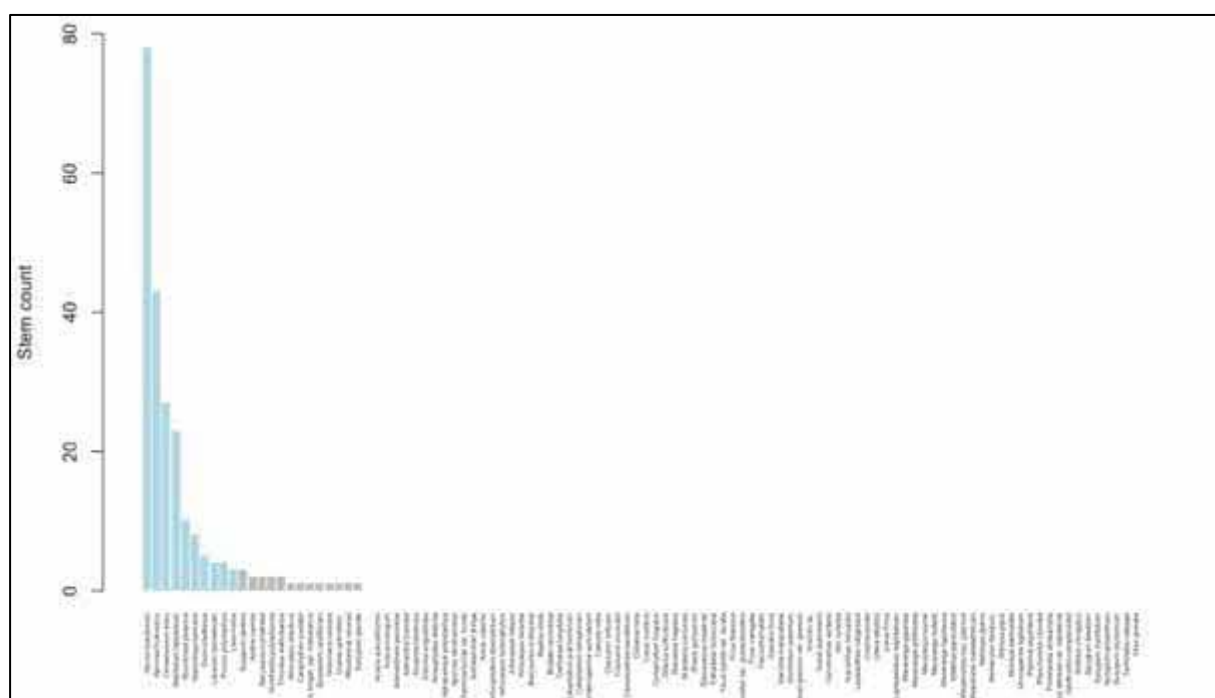


Figure 7-96 Number of Stems (33 In Total) with  $\geq 0.5$  m Girth for All Species Across Vegetation Plots in the Northern Forest Fragment. Bars in Light Blue belong to the Five Most Abundant Species.



**Figure 7-97 Number of Stems (224 In Total) with < 0.5 m Girth For All Species across Vegetation Plots in the Northern Forest Fragment. Bars in Light Blue belong to the Ten Most Abundant Species.**



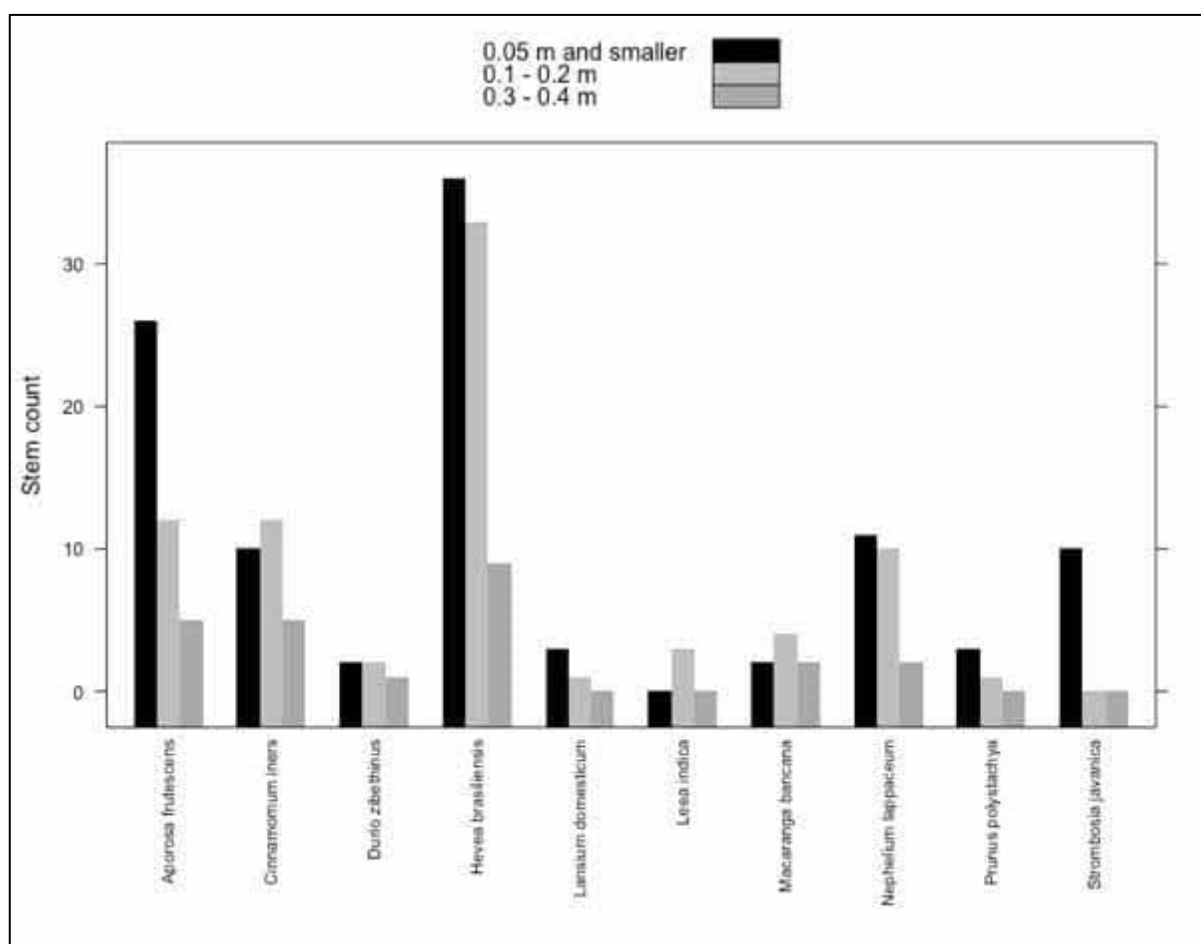


Figure 7-98 Girth-Size Distribution of the Ten Most Abundant Tree Species with < 0.5 m Girth in the Northern Forest Fragment



### 7.3.4.3 Faunistic Field Findings

#### 7.3.4.3.1 Overall

The desktop assessment identified 873 species of probable occurrence at Windsor, including 182 species of conservation significance (Table 7-35; Appendix H3).

The field assessment documented 229 species, dominated by birds (60 species) and butterflies (51 species). From these, 26 species of conservation significance were recorded, including one butterfly species that was not listed as probable. The findings for each faunal group are described in Sections 7.3.4.3.3 to 7.3.4.3.12. The list of probable and recorded species is available in Appendix H3, and summarised in Table 7-35. The list of faunal species of conservation significance and their conservation status is available in Table 7-36. The faunal survey and camera trap data are provided in Appendix I3 and Appendix J3 respectively.

**Table 7-35 Summary of Probable and Recorded Faunal Species at Windsor**

Faunal Group	No. of Probable Species		No. of Recorded Species		No. of Recorded Species Not on Probable List (CS Species)
	All Species	CS Species	All Species	CS Species	
<b>Aculeate hymenopterans</b>	86	1	20	0	0
<b>Bees</b>	42	1	8	0	0
<b>Stinging wasps</b>	44	0	12	0	0
<b>Odonates</b>	82	25	33	5	0
<b>Dragonflies</b>	56	11	23	1	0
<b>Damselflies</b>	26	14	10	4	0
<b>Butterflies</b>	307	52	51	2	1 (0)
<b>Freshwater decapod crustaceans</b>	5	2	1	0	0
<b>Freshwater fish</b>	45	1	15	0	0
<b>Herpetofauna</b>	99	48	30	7	0
<b>Amphibians</b>	24	6	14	2	0
<b>Reptiles</b>	75	42	16	5	0
<b>Birds</b>	209	38	60	7	0
<b>Mammals</b>	40	15	19	5	0
<b>Non-volant mammals</b>	24	7	14	5	0
<b>Bats</b>	16	8	5	0	0
<b>Total</b>	<b>873</b>	<b>182</b>	<b>229</b>	<b>26</b>	<b>1 (0)</b>

Note: 'CS species' refers to species of conservation significance.

The highest richness was recorded in the eastern part of the Study Area. Species recorded were dominated by birds (19 species) and butterflies (19 species). Species recorded were largely common, such as the variegated green skimmer (*Orthetrum sabina*), white-breasted waterhen (*Amaurornis phoenicurus*) and plantain squirrel (*Callosciurus notatus*). The presence of waterbodies in the area may have supported the higher richness observed. The open habitat here may allow for ease of detection of species.

Along the waterbodies, the highest richness (23 species) was recorded at the open-country pond near the entrance of the Park (D/S13). Records were dominated by odonates (10 species) that favour such habitats, as well as fish (7 species) which are largely non-natives possibly released by park users.

Due to the contiguity of the Study Area within the CCNR, it is likely for rare or forest-dependent species to occur here. Streams within the Study Area also serve as important habitats for forest-dependent species, which is an increasingly uncommon habitat in Singapore. The Study Area provides habitats for species of conservation significance which were distributed across the Study Area (Figure 7-99), including the nationally Vulnerable gold-ringed cat snake (*Boiga dendrophila*) and globally threatened Sunda slow loris (*Nycticebus coucang*).

Although separated by the Island Club Road, the Northern Forest Fragment shares similar faunal assemblage with Windsor Nature Park. Canopy connections present along the Island Club Road are important in providing crossings for non-gliding arboreal animals namely the Raffles banded langur (*Presbytis femoralis femoralis*). It is an important habitat connectivity for the langurs to move between northern and southern part of CCNR, as discussed in Section



7.3.4.3.11. Two canopy connections were noted at the eastern end of worksite, and the south-western end of worksite across the worksite. However, these canopy connections were occasionally observed to be broken by natural shedding of tree or pruning activity. Along the Island Club Road, there were also a few records of roadkills of amphibian, reptiles and mammal discussed in respective sections below.

Within the proposed worksites, species of conservation significance were recorded based on findings from this field assessment, ESC (2020) or ERM (2020). Notable findings are arboreal and terrestrial mammals, namely the Sunda colugo (*Galeopterus variegatus*), Sunda slow loris (*Nycticebus coucang*), Horsfield's flying squirrel (*Iomys horsfieldii*), Sunda pangolin (*Manis javanica*) and sambar deer (*Rusa unicolor*).





**Legend**

Study Area

Worksite and alignment

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route

Roadkill transect along Island Club Road

Boardwalk

Faunal species of conservation significance

Amphibian

Bird

Butterfly

Mammal

Odonate

Reptile

N

-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
(WINDSOR AND  
ENG NEO AVENUE FOREST)

Designed JW	Checked JAG	Approved JAG
	Drawn JW	Date JUN 2022

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Figure Title :  
**LOCATION RECORDS OF  
CONSERVATION SIGNIFICANT  
FAUNAL SPECIES IN WINDSOR**

Figure No. : 7 - 99	Rev. -	Sheet 1 of 1
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**Table 7-36 List of Faunal Species of Conservation Significance Recorded in Windsor**

Taxon	Species	Common Name	Local Status	Global Status
Odonate	<i>Coeliccia octogesima</i>	Telephone sylvan	Vulnerable	Not Assessed
Odonate	<i>Devadatta argyroides</i>	Malayan grisette	Endangered	Least Concern
Odonate	<i>Microgomphus chelifer</i>	Tiny sheartail	Vulnerable	Least Concern
Odonate	<i>Pericnemis stictica</i>	Dryad	Vulnerable	Least Concern
Odonate	<i>Podolestes orientalis</i>	Blue-spotted flatwing	Vulnerable	Least Concern
Butterfly	<i>Potanthus trachala tytleri</i>	Detached dart	Nationally Extinct (Rediscovered)	Not Assessed
Butterfly	<i>Troides helena cerberus</i>	Common birdwing	Vulnerable	Not Assessed; CITES protected (Appendix II)
Amphibian	<i>Nyctixalus pictus</i>	Cinnamon bush frog	Vulnerable	Near Threatened
Amphibian	<i>Pulchrana baramica</i>	Golden-eared rough-sided frog	Vulnerable	Least Concern
Reptile	<i>Amyda cartilaginea</i>	Asian softshell turtle	Vulnerable	Vulnerable
Reptile	<i>Boiga melanota</i>	Gold-ringed cat snake	Vulnerable	Least Concern
Reptile	<i>Draco melanopogon</i>	Black-bearded flying dragon	Vulnerable	Not Assessed
Reptile	<i>Dendrelaphis haasi</i>	Haas's bronzeback	Critically Endangered	Least Concern
Reptile	<i>Sibynophis melanocephalus</i>	Black-headed collared snake	Vulnerable	Least Concern
Bird	<i>Collocalia affinis</i>	Plume-toed swiftlet	Not Assessed	Not Assessed
Bird	<i>Copsychus malabaricus</i>	White-rumped shama	Critically Endangered	Least Concern
Bird	<i>Gallus gallus</i>	Red junglefowl	Endangered	Least Concern
Bird	<i>Loriculus galgulus</i>	Blue-crowned hanging-parrot	Endangered	Least Concern
Bird	<i>Nisaetus cirrhatus</i>	Changeable hawk-eagle	Endangered	Least Concern
Bird	<i>Psittacula longicauda</i>	Long-tailed parakeet	Not Assessed	Vulnerable
Bird	<i>Rallina fasciata</i>	Red-legged crake	Vulnerable	Least Concern
Bird	<i>Surniculus lugubris</i>	Square-tailed drongo-cuckoo	Critically Endangered	Least Concern
Mammal	<i>Iomys horsfieldii</i>	Horsfield's flying squirrel	Endangered	Least Concern
Mammal	<i>Macaca fascicularis</i>	Long-tailed macaque	Least Concern	Vulnerable
Mammal	<i>Manis javanica</i>	Sunda pangolin	Critically Endangered	Critically Endangered
Mammal	<i>Nycticebus coucang</i>	Sunda slow loris	Endangered	Endangered
Mammal	<i>Tragulus kanchil</i>	Lesser mousedeer	Endangered	Least Concern
Bird	<i>Collocalia affinis</i>	Plume-toed swiftlet	Not Assessed	Not Assessed
Bird	<i>Copsychus malabaricus</i>	White-rumped shama	Critically Endangered	Least Concern
Bird	<i>Gallus gallus</i>	Red junglefowl	Endangered	Least Concern

#### 7.3.4.3.2 Sampling Coverage

Along the terrestrial sampling routes and at aquatic sampling points, the sample coverage for each taxon was all above 70%, with the exception of aculeate hymenopterans from terrestrial sampling routes (67.7%) and reptiles at aquatic sampling points (31.6%) (Figure 7-100; Table 7-37). With doubled sampling effort, additional species may be detected. It is generally low across all taxa, although a higher number is expected for butterflies (17 species) and birds (9 species). Sample coverage was not calculated for faunal groups with less than two species recorded.



Both terrestrial and arboreal camera traps obtained a high coverage of 99.0% and 100.0% respectively (Figure 7-100; Table 7-37).

**Table 7-37 Result Summary of Taxon Sampling Analysis for Windsor**

Faunal Group	Sample Coverage (%)	Observed Richness	Estimated Richness ( $\pm$ Standard Error)	95% Confidence Interval for Estimated Richness	Estimated Coverage with Doubled Effort (%)	Estimated Richness (And Additional Species) with Doubled Effort
<b>Terrestrial Sampling Routes</b>						
Aculeate Hymenopteran	67.7	19	30 $\pm$ 9.4	21.9–65.8	87.2	26 (+7)
Odonate	86.5	25	33 $\pm$ 6.7	26.9–58.3	96.0	30 (+5)
Butterfly	74.3	45	78 $\pm$ 18.4	57.3–136.7	87.7	62 (+17)
Amphibian	89.9	11	12 $\pm$ 2.6	11.3–25.0	98.6	12 (+1)
Reptile	N.A.	1	N.A.	N.A.	N.A.	N.A.
Bird	94.9	50	65 $\pm$ 11.3	54.5–105.9	97.9	59 (+9)
Non-Volant Mammal	97.4	11	11 $\pm$ 1.8	11.1–21.8	99.6	11 (+0)
Mammal (Bat)	N.A.	1	N.A.	N.A.	N.A.	N.A.
<b>Aquatic Sampling Points</b>						
Odonate	76.3	21	34 $\pm$ 11.3	24.3–77.2	89.1	28 (+7)
Fish	86.5	13	18 $\pm$ 5.9	14.0–43.5	95.3	16 (+3)
Amphibian	89.3	8	9 $\pm$ 2.1	8.2–19.8	98.6	9 (+1)
Reptile	31.6	6	17 $\pm$ 15.5	7.5–90.7	55.7	9 (+3)
<b>Camera Trapping</b>						
Terrestrial Mammal	99.0	9	9 $\pm$ 0.7	9.0–13.7	100.0	9 (+0)
Arboreal Mammal	100.0	4	4 $\pm$ 0.1	4–4.2	100.0	4 (+0)

Note: Est: estimated; s.e.: standard error, CI: confidence interval



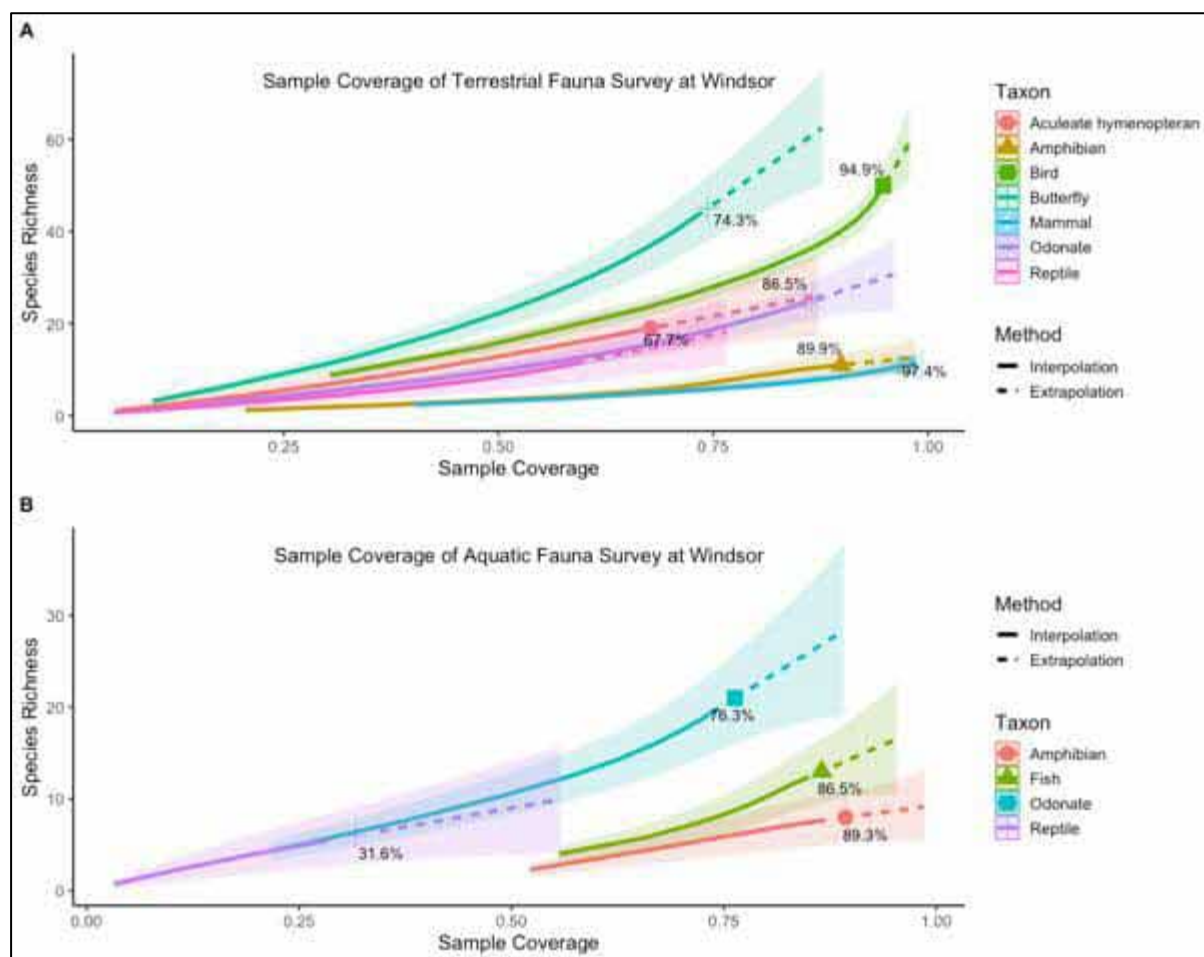
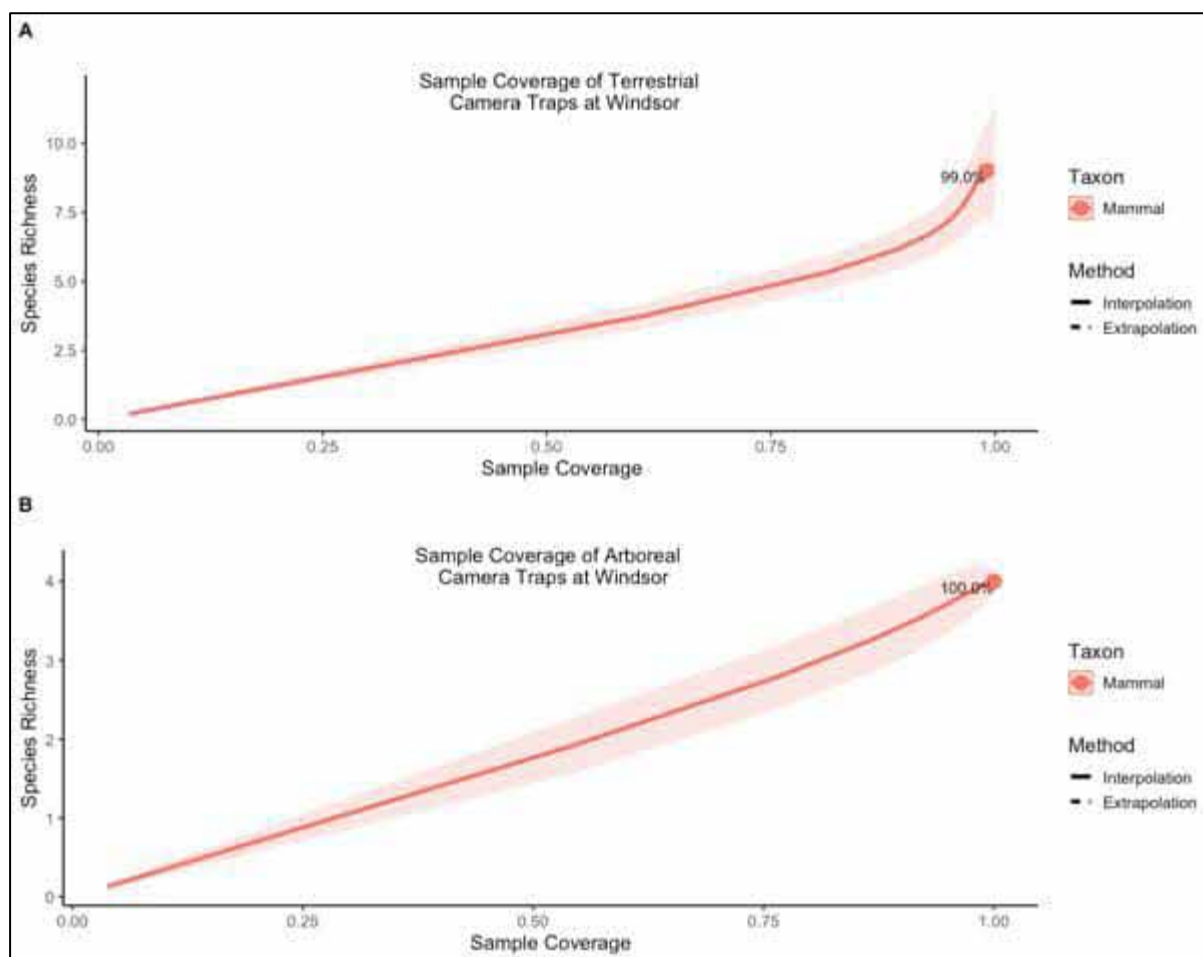


Figure 7-100 Taxon Sampling Curves for Respective Faunal Groups (A) Along Terrestrial Sampling Routes and (B) At Aquatic Sampling Points in Windsor





**Figure 7-101 Taxon Sampling Curve for (A) Terrestrial Camera Traps and (B) Arboreal Camera Traps in Windsor**

#### 7.3.4.3.3 Aculeate Hymenopterans

A total of 20 species of aculeate hymenopterans were recorded, from five families – Apidae (6 species), Halictidae (2 species), Crabronidae (2 species), Sphecidae (3 species) and Vespidae (7 species) (Table 7-35; Appendix H3). Records of aculeate hymenopterans were generally low along the terrestrial sampling routes, with higher records along the Island Club Road (6 species) and the entrance of Windsor Nature Park (5 species).

One wasp species, *Spheg subtruncatus*, is classified as Near-threatened following the criteria in Ascher et al. (in prep). It is a forest-inclined species (not strictly forest-dependent) that are usually found in natural habitats. The most abundantly recorded species was the Eastern honeybee (*Apis cerana*) with 17 individuals recorded, followed by Broad-handed carpenter bee (*Xylocopa latipes*) with 13 individuals recorded.

Several species were recorded feeding on plant species within the site, suggesting that the site provides foraging opportunities for the species. For example, the *Antepipona* sp. nr. *bipustulata*, *Ceratina nigrolateralis* and *Isodontia diodon* were observed feeding on *Leea indica*. The bees, *Tetragonula valdezi* and *Heterotrigona itama* were also observed feeding on *Heliconia* sp. Nests were observed for one wasp species, the *Parischnogaster mellyi*, confirming the use of the site by this species.

#### 7.3.4.3.4 Odonates

A total of 82 species of odonates were determined of probable occurrence in Windsor, including 25 of conservation significance (Table 7-35; Appendix H3). Due to its proximity to the CCNR, forest-dependent odonate species were also expected. A total of 33 species of odonates have been observed within the Study Area, including five of conservation significance (Table 7-35; Appendix H3).

Five species of conservation significance were recorded. One species, the nationally Vulnerable Tiny sheartail (*Microgomphus chelifer*; Figure 7-102) was recorded at the stream within the Windsor Nature Park (D/S13). This species is restricted and rare. It has been recorded five times in Singapore at two locations, in Nee Soon Swamp Forest and the CCNR (Tang et al., 2010), thus a noteworthy observation. It frequents “clear lowland forest streams



with sand or gravel bottoms" that were observed within Windsor Nature Park (Tang et al., 2010). An individual of teneral was recorded in the late morning, suggesting that this species is likely breeding within the Study Area.

The other four species were recorded within the Northern Forest Fragment. The dryad (*Pericnemis stictica*) was observed within the forest close to the Island Club Road. This species is known from Central Catchment and Bukit Timah Nature Reserves, and likely breeds in bamboos stumps filled with water (Tang et al., 2010). The blue-spotted flatwing (*Podolestes orientalis*) was also observed at the D/S26 stream parallel to Upper Thomson Road. This species is found in muddy streams or puddles, characteristic of where it was observed.

The nationally Endangered Malayan grisette (*Devadatta argyroides*; Figure 7-103) was recorded once. It is restricted to clear forest streams in the CCNR (Tang et al., 2010). The nationally Vulnerable telephone sylvan (*Coeliccia octogesima*) was recorded twice around D/S26 and D/S27 streams. It is locally common within the CCNR, and found in muddy forest streams (Tang et al., 2010). These records suggest the value of habitats in both Windsor Nature Park and Northern Forest Fragment for forest-dependent species.





**Legend**

Study Area

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Others (infrastructure)

Windsor Nature Park

Waterbody

Boardwalk

Worksites and alignment

Terrestrial sampling route

Roadkill transect along Island Club Road

Odonate species of conservation significance

P. orientalis

D. argyroides

M. chelifera

C. octogesima

P. stictica

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Description

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EIS (Windsor and Eng Neo Avenue Forest)

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Qualified Person Endorsement :  
NA

LTA Endorsement :  
NA

Consultant :  
**AECOM**

Project Title :  
**CONTRACT CR2005  
ENVIRONMENTAL IMPACT STUDY  
(WINDSOR AND  
ENG NEO AVENUE FOREST)**

Designed  
JT

Checked  
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Approved  
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Drawn  
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Date  
JUN 2022

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**LOCATIONS OF ODONATE SPECIES OF  
CONSERVATION SIGNIFICANCE AT WINDSOR**

Figure No. :  
7 - 102

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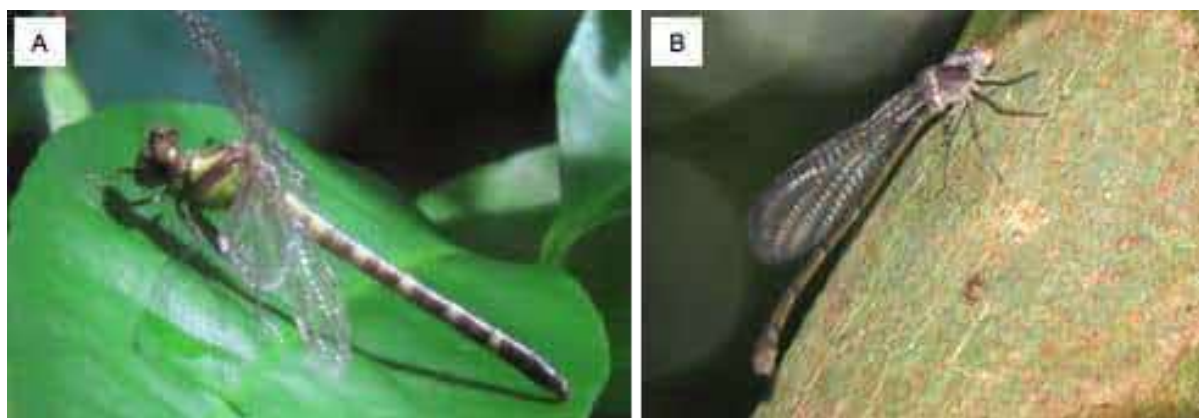
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**Figure 7-103 Odonate Species of Conservation Significance – (A) Tiny Sheartail (*Microgomphus chelifer*) and (B) Malayan Grisette (*Devadatta argyroides*)**

#### 7.3.4.3.5 Butterflies

A total of 307 butterfly species were deemed of probable occurrence at Windsor and 52 are of conservation significance (Table 7-35; Appendix H3). More than half of the species (160 species; 52%) are considered moderately to very rare due to the rarity of host plants of sightings. The rarity of four species were not assessed in Khew (2015). The field assessment recorded 52 species of butterflies, including three only identified to the genus or family level – *Baoris* sp., *Cephrenes* sp., and *Polyura* sp. (Table 7-35; Appendix H3). Due to the lack of records, *Caltois bromus* was not regarded as of probable occurrence but was recorded. Butterfly traps recorded only the Malay viscount (*Tanaecia pelea pelea*).

Two species of conservation significance were recorded. The nationally Vulnerable common birdwing (*Troides helena cerberus*) is now considered moderately common as its host plant is frequently planted in the urban landscape. It was observed once along the Island Club Road (Figure 7-104). The detached dart (*Potanthus trachala tytleri*) is listed as Nationally Extinct in Davison et al. (2008) but has since been rediscovered (Jain et al., 2018), although it remains moderately rare. Its host plants, grasses in the Poaceae family can be found in the extensive scrubland and herbaceous vegetation areas in the Study Area. One individual was recorded along the eastern end of Windsor Nature Park's trail. Forest-associated species, such as the saturn (*Zeuxidia amethystus amethystus*) and great helen (*Papilio iswara iswara*) were also recorded within the Study Area. This shows that the Study Area has value in providing habitats for conservation significant or forest-associated butterfly species.

Butterflies recorded within the proposed worksites were common species, and most of them were also observed in other parts of the Study Area.





**Legend**

- Study Area
- Vegetation
  - Native-dominated secondary forest
  - Abandoned-land forest
  - Scrubland and herbaceous vegetation
  - Managed vegetation
  - Others (infrastructure)
  - Windsor Nature Park
- Waterbody
- Boardwalk

- Worksites and alignment
- Terrestrial sampling route
- Roadkill transect along Island Club Road

Butterfly species of conservation significance

- P. t. tytleri
- T. h. cerberus

N

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#### 7.3.4.3.6 **Freshwater Decapod Crustaceans**

Due to the connectivity of waterbodies in the Study Area to the more biodiverse freshwaters of the CCNR, five species were considered of probable occurrence, including two species of conservation significance (Table 7-35; Appendix H3). Only one species, the native freshwater prawn (*Macrobrachium malayanum*) was recorded. While the freshwater prawn is not globally or nationally threatened, it is restricted to the forest streams within and around nature reserves (Ng, 1997), therefore is of significance. This species was recorded only within the streams of Windsor Nature Park (D/S13), up to three individuals recorded at each aquatic sampling point. One *Macrobrachium* sp. was also recorded at D/S13.

#### 7.3.4.3.7 **Freshwater Fish**

The desktop assessment identified 45 species of probable occurrence at the Study Area, with 15 species recorded (Table 7-35; Appendix H3). Eight are native species and six are non-native species. One species, *Geophagus* sp., was only identified to genus level.

The fish assemblage in the middle channel was dominated by native species, while downstream was characterised by only non-native species which are possibly released by park users.

While it is not listed as nationally or globally threatened, the presence of the common walking catfish (*Clarias* cf. *batrachus*) is notable. It was recorded at four locations across all streams (D/S13, D/S26 and D/S27), and in a small water puddle along the terrestrial sampling route. This species is capable of walking on land and likely dispersed when water overflowed during the rainy period. The Malayan forest betta (*Betta pugnax*) is a native species. While not listed as nationally or globally threatened, this species is restricted to forest streams in the CCNR and Western Catchment Area (Baker & Lim, 2012), thus considered a notable record. It was only recorded along the D/S27 stream in the Northern Forest Fragment. Similarly, it was also only recorded at this stream by ESC (2020).

#### 7.3.4.3.8 **Amphibians**

A total of 24 amphibians, six of conservation significance, were deemed of probable occurrence (Table 7-35; Appendix H3). The field assessment recorded 14 amphibian species including two of conservation significance (Table 7-35; Appendix H3). Three non-native frogs, the greenhouse frog (*Eleutherodactylus planirostris*), banded bull frog (*Kaloula pulchra*) and East Asian ornate chorus frog (*Microhyla mukhlesuri*) were also recorded.

Two species of conservation significance were recorded. The nationally Vulnerable golden-eared rough-sided frog (*Pulchrana baramica*) was only recorded through auditory calls, mostly from the streams in Windsor Nature Park. This species is considered rare and restricted to CCNR, Western Catchment Area and Pulau Tekong (Baker & Lim, 2012). There were five records of this species (Figure 7-105). The nationally Vulnerable cinnamon bush frog (*Nyctixalus pictus*) is also considered rare and confined to the CCNR (Baker & Lim, 2012). It is also Near Threatened globally due to threat from habitat loss and habitat degradation. This species was only heard once at the western end of the Windsor Nature Park's trail (Figure 7-105).

The copper-cheeked frog (*Chalcorana labialis*) was recorded in both Windsor Nature Park, as well as D/S26 and D/S27 streams in the Northern Forest Fragment. While this species is not listed as threatened, it is a forest-associated species that is largely restricted to CCNR and Western Catchment Area (Baker & Lim, 2012). Its presence suggests the value of Northern Forest Fragment in providing habitats for forest-associated species.

A roadkill of field frog (*Fejervarya limnocharis*) was observed along the Island Club Road.





**Legend**

Study Area

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Scrubland and herbaceous vegetation

Managed vegetation

Others (infrastructure)

Windsor Nature Park

Waterbody

Boardwalk

Worksites and alignment

Terrestrial sampling route

Roadkill transect along Island Club Road

Amphibian species of conservation significance

P. baramica

N. pictus

Roadkill (F. limnocharis)

N

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#### 7.3.4.3.9 Reptiles

The probable species list amounted to 75 reptiles comprising seven terrapins, 21 lizards and 47 snakes (Table 7-35; Appendix H3). Of this, 42 species were of conservation significance. The field assessment recorded 16 reptiles (two terrapins, seven lizards and seven snakes), five of which are of conservation significance (Table 7-35; Appendix H3). Richness of reptiles was generally low across all terrestrial sampling routes. The nationally Vulnerable black-bearded flying dragon (*Draco melanopogon*) was recorded twice along the western end of Windsor Nature Park's trail. It is uncommon and restricted to the CCNR (Baker & Lim, 2012).

The gold-ringed cat snake (*Boiga melanota*) was recorded once in the stream at Windsor Nature Park (D/S13; Figure 7-106). It was swimming in the stream and appears to be foraging. This species is considered widespread but rare, and largely restricted to the CCNR (Baker & Lim, 2012).

The Asian softshell turtle (*Amyda cartilaginea*) is globally and nationally Vulnerable. There were five records of the turtle from diurnal and nocturnal surveys at the pond habitat at the entrance of Windsor Nature Park (D/S13; Figure 7-106). The records may be from the same individual.

The nationally Near Threatened Wagler's pit viper (*Tropidolaemus wagleri*) was recorded at four locations in both Windsor Nature Park and Northern Forest Fragment (Figure 7-106). This species was only reported as a new snake record for Singapore in 2011 (Lim & Cheong, 2011) as it was previously misidentified as painted bronzeback (*Dendrelaphis pictus*). Two recent records from Lower Peirce Reservoir and Upper Seletar Reservoir Park, suggest that this species is a forest specialist and is rare (Lim & Cheong, 2011). Therefore, it is a notable record and considered of conservation significance.

The Haas's bronzeback (*Dendrelaphis haasi*) was recorded once within Windsor Nature Park (Figure 7-106). It was not assessed in the SRDB as it was only reported as a new snake record for Singapore in 2011 (Lim & Cheong, 2011). It was previously misidentified as painted bronzeback (*Dendrelaphis pictus*). Two recent records from Lower Peirce Reservoir and Upper Seletar Reservoir Park, suggest that this species is a forest specialist and is rare (Lim & Cheong, 2011). Therefore, it is a notable record.

The nationally Vulnerable black-headed collared snake (*Sibynophis melanocephalus*; Figure 7-107) was observed dead on road along the western end of Island Club Road (Figure 7-106). This species is known from the CCNR, Western Catchment Area and Pulau Tekong (Baker & Lim, 2012). It is widespread but uncommon. ERM (2020) also reported two roadkills during their study. The species recorded are the water monitor (*Varanus salvator*) and elegant bronzeback (*Dendrelaphis formosus*). The latter is nationally Vulnerable and considered as rare.





**Legend**

Study Area

Worksite and alignment

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route

Roadkill transect along Island Club Road

Boardwalk

Reptilian species of conservation significance

A. cartilaginea

B. melanota

D. haasi

D. melanopogon

Roadkill (existing study; ERM, 2020)

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**Figure 7-107 The Black-Headed Collared Snake (*Sibynophis melanocephalus*) was Observed Dead on Road along Island Club Road**

#### 7.3.4.3.10 Birds

A total of 209 species of birds were deemed of probable occurrence, of which 122 are resident (15 introduced), 2 are introduced non-resident and 85 are migrant/visitor species (Table 7-35; Appendix H3). The contiguity of the Study Area to the larger CCNR also means that rarer forest-dependent species are expected.

The field assessment recorded 60 species which comprised 49 residents (8 introduced), 1 introduced non-resident, and seven migrant/visitor species (Table 7-35; Appendix H3). The remaining three species were recorded only to genus level, hence not classified by their native status. The changeable hawk-eagle (*Nisaetus cirrhatus*) was only recorded from a camera trap (CT\_04).

Migratory species recorded comprise common and uncommon species, except for the rare Sakhalin leaf warbler (*Phylloscopus borealoides*) that was heard once in the Northern Forest Fragment. This species is considered a rare accidental visitor and discussed in Section 7.3.2.4.10. While not of conservation significance, these records show the value of the Study Area in providing habitats for some uncommon and rare migratory species.

Of the 38 probable conservation significant species, seven were recorded (Table 7-35; Appendix H3). Sightings were distributed across the Study Area (Figure 7-108). Most of these species were previously regarded as rare but have since increased in range and numbers, namely the changeable hawk-eagle (*Nisaetus cirrhatus*), red junglefowl (*Gallus gallus*), blue-crowned hanging parrot (*Loriculus galgulus*), long-tailed parakeet (*Psittacula longicauda*), red-legged crane (*Rallina fasciata*) and square-tailed drongo cuckoo (*Surniculus lugubris*)

The white-rumped shama (*Copsychus malabaricus*) is nationally Critically Endangered. It was heard once in the Northern Forest Fragment (Figure 7-108). This species is considered uncommon. This species is largely restricted to CCNR and surrounding green spaces, and Pulau Ubin. While there are records of escaped individuals, the proximity of the Study Area to CCNR suggests the record is more likely of a resident individual.

The blue-winged pitta (*Pitta moluccensis*) is listed as an uncommon migrant breeder. It is listed as “Not Assessed” in the SRDB and “Least Concern” on IUCN Red List. It was heard once in the Northern Forest Fragment in June (Figure 7-108), well after the migratory season had ended (September to March). This could be an indication that a breeding population exists within the Study Area. Low et al. (2016) reported that blue-winged pittas have been



heard calling at “western Singapore, around the periphery of a military training area” between late April and July since 2008. Currently, the only confirmed local breeding record of this species is from Pulau Ubin (Low et al., 2016). This makes it a notable species record for the Study Area.

The plume-toed swiftlet (*Collocalia affinis*) was previously recognised as the nationally Critically Endangered glossy swiftlet (*C. esculenta*). As its scientific name was updated in 2017 (Rheindt et al., 2017), its conservation status is not reflected in the SRDB. Yong et al. (2016) noted that it appears to be localised to the Bukit Batok and Bukit Timah areas, where they are likely to be nesting. Therefore, it likely remains as a threatened species and is regarded as a notable record in this study. It was recorded on one occasion along Windsor Nature Park trail (Figure 7-108), where a flock of at least 50 individuals were seen.

Within the proposed worksites, species recorded were largely common although the nationally Endangered red junglefowl (*Gallus gallus*) was also recorded.





**Legend**

Study Area

Worksite and alignment

Vegetation

Native-dominated secondary forest

Abandoned-land forest

Waste woodland

Scrubland and herbaceous vegetation

Managed vegetation

Waterbody

Others (infrastructure)

Terrestrial sampling route

Roadkill transect along Island Club Road

Boardwalk

Bird species of conservation significance

C. malabaricus

G. gallus

L. galgulus

N. cirrhatus

P. longicauda

R. fasciata

S. lugubris

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### 7.3.4.3.11 Non-volant mammals

A total of 24 species of non-volant mammals were deemed of probable occurrence, including seven of conservation significance (Table 7-35; Appendix H3). Visual surveys and camera trapping documented 14 species of non-volant mammals (Table 7-35; Appendix H3). Of this, five species are of conservation significance.

The highest richness (6 species) was recorded at the western end of Northern Forest Fragment. Species recorded here include the common palm civet (*Paradoxurus musangus*), Sunda colugo (*Galeopterus variegatus*) and Horsfield's flying squirrel (*Iomys horsfieldii*).

The eight terrestrial and six arboreal camera traps accumulated 878 trap-nights. The terrestrial and arboreal camera traps yielded 1,428 and 226 independent detections respectively and recorded a total of 13 species (Table 7-38). The list of camera trap data is available in Appendix J3.

The most commonly recorded species on the arboreal camera traps was the plantain squirrel (*Callosciurus notatus*) with 259 detections, followed by long-tailed macaque (*Macaca fascicularis*). Mammal richness was also relatively even across all camera traps (4–5 species), except for ARBCT\_05 which only recorded the slender squirrel (*Sundasciurus tenuis*). The highest mammal detection rate was recorded at ARBCT\_1B (1.1 independent detections per trap-night) and ARBCT\_01 (1.0 independent detections per trap night), contributed by the plantain squirrel and long-tailed macaque.

The most commonly recorded species on the terrestrial camera traps is the wild pig (*Sus scrofa*) with 831 detections. The highest mammal richness (8 species) was recorded at two locations, CT\_04 and CT\_08. However, the highest mammal detection rate (3.7 independent detections per trap-night) was recorded in the Northern Forest Fragment at CT\_03.

**Table 7-38 Locations and Number of Independent Detections of Mammalian Species at Windsor**

Species	Common name	Locations	No of independent detections
<i>Callosciurus notatus</i>	Plantain squirrel	ARBCT_01–ARBCT_04, CT_01–CT_08	259
<i>Felis catus</i>	Feral cat	CT_03	2
<i>Galeopterus variegatus</i>	Sunda colugo	ARBCT_01, ARBCT_02, ARBCT_03	13
<i>Macaca fascicularis</i>	Long-tailed macaque	ARBCT_01–ARBCT_04, CT_01–CT_08	141
<i>Manis javanica</i>	Sunda pangolin	CT_01–CT_08 (except CT_05)	15
<i>Paradoxurus musangus</i>	Common palm civet	CT_01, CT_04–CT_07	8
Family Muridae	Rat	CT_01–CT_05, CT_07	151
<i>Sundasciurus tenuis</i>	Slender squirrel	ARBCT_01, ARBCT_1B, ARBCT_03–ARBCT_05, CT_04, CT_06	16
<i>Sus scrofa</i>	Wild pig	CT_01–CT_08	831
<i>Tragulus kanchil</i>	Lesser mousedeer	CT_02	6
<i>Tupaia glis</i>	Common treeshrew	CT_01–CT_07	78
N.A	Flying squirrel	ARBCT_02, ARBCT_04	4
N.A	Bat	CT_07	1
N.A	Fruit bat	ARBCT_1B	3

**Table 7-39 Number of Species and Detection Rate of Mammals Recorded at Each Camera Trap in Windsor**

Station	No. of Trap Nights	No. of Mammalian Species Recorded	No. of Detections of Mammals	Detection Rate of Mammals
CT_01	72	7	262	3.6
CT_02	66	7	144	2.2
CT_03	61	6	226	3.7
CT_04	72	8	222	3.1
CT_05	71	6	114	1.6



Station	No. of Trap Nights	No. of Mammalian Species Recorded	No. of Detections of Mammals	Detection Rate of Mammals
CT_06	48	7	76	1.6
CT_07	55	8	189	3.4
CT_08	71	4	94	1.3
ARBCT_01	61	4	59	1.0
ARBCT_02	46	4	33	0.7
ARBCT_03	75	4	42	0.6
ARBCT_04	76	4	29	0.4
ARBCT_05	71	1	1	0.0
ARBCT_1B	33	5	37	1.1

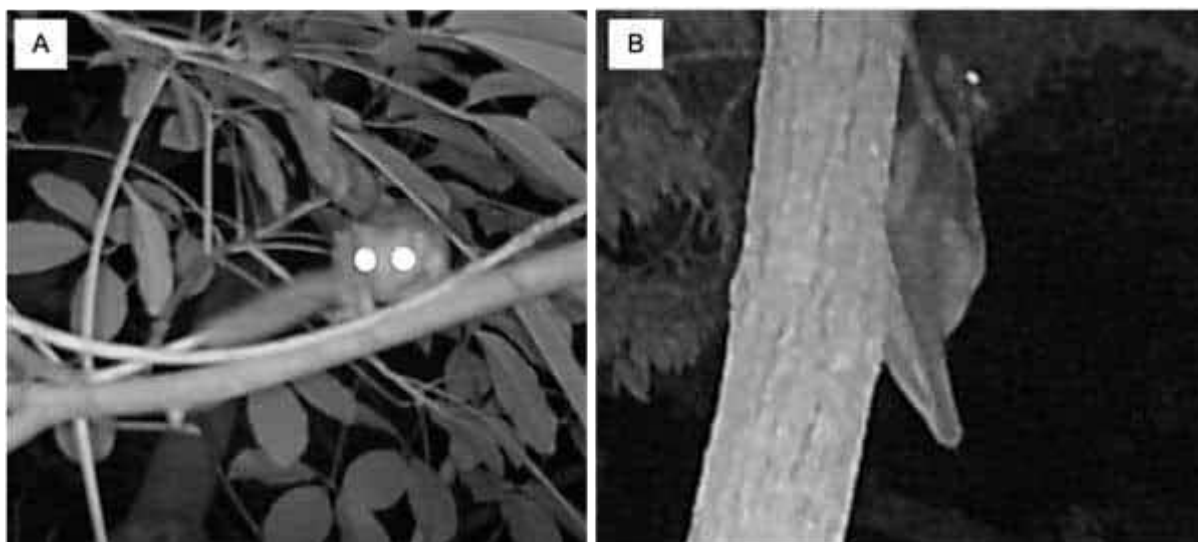
The nationally Endangered Horsfield's flying squirrel (*Iomys horsfieldii*; Figure 7-109A) was also recorded at multiple locations across the Study Area (Figure 7-111). This species is restricted to the CCNR (Baker & Lim, 2012). Notably, the western end of Northern Forest Fragment appears to be an activity spot for the flying squirrels. Out of the four visits, flying squirrels were observed on three visits. Up to three individuals were recorded in a single night, and a pair was often observed in the same tree. On one occasion, an individual was also noted gliding from this forest patch towards Windsor Nature Park. The flying squirrels were observed between 6 to 15 m from eight records. Two of the six arboreal camera traps (ARBCT\_02 and ARBCT\_04; Figure 7-110A) recorded four detections of flying squirrels which was not identified to species level. The distribution records suggest that flying squirrels are likely using the entire Northern Forest Fragment as well as the Windsor Nature Park, and likely moving between these forest patches.

The Sunda colugo (*Galeopterus variegatus*; Figure 7-109B) was recorded visually at multiple locations across the Study Area (Figure 7-109), and on three arboreal camera traps deployed on the edge of Northern Forest Fragment (ARBCT\_01 to ARBCT\_03; Figure 7-110B). This species is listed as "Near Threatened" in the SRDB and "Least Concern" on IUCN Red List. However, it is largely restricted to the CCNR and its surrounding forests, although it has been sighted in discreet forest patches (Bromley et al., 2019), therefore considered a species of interest that requires additional mitigation measures. During visual surveys, they were recorded between heights of 2 to 20 m from 15 records. There were two records of infants in June and July, indicating the presence of a breeding population. There was also an incidental record of a Sunda colugo with infant observed gliding across the Upper Thomson Road towards the Study Area. A total of 13 independent detections were recorded on the arboreal camera traps. Despite having the lowest trap-nights amongst the three camera traps, most detections (11 detections) were recorded from ARBCT\_03, suggesting that the tree is regularly used by Sunda colugo.



Figure 7-109 Visual Records of (A) Horsfield's Flying Squirrel (*Iomys horsfieldii*) and (B) Sunda colugo (*Galeopterus variegatus*) at Windsor





**Figure 7-110 Records of (A) Horsfield's Flying Squirrel (*Iomys horsfieldii*) and (B) Sunda colugo (*Galeopterus variegatus*) on Arboreal Camera Traps at Windsor**

The Sunda slow loris (*Nycticebus coucang*) is globally and nationally Endangered, and was only recorded from the CCNR and Pulau Tekong (Baker & Lim, 2012). It was observed once at more than 50 m from the Windsor Nature Park's trail and at a height of 20 m (Figure 7-111). ERM (2020) also recorded this species on two arboreal camera traps located within the Windsor Nature Park and Northern Forest Fragment.

The Raffles banded langur (*Presbytis femoralis femoralis*) was not recorded in the field assessment. However, it has been recorded from past studies (Ang & Jabbar, 2019; ERM, 2020). Notably, the Northern Forest Fragment is considered of importance to the Raffles' banded langur as it provides habitat connectivity for the langurs to move between the northern and southern part of CCNR (Low, 2019). The Species Action Plan for the Conservation of Raffles' Banded Langur highlights forest connectivity as the utmost priority for the conservation of the langurs (Ang et al., 2016). The langurs are Critically Endangered nationally, with only an estimated 61 individuals left in Singapore (Ang et al., 2020). A group of five males were observed to cross the from the southern end of Upper Peirce Reservoir Park through the Singapore Island Country Club into Windsor Nature Park on the morning of 11th July 2017 (Ang & Jabbar, 2019). Since then, the group has been observed at MacRitchie Reservoir Park, which represents an extension of the range of langur population towards the south (Ang & Jabbar, 2019). During the study period between August to December 2019, Ang et al. (2020) reported one opportunistic visual sighting of the langurs within Windsor Nature Park (Figure 7-111), suggesting that they are still utilising the Study Area. In addition, there were several occurrences on the arboreal camera traps deployed over the same period, within the Windsor Nature Park and Northern Forest Fragment that indicated potential langur or macaque sightings.





**Arboreal mammals of conservation significance or interest**

- ♣ Canopy connections
- Existing study
  - Flying squirrel
  - N. coucang
  - G. variegatus
- Past studies (ERM, 2020; ESC, 2020)
  - + Flying Squirrel
  - + N. coucang
  - + P. f. femoralis
  - + G. variegatus

**Legend**

- Study Area
- Worksite and alignment
- Vegetation
  - Native-dominated secondary forest
  - Abandoned-land forest
  - Waste woodland
  - Scrubland and herbaceous vegetation
  - Managed vegetation
  - Waterbody
  - Others (infrastructure)
- Terrestrial sampling route
- Roadkill transect along Island Club Road
- Boardwalk

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The Sunda pangolin (*Manis javanica*; Figure 7-112A) was recorded throughout the Study Area. This species is globally and nationally Critically Endangered. It was recorded on all terrestrial camera traps except for CT\_05 at the western end of Windsor Nature Park (Figure 7-113). There were a total of 15 independent detections and the highest number of detections (5 detections) was recorded at CT\_02 in the Northern Forest Fragment. An adult pangolin with juvenile was also recorded at this location. The nationally Endangered lesser mousedeer (*Tragulus kanchil*; Figure 7-112B) was recorded only at one location on terrestrial camera trap, CT\_02 (Figure 7-113). There were six independent detections. This species is restricted to the CCNR (Baker & Lim, 2012). According to ERM (2020), a sambar deer (*Rusa unicolor*) was recorded visually in the proposed worksite. It was not recorded during our field assessment.



**Figure 7-112 Mammal Species of Conservation Significance Recorded on Terrestrial Camera Traps – (A) Sunda Pangolin Adult and Juvenile (*Manis javanica*) and Lesser Mousedeer (*Tragulus kanchil*)**

The widespread and common long-tailed macaque (*Macaca fascicularis*) was recently up-listed as a globally Vulnerable species as a result of human persecution across the rest of South-east Asia (Eudey et al., 2020). Based on the field assessment, there was a resident troop present in the Study Area. They were recorded at multiple locations across the Study Area and they were often observed along the Island Club Road (Figure 7-112).

No mammal roadkill was recorded during our field assessment. However, ERM (2020) observed a common treeshrew that was dead on road along Island Club Road (Figure 7-112). Within the proposed worksites, terrestrial and arboreal mammals of conservation significance were observed.





**Legend**

Study Area

**Vegetation**

- Native-dominated secondary forest
- Abandoned-land forest
- Scrubland and herbaceous vegetation
- Managed vegetation
- Others (infrastructure)
- Windsor Nature Park
- Waterbody
- Boardwalk

Worksites and alignment

Terrestrial sampling route

Roadkill transect along Island Club Road

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A3



### 7.3.4.3.12 Bats

A total of 16 bat species were deemed of probable occurrence within the Study Area, including eight of conservation significance (Table 7-35; Appendix H3). Of these, five species were recorded via visual surveys and acoustic sampling (Table 7-35; Appendix H3).

The lesser dog-faced fruit bat (*Cynopterus brachyotis*) was recorded visually. The other four species, the pouch-bearing bat (*Saccolaimus saccolaimus*), glossy horseshoe bat (*Rhinolophus refulgens*), whiskered myotis (*Myotis muricola*) and Asiatic lesser yellow house bat (*Scotophilus kuhlii*) were recorded via acoustic sampling. The glossy horseshoe bat was recorded acoustically during roost emergence surveys for all three bamboo clusters (Figure 7-113). It was previously thought to be confined to CCNR (Baker & Lim, 2012).

Roost emergence surveys were conducted for three bamboo clusters that lie within the propose worksites. Bamboo bats were not recorded but they were considered potential roosting sites for the bats due to presence of slits.

## 7.3.5 Plant Species Accumulation Curves

Species accumulation curves (SAC) were plotted using data on floristic diversity from the vegetation plots. Species richness was plotted against sample coverage, as opposed to survey effort, to estimate sample completeness/survey adequacy, i.e., how extensively we have sampled the species in the community. As all the curves were plotted on the same graph, here we present the results for both Eng Neo Avenue Forest and Windsor, as opposed to having two distinct result sub-sections for each Study Area.

Majority (> 50%) of the plant species present in the four Study Areas were recorded via vegetation plot sampling alone (Table 7-40). Sample coverage is the higher for Eng Neo Avenue Forest at 66.7%, i.e., this proportion of the total number of species in the community belongs to those represented in the vegetation plots (Chao & Jost, 2012), while that for Windsor is lower at 56.0%. Upon extrapolation, i.e., sample sizes were theoretically doubled using the statistical programme, sample coverage across the Study Areas increases to between 78% and 90%. It becomes higher for Windsor at 87.3% and lower for Eng Neo Avenue Forest at 78.9%.

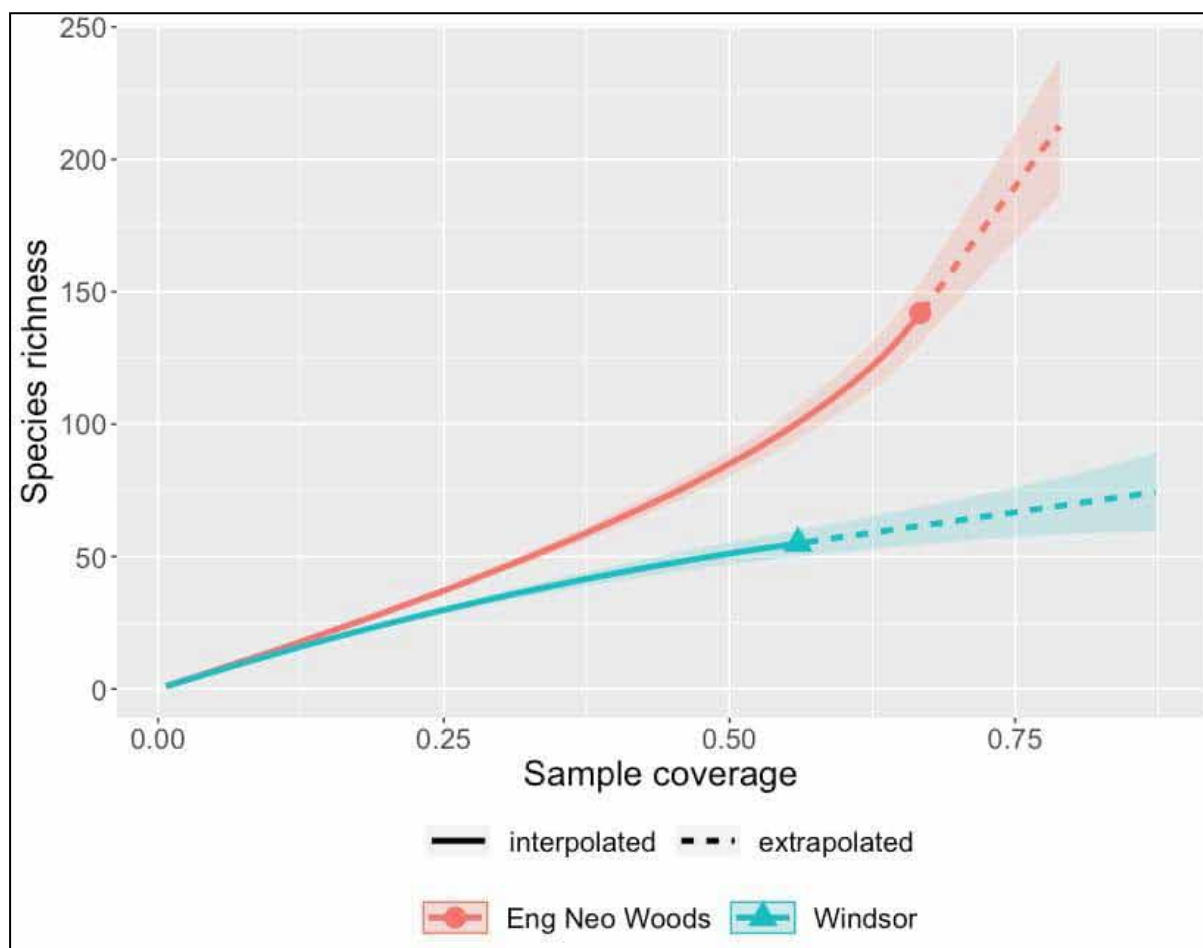
The doubling of survey effort (vegetation plot sampling only) at Windsor would theoretically result in a large increase in sample coverage of up to 31.3%, where species richness increases to 74.31 (the 95% confidence interval is between 60.57 and 88.06). Owing to access and survey restrictions in Windsor Nature Park, vegetation plots were not set up and sampled (Section 7.2.4). As such, the many species recorded only in Windsor Nature Park and not in the Northern Forest Fragment would account for the substantial increase in sample coverage at Windsor should sampling effort be doubled and plots be located within the nature park. On the contrary, the increase in sample coverage for the Eng Neo Avenue Forest is only approximately 12% upon extrapolation. Nonetheless, the caveats as a result of survey restrictions at Windsor Nature Park were compensated for via other floristic survey methods aside from vegetation plot sampling.

Even with increased vegetation plot sampling, however, slightly more than 20% of plant species in Eng Neo Avenue Forest will still remain undetected. This could be attributed to the large number of species likely to be present in the highly diverse native-dominated secondary forest patches. For diverse communities, more species will be recorded with greater number of survey units being sampled (Bunge & Fitzpatrick, 1993). As such, sampling effort would have to increase greatly in order to document most species present in the community. This is also reflected in Figure 7-114, where the species accumulation curve of Eng Neo Avenue Forest does not appear to be reaching a steady asymptote and is much steeper than that for Windsor. For such non-asymptotic datasets, richness estimators can be used to estimate true species richness (Gotelli & Colwell, 2001).

**Table 7-40 Number of Recorded Species and Sample Coverage from Vegetation Plot Sampling**

	Eng Neo Avenue Forest	Windsor
No. of species (observed)	142	55
Sample coverage (observed)	66.7%	56.0%
No. of species (extrapolated)	212.61	74.31
95% confidence interval	186.96–238.26	60.57–88.06
Sample coverage (extrapolated)	78.9%	87.3%





**Figure 7-114 Coverage-based Sampling Curves**

The Chao estimator was used to predict total number of species in the species pool in each Study Area. Using the 'ChaoRichness' function in the iNEXT 2.0.20 package (R Development Core Team, 2016), total species richness and the 95% confidence interval was estimated and presented in Table 7-41.

In this study, the recorded total species richness is 285 for Eng Neo Avenue Forest and 329 for Windsor. For Windsor, this figure greatly exceeds the total number of species predicted using the Chao estimator. This is likely because most species undetected or absent in the vegetation plots were documented during general floristic surveys, so that the recorded total species richness surpasses even the higher bound and more conservative estimates of total species richness. Hence, the combined survey effort consisting of general floristic surveys and vegetation plot sampling was adequate in documenting floristic composition of plant communities in Windsor.

For Eng Neo Avenue Forest, the proportion of the number of observed species (285) out of the higher bound predicted total number of species (496, to the nearest integer) is 57.5%. This indicates that all the species documented during general floristic surveys and in vegetation plots only make up slightly more than half of what might be in the species pool in Eng Neo Avenue Forest. Considering that species assemblages of abandoned-land forest and waste woodland are generally homogeneous, we postulate that several more species would likely be recorded from the species-rich native-dominated secondary forest patches in Eng Neo Avenue Forest. Increased survey effort—whether general floristic walking surveys, vegetation plot sampling, or both—is likely to yield new records of species not already documented during present surveys. It is also important to note, however, that the proportion was calculated using the higher bound and more conservative estimate of total number of species (495.87); the predicted total number of species is  $334.87 \pm 61.18$  (Table 7-41).

**Table 7-41 Estimated Total Number of Species ( $\pm$  Standard Error) and 95% Confidence Interval using the Chao Estimator**

	Estimated Total Number of Species $\pm$ Standard Error	95% Lower	95% Upper
Eng Neo Avenue Forest	$334.87 \pm 61.18$	247.12	495.87
Windsor	$82.16 \pm 12.21$	66.72	117.97