SINGAPORE

5th NATIONAL REPORT TO THE CONVENTION ON BIOLOGICAL DIVERSITY (2010-2014)

NATIONAL PARKS BOARD SINGAPORE
2015

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LIST OF ACRONYMS

ABC	Active, Beautiful and Clean
ABS	Access and Benefit Sharing
ACB	ASEAN Centre for Biodiversity
ACRES	Animal Concerns Research and Education Society
AFoCo	Agreement between the Governments of the Member States of ASEAN and the Republic of Korea on Forest Cooperation
AHP	ASEAN Heritage Parks
AMS	ASEAN Member States
ASEAN	Association of Southeast Asian Nations
AWGCME	ASEAN Working Group on Coastal and Marine Environment
AWGESC	ASEAN Working Group on Environmentally Sustainable Cities
AWGNCB	ASEAN Working Group on Nature Conservation and Biodiversity
AVA	Agri-Food & Veterinary Authority
BIA	Biodiversity Impact Assessment
BIOME	Biodiversity and Environment Database System
BKE	Bukit Timah Expressway
BoSS	Biodiversity of Singapore Symposium
BTNR	Bukit Timah Nature Reserve
BWV	Blue Water Volunteers
CBC	Cities Biodiversity Centre (ICLEI)
CBD	Convention on Biological Diversity
CBI	City Biodiversity Index (also known as the Singapore Index on Cities' Biodiversity)
CCNR	Central Catchment Nature Reserve
CIAG	City in a Garden
CIB	Community in Bloom
CIN	Community in Nature
CMBS	Comprehensive Marine Biodiversity Survey
CME	Coastal and Marine Environment
CMEPC	Coastal and Marine Environment Policy Committee
CSP	Consortium of Scientific Partners
CUGE	Centre for Urban Greenery and Ecology
EIA	Environmental Impact Assessment
EMMP	Environmental Monitoring and Management Plans
FOB	Festival of Biodiversity
FUN	Friends of Ubin Network
GCAC	Garden City Action Committee
GCF	Garden City Fund
GDP	Gross Domestic Product
GIST	Geospatial Information Systems and Technology
HSBC	Hongkong and Shanghai Banking Corporation Limited
IAS	Invasive Alien Species
ICCS	International Coastal Cleanup Singapore
ICLEI	Local Governments for Sustainability
ICM	Integrated Coastal Management
IMCSD	Inter-Ministerial Committee on Sustainable Development
IUCM	Integrated Urban Coastal Management
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported and unregulated
JOSE	Joint Oil Spill Exercise
KTM	Keretapi Tanah Melayu

KTPH	Khoo Teck Puat Hospital
LKCNHM	Lee Kong Chian Natural History Museum, formerly known as the Raffles Museum of Biodiversity Research
MEAP	Marine Emergency Action Procedure
MEWR	Ministry of the Environment and Water Resources
MND	Ministry of National Development
MOE	Ministry of Education
MOU	Memorandum of Understanding
MPA	Maritime and Port Authority of Singapore
MRT	Mass Rapid Transit
NBC	National Biodiversity Centre
NBSAP	National Biodiversity Strategy and Action Plan
NCMP	Nature Conservation Master Plan
NEA	National Environment Agency
NGO	Non-governmental Organisations
NIE	National Institute of Education
NPTD	National Population and Talent Division
NParks	National Parks Board
NSS	Nature Society (Singapore)
NTU	Nanyang Technological University
NUS	National University of Singapore
NYAA	National Youth Achievement Awards
PAL	Programme for Active Learning
PCN	Park Connectors Network
PEMSEA	Partnerships in the Environmental Management for the Seas of East Asia
PUB	PUB, Singapore's national water agency
RIR	Round Island Route
RMBR	Raffles Museum of Biodiversity Research, now known as the Lee Kong Chian Natural History Museum
RUM	Restore Ubin Mangroves
SBWR	Sungei Buloh Wetland Reserve
SCBD	Secretariat of the Convention on Biological Diversity
SI	Singapore Index on Cities' Biodiversity (also known as the CBI)
SLA	Singapore Land Authority
SSB	Sustainable Singapore Blueprint
SPH	Singapore Press Holdings
STEP	Singapore Technologies Endowment Programme
SWCDC	Southwest Community Development Council
TCCME	Technical Committee on Coastal and Marine Environment
TMSI	Tropical Marine Science Institute
UNFCCC	United Nations Framework Convention on Climate Change
URA	Urban Redevelopment Authority
URBIO	Urban Biodiversity and Design
WRS	Wildlife Reserves Singapore

EXECUTIVE SUMMARY

Singapore is a city-state with a land area of about 718.3 km^2 located within the Sundaland biodiversity hotspot. It is one of the most densely populated countries in the world and yet, despite being highly urbanised, harbours rich native biodiversity within its borders.

The unique circumstances of Singapore present considerable challenges to the conservation of biodiversity, as there are many competing needs within a small land area. Conversely, it also presents opportunities for innovative solutions to address these challenges, including the development of expertise on urban biodiversity conservation.

The current state of biodiversity shows some signs of improvement, as there have been fairly significant increases in the numbers of species for certain groups of plants and animals, most notably vascular plants, birds, spiders, soft corals and some of the insects. Furthermore, many species once thought lost have been found again in local habitats and home ranges of some rare species have expanded. In addition to facing ongoing threats to biodiversity from scarcity of land, some other challenges to biodiversity conservation include potentially invasive species. These are being monitored for longer term impacts to habitats or are being studied more closely to find solutions.

There have been several key initiatives under the five strategies outlined in the 2009 version of Singapore's National Biodiversity Strategy and Action Plan (NBSAP). Species conservation and recovery programmes, habitat restoration and enhancement initiatives as well as efforts to improve habitat connectivity are some of the ways in which Singapore safeguards biodiversity. The Sustainable Singapore Blueprint 2015 and Singapore's land use planning process are examples of ways in which Singapore takes biodiversity issues into consideration in policy and decision-making. Knowledge of Singapore's biodiversity is also improved through research and the information is managed using tools such as the BIOME database (Biodiversity and Environment Database System). Great emphasis is placed on enhancing education and public awareness, with various events being held such as the Festival of Biodiversity under the Community in Nature initiative. Singapore also works towards strengthening partnerships on biodiversity issues at the national, regional and international levels.

On the whole, Singapore has made good progress on the targets that are relevant, and this was assessed based on the initiatives carried out under the strategies of the NBSAP as well as Singapore's score on the Singapore Index on Cities' Biodiversity (SI). Singapore's NBSAP is currently undergoing a review to develop nationally relevant targets which will allow better tracking of the state of biodiversity in Singapore.

CHAPTER 1

INTRODUCTION

Singapore is an island city-state in Southeast Asia, located at the southern tip of the Malaysian peninsula, and consists of one main island and 46 smaller offshore islands (Tun, 2012). Located within the Sundaland biodiversity hotspot, Singapore has a rich array of native biodiversity in numerous habitats despite its small size. Singapore currently has four legally gazetted Nature Reserves and 20 other administratively protected Nature Areas that cover the majority of natural habitats within Singapore such as primary dryland forest, tall secondary forest, freshwater swamps, rocky shores, mangroves, mudflats, seagrass beds and coral reefs.

At just 718.3 km^2, Singapore is one of the most densely populated countries in the world, with a population of 5.47 million and a population density of 7,615 persons per km^2 (Singapore Department of Statistics, 2014). This unique situation presents considerable challenges for biodiversity conservation, as Singapore has to constantly balance numerous competing needs within this small area.

1.1 Context and challenges

All of Singapore's activities, including biodiversity conservation, take place in the context of the limited available land area. While most other countries have a hinterland that can be utilised for other uses such as ports, airports and reservoirs, Singapore is a city-state with a diversified economy based on manufacturing and services, and has to fulfil all the land use needs of a country within the city, ranging from housing, offices, commercial centres, to infrastructure and utilities, as well as water catchments and military training land. To satisfy these competing demands, there is a need for a pragmatic approach in balancing different land requirements.

Table 1: Singapore's land requirements (Ministry of National Development, MND, 2013)

Land Use	**2010**		**2030**	
	Ha	**%**	**Ha**	**%**
Defence	13,300	19.0	14,800	19.3
Housing	10,000	14.3	13,000	17.0
Industry and Commerce	9,700	13.8	12,800	16.7
Land Transport Infrastructure	8,300	11.8	9,700	12.7
Parks and Nature Reserves	5,700	8.1	7,250	9.5
Community, Institution and Recreational Facilities	5,400	7.7	5,500	7.2
Ports and Airports	2,200	3.1	4,400	5.7
Reservoirs	3,700	5.3	3,700	4.8
Others	10,000	14.3	2,800	3.7
Utilities (e.g. Power, water treatment plants)	1,850	2.6	2,600	3.4
Total	**71,000**	**100**	**76,600**	**100**

Singapore's urban context and drive to optimise use of limited land provides the opportunity to promote and explore innovative urban biodiversity conservation strategies. Singapore has taken

great efforts to introduce nature in every available space, from rooftop gardens to vertical greenery and the use of relatively small spaces as parks and building linear parks (known as park connectors) that stretch for kilometres. Habitat enhancement and restoration also play a major role, for areas in Singapore that were previously cleared or developed that can now be re-developed to incorporate existing uses with the presence of nature.

Singapore's previous National Report covered the period up to 2009, and thus the scope of this National Report will cover the period 2010 to 2014. It will provide updates on the status of biodiversity in Singapore since the last report, as well as highlighting some of the biodiversity conservation efforts Singapore has made in the context of our National Biodiversity Strategy and Action Plan (NBSAP) before finally bringing these together to gauge our efforts with respect to the Aichi Biodiversity Targets.

CHAPTER 2

UPDATES ON THE STATUS AND TRENDS ON BIODIVERSITY IN SINGAPORE

2.1 Importance of biodiversity

Singapore has always prided herself on maintaining lush greenery within a highly urbanised, densely populated city. The task of maintaining the greenery in Singapore is carried out by the National Parks Board (NParks). NParks' objective is to transform Singapore into a "City in a Garden", and one of the six key areas of this vision is to enrich biodiversity in the urban environment. The benefits of biodiversity within a predominantly urban environment are numerous, and biodiversity is a significant aspect of the development plans of Singapore for the following reasons.

Quality of life:

Quality of life refers to the physical and emotional well-being of people which is often influenced by our environment. Research has shown that being exposed to nature and biodiversity improves our health and psychological well-being as it engages our senses of sight, sound, scent and touch (University of Minnesota, 2015). The provision of a natural environment is in line with NParks' mission - to create the best living environment through excellent greenery and recreation, in partnership with the community. NParks manages greenery and natural areas to maximise ease of access to nature for Singaporeans, thus improving their physical and psychological well-being.

Natural spaces act as inspiration for imagination and creativity. It also provides relief from the concrete urbanised environment, giving Singaporeans space to unwind and relax, helping to improve physical and emotional well-being. Studies have shown that taking time to appreciate nature helps alleviate the fatigue from directed attention used at work, and that office workers with a view of nature liked their jobs more, enjoyed better health and reported greater life satisfaction (Clay, 2001).

Recreation and health:

The links between biodiversity and human health and well-being are well documented (Chivian & Bernstein, 2008), and often there will be a need for city dwellers to seek respite from the concrete and steel of urban city life. To increase the liveability of the city for citizens, a variety of options for nature-based recreation have to be provided, and this involves maintaining some level of greenery and nature within the city – both managed vegetation and natural habitats. While residents of most other countries have the option to leave the city and travel to less urbanised areas, this is not an option available in Singapore, and any natural areas need to be within the city proper.

The positive benefits of biodiversity have been recognised in Singapore in the design of Khoo Teck Puat Hospital (KTPH). KTPH is designed with the philosophy that every patient should have a view of nature, as an aid in the recovery process. Selected areas were used to create habitats, and plants were effectively used in all the wards to bring this about, incorporating green areas throughout the hospital design. The designers also selected specific species of plants to encourage butterflies and birds to visit the plants to enhance the experience patients can get from their window or by walking in the garden (Alexandra Health System, 2013).

Research:

Singapore's rich biodiversity has always been a subject of academic research. Taxonomic specimens collected by British naturalists such as Sir Stamford Raffles (the founder of Singapore) are still kept in museum collections locally. Today, new taxonomic discoveries are still possible, and research forms an integral part of informing how Singapore maintains a green and natural built environment. Research in conservation and ecology are particularly relevant for the management of Singapore's Nature Reserves and natural areas. In recent years, Singapore has had a strong focus on research and development in the biomedical sciences, and maintains the capability of utilising the native microbes, flora and fauna for such research by conserving our habitats.

Education:

In this country where the entire population resides in urban areas, there is a need to conserve nature to expose Singapore's youth to the richness of biodiversity in Singapore, since the heavily urbanised environment within the city where most children are brought up has relatively little biodiversity - short of domesticated pets, pests and ornamental plants.

With environmental challenges like climate change and biodiversity loss gaining prominence in the global agenda, it is increasingly pertinent that the young have some basic exposure to biodiversity, to better understand the global context that we have to operate in. Exposing youth to biodiversity and the associated career options would also form the basis for eventually having home grown researchers that can help to carry forward Singapore's research agenda.

Heritage:

Singaporeans sometimes travel to neighbouring countries to enjoy the habitats they offer. What few realise is that such habitats can also be found in Singapore, and still remain to be enjoyed. Singapore works hard to conserve our biodiversity, as such natural heritage is difficult, if not impossible, to restore once lost.

Culture and tradition:

Ethnic groups in Singapore have a long history of dependence on nature and natural products in their traditional practices and remedies. In addition to typical western medicine, Singaporeans are still known to seek alternative remedies from traditional Chinese, Malay and Ayurvedic medicine.

Nature-based tourism:

Tourism is a major industry in Singapore, and in 2013, Singapore hosted over 15.5 million visitors (Singapore Tourism Board, 2014). In addition to rich biodiversity, part of the draw for visitors from overseas is the accessibility of Singapore's natural areas – the Singapore Botanic Gardens harbours one of the last remaining patches of primary rainforest in Singapore, and yet it is within walking distance from Orchard Road, one of the main retail areas of Singapore. Labrador Nature Reserve has a dedicated Mass Rapid Transit (MRT, one of the primary forms of public transport) station, and shares this with the Alexandra Retail Centre, a large shopping mall. It is also just a five minute drive away from VivoCity, one of the largest shopping malls in Singapore, and Sentosa island which has numerous tourist attractions.

Potential changes to endemism:

Given Singapore's size and degree of urbanisation as well as the richness of biodiversity that can be found in the much larger neighbouring countries, it has always been generally assumed that almost any species that goes extinct in Singapore has a reasonably good chance of being found in the habitats of neighbouring countries. This may no longer be a valid assumption, as the natural range of animals in the region changes over time through extinctions in other areas or entire countries.

> "Finally, the lowland ecosystems of Malaysia and Indonesia have experienced catastrophic human impacts over recent decades, with vast areas now under industrial crop monocultures or expanding urban areas (Miettinen, Shi and Liew, 2011). It is no longer safe to assume that a non-endemic species lost from Singapore still persists elsewhere in the region." – Corlett, 2013.

Species once thought to be widespread in neighbouring countries may eventually become endemic to Singapore, due to local extinctions elsewhere, as the natural range of the remaining populations are gradually reduced to within Singapore. As such, the importance of conserving Singapore's biodiversity becomes all the more crucial to prevent global extinctions.

2.2 State of biodiversity

Although Singapore has a small land area, her geographical location and climate both present opportunities for a wide array of habitats within this small space. However, the diversity of habitats found here requires a broader range of expertise in order to study properly. Hence, there have been quite a number of new species discovered, and re-discoveries of species thought to have been lost.

One example is the ongoing Comprehensive Marine Biodiversity Survey (CMBS) of the mudflats and waters off the coast of Singapore. The CMBS is a five-year national initiative that began in 2010 to take stock of our marine ecosystems, species diversity and distribution of marine life. It is organised by NParks in collaboration with taxon experts from tertiary institutions, non-governmental organisations (NGOs) and individual enthusiasts. Although the results have yet to be published, the initial findings are very promising as some of these habitats have been very difficult to study before this, requiring specialised equipment and strong government support. It is estimated that the surveys have discovered 100 species that might possibly be new to science, about 200 new records and about 10 rediscoveries for Singapore since the beginning of the CMBS (National Biodiversity Centre, unpublished data).

Current research on relatively neglected taxa has also greatly contributed to the current state of knowledge of local biodiversity. Research work on some of the most highly diverse groups has only just been initiated, and already some promising results are being found, for example, new species and new records have been found for flies, orthopterans and the allied cowries, which were relatively neglected groups previously.

2.2.1 New species descriptions

New species found in Singapore are indicative of the amount of research work currently being undertaken by scientists in our native habitats. Groups that are relatively under-studied benefit most from additional work done in this area, but unfortunately the more obscure the group is, the

greater the expertise required in order to identify new species. Singapore has generated quite a good amount of research interest over the years, in some cases bringing in experts in taxa from as far away as Belgium in order to survey our habitats. Of note would be the mangrove insects as indicators of habitat quality project, supported by NParks, which described a total of 32 new species of flies (Grootaert & Shamshev, 2012; Grootaert, 2013). Another project on the orthopterans (crickets and grasshoppers) of Singapore described 16 new orthopteran species (Gorochov & Tan, 2011; 2012; Ingrisch & Tan, 2012; Robillard & Tan, 2013; Tan, 2011; 2012a; 2012b; Tan & Ingrisch, 2013; Tan & Robillard, 2012), while other surveys generated more modest numbers in terms of species descriptions from Singapore: 1 bee (Pauly, 2012), 5 beetles (Jäch et al., 2013), 2 soft corals (Benayahu & Chou, 2010; Benayahu & van Ofwegen, 2011), 3 crustaceans (Naruse & Ng, 2010; Mendoza & Ng, 2011; Cai & Teo, 2012), 1 mollusc (Houart, 2011) and 1 sponge (Lim et al., 2012b). In addition, a new sub-species of snail was also documented from here: *Amphidromus atricallosus temasek* is a new sub-species of arboreal land snail distinct from the sub-species found in Peninsular Malaysia (Tan et al., 2011).

2.2.2 New records and rediscoveries

Ongoing surveys have found numerous species that are recorded in Singapore for the first time, as well as some rediscoveries of species once thought extinct from local habitats.

Most notably, researchers have recently rediscovered the Neptune's cup sponge, *Cliona patera*, in local waters (Lim, Tun & Goh, 2012). Once thought to be globally extinct, this large sponge was first described from Singapore in 1820 (Hardwicke, 1820; 1822; Low, 2012). However, their large size made them desirable for collectors and they soon went extinct from local waters by the 1870s when the last two specimens found here were dredged up. There had been no sightings of living individuals of this species since 1908 in Indonesia, but dead specimens washing up on Australian shores in the 1990s gave hints that the species had yet to go extinct (Lim, Tun & Goh, 2012). In March 2011, marine biologists were conducting routine surveys when they came across an unusual looking sponge that was later identified as the Neptune's cup (Tun & Goh, 2011). A second individual was later found just 50m distant from the first, and the two sponges are being closely monitored and their biology studied. Surveys are already turning up new insights into their biology, as their growth is much faster than previously thought (Platt, 2011).

Another notable rediscovery was the confirmation that the Malay civet, *Viverra tangalunga* can be found here. This species was purportedly found in Singapore based on a single specimen in the Muséum National d'Histoire Naturelle in Paris, France, but its presence here has not been confirmed until 2012 when it was captured by a camera trap at the Central Catchment Nature Reserve (CCNR, Lim & Ou Yang, 2012). Although only one individual has been recorded thus far, the find is an encouraging addition to Singapore's mammal fauna given the lack of predators here.

The rediscovery of 33 species of plants previously thought to be locally extinct is also highly significant. These rediscoveries are likely to be the result of increased botanical surveys rather than re-introductions. Their conservation status will also have to be re-assessed, although in general most of the rediscoveries still remain as relatively isolated populations.

Other noteworthy new records were the finding of 30 soft coral species that have been found in local waters (Benayahu & Chou, 2010).

2.2.3 Possible extirpations

Recent studies of giant clams (Neo & Todd, 2012, 2013) in the local waters have failed to find two species that were once recorded from the literature. *Tridacna gigas* was last recorded from Singapore in 1866 (Daily Telegraph, 1914), and *Hippopus hippopus* was last recorded in 1963 from an area that has since been reclaimed. As it has been just over 50 years since it was last recorded, *H. hippopus* currently meets the criteria to be considered locally extirpated.

Although this is not documentation of a species that has been extirpated, there has been some confusion in two varieties of orchid found in local forests, one of which is extinct. *Cystorchis variegata* var. *purpurea* differs from *Cystorchis variegata* var. *variegata* only in leaf colouration. Although var. *variegata* had been previously listed as Nationally Extinct, it has been collected from various places around Singapore recently (Lok et al., 2011b), whereas recent extensive surveys have yet to find any var. *purpurea*. As such, the authors propose that previous publications that purport to have found *Cystorchis variegata* var. *purpurea* had misidentified the specimens, that the conservation statuses of the two varieties should be reversed. Hence, *Cystorchis variegata* var. *purpurea* is considered extirpated in Singapore.

Although it was last seen in 1980, the wasp *Polybioides raphigastra* has not been seen since. Given that this species lives in very large colonies and has a defensive nature, the fact that it has not been reported for over 30 years makes it fairly likely to be locally extirpated as well (Lee, J. X. Q., 2013, pers. comm. 28 Oct).

There are various studies that have been done attempting to document historical extirpations from past records, with comparison to the current state of those particular taxa. Although these are not considered as extirpations for the purposes of this national report, it is useful to bear in mind these historical extirpations as a reminder of what has been lost. For example, a recent study surveying mainland Singapore's pteridophyte flora (ferns and fern allies) found 81 species present (Tan et al., 2014). They used this figure to estimate the number of pteridophyte species likely to be extant in Singapore, and based on this they have estimated that about 81-86 species have been extirpated locally from historical records (170 species, based on the figure provided by Holttum, 1968). Similarly, the current list of butterflies (Khew, 2014) shows a decrease of 116 species from historical records (Corbet & Pendlebury, 1992; Fleming, 1975). These 116 species (not included in the checklist) have not been sighted in Singapore since the 1970s and represent potential local extinctions.

2.2.4 Updates on the numbers of species

Taking all the new species descriptions, new records and rediscoveries for Singapore into consideration, the number of extant (native and non-native) species for taxa reported in the 4th National Report can now be updated, as shown in the following table:

Table 2: Updates on the number of extant (native and non-native) species for various taxa found in Singapore.

See Annex A for more details on sources of information for each taxa.

	Taxonomic group	No. of species	Increase in number	New Species	New Records	Rediscoveries	Extirpations
Plants and others	Vascular Plants	3604	54	0	21	33	0
	Algae	1054	0	0	0	0	0
	Fungi	950	0	0	0	0	0
	Lichens	376	0	0	0	0	0
	Bryophytes	233	1	0	1	0	0
Vertebrates	Mammals	93*	2	0	1	1	0
	Birds	384	20	0	18	3	1
	Reptiles	152*	4	0	4	0	0
	Amphibians	29	0	0	0	0	0
	Freshwater fishes	106*	2	0	2	0	0
	Marine fishes	585	13	0	12	1	0
Insects and Arachnids	Butterflies	317	22	0	17	5	0
	Beetles	10000+	9	5	3	1	0
	Dipterans	910	32	32	0	0	0
	Hymenopterans	540	1	1	1	0	1
	Myriapods	55	0	0	0	0	0
	Odonates	127	15	0	15	0	0
	Orthopterans	200+	18	16	1	1	0
	Spiders	425	26	1	25	0	0
Marine invertebrates	Crustaceans	1000+	8	3	4	1	0
	Molluscs	1291	6	1	5	1	1
	Octocorallia	63	32	2	30	0	0
	Hard corals	255	0	0	0	0	0
	Ascidians	32	14	0	14	0	0
	Sponges	228	3	1	1	1	0
	Echinoderms	120	1	0	1	0	0
	Marine mites	39	0	0	0	0	0

* - Figures for these taxa include species of indeterminate status.

2.2.5 Biodiversity trends

There have been some positive trends in Singapore's biodiversity that were observed in recent years. However, with the exception of findings on the banded leaf monkey, these new findings on increases in range or population highlighted below are likely to be representative of greater sampling effort rather than an actual trend in biodiversity arising from conservation efforts.

2.2.5.1 Changes in the distribution of native species

Some of the surveys conducted in recent years have found some animals whose distribution ranges are wider than previously thought. Surveys in the Western Catchment area have found the greater mousedeer (*Tragulus napu*), the malayan porcupine (*Hystrix brachyura*) and the green tree snail (*Amphidromus atricallosus temasek*) in this area for the first time (Chua, M. A. H., 2013, pers. comm., 25 Oct). Another study showed that two species of flying squirrels, the red-cheeked flying squirrel (*Hylopetes spadiceus*) and the Horsfield's flying squirrel (*Iomys horsfieldii*), have been found in new areas adjacent to those where they were originally found (Chua et al., 2013).

A study on the locally critically endangered thorny bush frog, *Theloderma horridum*, found that its range may be larger than once thought (Figueroa & Selveindran, 2011). Originally thought to be confined to the Bukit Timah Nature Reserve (BTNR), it has now been found in the Nee Soon swamp forest, and part of the CCNR, with indications that the species may be present within other parts of the CCNR.

2.2.5.2 Increases in the population of vulnerable species

The banded leaf monkey (*Presbytis femoralis*) was first described from Singapore in 1838, and Singapore is thus the type locality for this species. Currently, three sub-species are recognised, with the population in Singapore and Johor belonging to the sub-species *Presbytis femoralis femoralis* (Ang, 2010; Ang et al., 2012). This animal was once assessed as having a population too low to be viable (Brook et al., 2003), and was expected to decline locally and become extinct within a few decades. In 1990, the population was estimated to be around 10-15 individuals (Yang et al., 1990). In 2008, a 22 month long study of the population of *P. f. femoralis* was undertaken. The results of the study show that the population was estimated to be approximately 40 individuals, and that the monkeys were reproducing (Ang, 2010). Although the population had more than doubled over 20 years, the genetic variability of this population was found to be low (Ang et al., 2012), which is a cause for concern over the long term viability of the species locally. Although the sub-species for Singapore and Johor are the same, more detailed studies need to be conducted to determine if a project to increase genetic variability is feasible.

2.2.6 Threats to biodiversity

The majority of the threats facing biodiversity in Singapore have been highlighted in the 4th National Report. An update of some of these issues is presented below.

Modification to waterbodies:

Singapore's limited land also means that there is a need to maximise the catchment area used to collect water as one of its water supply sources, and this can lead to loss or changes in habitats due

to damming up of rivers to form reservoirs or the canalisation of streams and waterways. In 2011, the water catchment area was increased from half to two-thirds of Singapore's land surface with the completion of the Marina, Punggol and Serangoon reservoirs (PUB, 2015). This has led to significant changes in the species compositions at the mouth of the rivers that had been dammed, which changed from a marine to a freshwater habitat (Ng & Tan, 2013).

Land reclamation:

One of Singapore's key strategies in creating space has been to reclaim land from the surrounding waters off the mainland, but sedimentation and water clarity issues may have some impact on the marine and intertidal biodiversity (Chou, 2006; Huang et al., 2009). Environmental Monitoring and Management Plans (EMMP) have been implemented in order to address these impacts.

Shipping:

Singapore has one of the world's busiest ports with the maritime industry contributing 7% of Singapore's Gross Domestic Product (GDP). Every year, Singapore attracts an average of 140,000 vessel calls, some of which carry crude oil or related cargo. Recognising the potential for incidents leading to oil spills and the associated pollution, the Maritime and Port Authority of Singapore (MPA) has put in place a comprehensive system to ensure navigational safety in the Straits to minimise marine incidents (see section 3.2.1). The number of marine incidents per 1,000 vessel movements in Singapore waters have remained low in Singapore's port waters and the Singapore Strait. Nonetheless, incidents that do occur can affect Singapore's rich coastal and marine habitats. An incident in May 2010 resulted in approximately 2,500 tonnes of light crude spilled, affecting biodiversity-rich areas such as Tanah Merah and Pulau Ubin (Kwan, 2010; Tan, 2010).

Maintaining shipping routes poses other challenges. To maintain the required depth for ships in shipping fairways and anchorages, MPA conducts dredging operations on the seabed. The high volume of ship traffic generates waves that may cause erosion along our shores, particularly those of the islands located off the southern coast (Chong, 2006; Friess et al, 2012). Finally, there is also the potential introduction of invasive alien species (IAS) from the discharge of ballast water of ships in Singapore waters.

Invasive alien species (IAS) or non-native species:

Another potential threat to Singapore's biodiversity would be the possible impact from non-native or alien species. Most of the non-native species here have yet to demonstrate impact to the habitats and species here, and are hence not considered as invasive at the present moment (Yeo and Chia, 2010) based on the International Union for Conservation of Nature (IUCN) definition of "invasive"[1]. Singapore is monitoring various introduced species that are considered potential invasive species. In addition, inputs from academics and nature interest groups have highlighted some other non-native species that have recently come to light as having established populations in Singapore, and should be monitored for invasive behaviours as well. The following cases of potential invasive species were highlighted by the research/nature community:

[1] IUCN defines "invasive species" as "a species that has been introduced to an environment where it is non-native, or alien, and whose introduction causes environmental or economic damage or harm to human health".

- An exotic plant originally brought in to Singapore as an ornamental plant, *Costus lucanusianus* has been found on the fringes of Nature Reserves - large patches of about 100m^2 in size were observed in Dairy Farm Nature Park and Hindhede Nature Park, adjacent to BTNR (Leong-Škorničková, 2013).
- The ant associated pioneer, *Cecropia pachystachya*, has been observed spreading rapidly in some areas around our forests. This species has the potential to outcompete other native species occupying similar ecological niches, such as *Macaranga gigantea* (Lok et al., 2010).
- At least five species of introduced parrots, including *Cacatua goffiniana* and *Psittacula alexandri*, have established breeding populations in Singapore, originating from the pet trade. They might introduce competition for hole-nests with native hole-nesters, such as *Dinopium javanense* and *Eurystomus orientalis* (Neo, 2012). In addition, populations of the rainbow lorikeet, *Trichoglossus haematodus*, have increased significantly over the last five years (Low, B. W., 2015, pers. comm. 29 July).
- A potentially invasive frog, Günther's frog, *Hylarana guentheri*, that was initially found in the western parts of Singapore (Leong and Lim, 2011), has since been reported in various other parts of the country (Low, B. W., 2015, pers. comm. 29 July).
- The non-native brown anole (*Norops sagrei*) was found in the vicinity of Gardens by the Bay, and may possibly compete with native lizards (Tan and Lim, 2012). There have also been some sightings of this animal outside of this area since late 2014 (Low, B. W., 2015, pers. comm. 29 July).
- An invasive marine goby, *Yongeichthys virgatulus*, was found in local waters and could potentially compete with the native *Y. caninus* (Jaafar, Z., 2013, pers. comm. 17 Oct).
- Populations of a native apple snail, *Pila scutata*, have decreased in recent decades and could potentially have been caused by the introduced *Pomacea canaliculata* (Tan, Lee & Ng, 2013).

One potential route of introduction of non-native species is the release of animals imported for food or pets, either as mercy releases or unwanted pets. NParks conducts ongoing exercises in collaboration with schools and volunteers to patrol likely areas of animal release to prevent and educate members of the public that might be trying to release animals. So far, "Operation No Release" has been quite successful, reducing the number of instances of animal release down from ten cases in 2009 to no cases reported in 2011. The public are informed of the potential impact to native species and habitats that can be brought about through incursions by invasive species, and of the very low likelihood of survival for any animals that are released, defeating the purpose and intent of releasing them in the first place.

Another area of concern for Singapore is the recent confirmation that a fungus implicated in the decline of amphibian populations worldwide has been found in local frog populations. The chytrid fungus, *Batrachochytrium dendrobatis* (*Bd*), is thought to have been introduced to Singapore's amphibian population via the import of frogs for food (Seow, 2011). Frogs that are sold for consumption locally were found to carry the fungus, and conditions in the tanks that the imported frogs are kept are ideal for transmission. Taken in combination with the common practice of purchasing animals for mercy release, this represents a potential transmission pathway into local amphibian populations. The disease has also been confirmed in wild frog populations but it was not confirmed if the strains were endemic in Singapore or introduced. Following the report, Singapore has initiated a surveillance programme for imported frogs. Batches of frogs detected with *Bd* will have to be culled or harvested immediately to minimise the risk of transmission to local frog

populations. Importers are also advised not to import frogs from the same supplier. Although there have been no reported cases of amphibian population declines or mass mortalities attributed to the fungus, the possibility that the disease might subsequently impact native frog species cannot be discounted. However, further studies are required to better understand the disease epidemiology and *Bd* strains in both wild and imported frog populations.

Harmful algal blooms:

There have been some occurrences of harmful algal blooms (HAB) in the waters off Singapore in recent years which may have potential impact on marine biodiversity. In December 2009, one of the first cases of massive fish deaths due to a HAB incident was reported, killing 200,000 fish from fish farms along the Straits of Johor, which is also predominantly utilised for fish farming. In February 2014, another massive fish kill associated with a HAB event was observed, and both farmed fish and wild fish were affected (Leong, undated). Some examples of marine wildlife that were affected were frogfish, horseshoe crabs and pufferfish that were found washed up on nearby shores (Siau, 2015). Global climate change may have the effect of increasing the frequency of HAB incidents, along with eutrophication events and high levels of sediments in the water. In order to better understand this phenomenon in the local context, the Tropical Marine Science Institute (TMSI) is currently carrying out studies that would help us to better understand the root causes and hopefully reduce the impact of HABs in the future (Khew, 2015).

Human-wildlife conflict:

Rapid urbanisation and development near natural areas has brought humans and animals into ever closer proximity. This has led to a wide array of human-wildlife conflicts in Singapore involving Eurasian wild pigs (*Sus scrofa*), Javan mynas (*Acridotheres javanicus*), common palm civets (*Paradoxurus hermaphroditus*), snakes (e.g. *Python reticulatus*) and most extensively, long-tailed macaques (*Macaca fascicularis*). Long-tailed macaques are native to Southeast Asia, where they arguably contribute to most of the human-wildlife conflicts (Gumert, 2011).

Complaints about long-tailed macaques in Singapore date back to the 1970s when a group of aggressive macaques was removed from the Singapore Botanic Gardens (Anon, 2010). More recently, complaints from the public have escalated to nearly 1000 in the year 2012 as reported by the Agri-Food & Veterinary Authority of Singapore (AVA) (Feng, 2013). One of the main reasons for the conflict is that the macaques adapt to and benefit from living in human environments. Intentional or unintentional food provisioning is one of the major drivers for the conflict, constituting two-thirds of the interactions (Sha et al., 2009a). The majority of public complaints came from residents living near Nature Reserves, parklands and forested areas and the natural preference for the macaques to live in forest edges only escalates the conflict situation (Sha et al., 2009b). The nature of conflicts mainly include macaques entering human premises, raiding rubbish bins, approaching or following people for food handouts and snatching food from people.

The root of the increase in conflicts lies not just with human encroachment onto what was previously animal habitat, but also from human reactions in these interactions. Singapore's solution to the problem has been to attempt to modify the human behaviour aspect, and the existing management practices include enforcement against feeders, educational programmes and maintaining macaque proof environments, which have been effective in reducing the conflict levels.

Advisories focussing on best environmental, housekeeping practices and appropriate behaviour around macaques are distributed to residents living in macaque interface zones and to park visitors (Lee & Chan, 2011). In the longer term, collaborative effort from all stakeholders is important in conflict management and conservation of this species in Singapore.

CHAPTER 3:

UPDATES ON SINGAPORE'S NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN

3.1 Singapore's National Biodiversity Strategy and Action Plan, 2009

In 2009, Singapore developed a National Biodiversity Strategy and Action Plan (NBSAP) that outlines the key principles and goals for Singapore in conserving and managing biodiversity. The three goals mirror those of the Convention on Biological Diversity (CBD), and are thus representative of Singapore's commitment to the implementation of the Convention. The NBSAP also lists five broad strategies, as well as various actions that would be carried out under each strategy to accomplish these goals.

In line with the recommendation to review the NBSAP every five years, in late 2014 Singapore embarked on a review of the 2009 NBSAP in light of the CBD Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. Primarily, this review intends to develop national targets that are aligned with relevant Aichi Biodiversity Targets to be incorporated into the NBSAP. At the same time, Singapore intends to track progress in achieving these national targets using relevant indicators from the Singapore Index on Cities' Biodiversity (SI).

NParks is also developing a Nature Conservation Master Plan (NCMP) that will support the implementation of the NBSAP. The NCMP further outlines Singapore's biodiversity conservation approaches which will comprise of four thrusts:

1. Physical Thrust
2. Programmatic Thrust
    a. Habitat Enhancement
    b. Species Recovery
    c. Human/Wildlife Management
3. Research Thrust
4. Community Stewardship Thrust

3.2 Implementation of Singapore's NBSAP

Singapore's NBSAP (2009) features five strategies that Singapore executes in biodiversity conservation, and under each strategy, specific actions are outlined and further implemented in the form of activities carried out under each action:

Strategy 1: Safeguard our biodiversity

Actions:

- Implement species conservation and recovery programmes
- Rehabilitate areas that have previously been degraded
- Extend green corridors to counter fragmentation
- Utilise parks for ex-situ conservation and to house or re-create ecosystems that have been lost

Strategy 2: Consider biodiversity issues in policy and decision-making

Actions:

- Incorporate biodiversity conservation considerations, including integrated coastal management principles, into existing administrative processes
- Enhance biodiversity assessment capabilities
- Strengthen the current processes on access and benefit sharing, to ensure that biodiversity conservation is considered when granting access to Singapore's natural genetic resources

Strategy 3: Improve knowledge of our biodiversity and the natural environment

Actions:

- Encourage and facilitate research, in particular on ecosystem and species-specific biodiversity conservation, the interactions between the biological components and their physical environment, biodiversity valuation studies and the impact of climate change on biodiversity
- Monitor the health of ecosystems and species as part of the management process
- Develop and maintain a central information portal on biodiversity to facilitate more informed decision-making
- Maintain a list of species with their conservation status (red data list)
- Compile case studies on and assess best practices that have been implemented

Strategy 4: Enhance education and public awareness

Actions:

- Increase appreciation, awareness and understanding of Singaporeans for nature through public seminars, road shows and events
- Promote volunteerism through biodiversity interest groups
- Incorporate elements of biodiversity conservation into the curricula of all levels of education

Strategy 5: Strengthen partnerships with all stakeholders and promote international cooperation

Actions:

- Encourage active participation in the stewardship of the environment for all sectors
- Promote partnerships with regional and international organisations, in particular the ASEAN Centre for Biodiversity and the Secretariat of the Convention on Biological Diversity, as an indication of our commitment to biodiversity conservation at the global level

3.2.1 Strategy 1: Safeguard our biodiversity

Species conservation and recovery programmes

There have been various ongoing efforts in recent years to restore habitats and re-introduce species lost from particular habitats by academic institutions such as the National University of Singapore (NUS), Nanyang Technological University (NTU) and TMSI as well as NParks. One example of these projects was the reintroduction of giant clams (*Tridacna gigas* and *T. squamosa*, Neo, M. L., pers. comm. 23 Oct 2013) to local waters. Giant clams in Singapore were once abundant and diverse, with five recorded species: *Hippopus hippopus*, *Tridacna crocea*, *T. gigas*, *T. maxima* and *T. squamosa*. Since the 1960s, *T. gigas* and *H. hippopus* have been locally extinct and there are relatively few remaining *T. crocea*, *T. maxima* and *T. squamosa*. The restocking programme was initiated as it is uncertain if the few remaining giant clams are capable of regenerating substantial healthy

populations. The programme started in May 2011, using existing *T. squamosa* broodstock and new specimens imported for the project. The first batch of new clams was produced at the giant clam hatchery at TMSI on St John's Island in early 2012. Research was also conducted to increase the chances of establishing self-sustaining populations such as on gamete viability and larval behaviour. In addition, the project also aims to reintroduce *T. gigas*, the world's largest living bivalve mollusc. This species is a popular choice for mariculture and restocking in the region (e.g. Bolinao, Philippines) and there should be few technical barriers to raising stocks in Singapore. The animals are currently being reared in the hatchery pending the identification of suitable sites for transplantation. Apart from helping to recreate Singapore's former reef community, due to their spectacular size, giant clams have the potential to stimulate public interest in the marine life found around Singapore's coastline.

Another notable effort in this area was the initiation of a study on the critically endangered endemic Singapore freshwater crab - *Johora singaporensis*, with the intention of implementing a detailed conservation plan for the species. First discovered and described in 1986, the crab is listed as Critically Endangered in the IUCN Red List of Threatened Species, and is among the 100 most threatened species in the world. Four organisations are involved in the effort: NParks, NUS, IUCN, and Wildlife Reserves Singapore (WRS); and key stakeholders include the Nature Society (Singapore) (NSS) and other government agencies. Current conservation efforts include plans to establish a breeding programme, as well as an ongoing two-year collaborative research project launched in 2013 by NParks and NUS to study the conditions of the crabs' existing habitats and possible remedial actions. These crabs would subsequently be reintroduced into restored, rehabilitated streams.

Rare native plants are also propagated for reintroduction to suitable habitats. Since 2010, the following plants have been propagated for reintroduction to various parks and Nature Reserves (Leong-Škorničková, J., pers. comm. 10 Oct 2013; Hassan Ibrahim pers. comm. 9 Sept 2014):

Table 3: List of plant species propagated since 2010

Plant species		
Aeschynanthus albidus	*Cissus repens*	*Hornstedtia leonurus*
Adenia macrophylla var. *singaporeana*	*Donax canniformis*	*Hornstedtia scyphifera*
Alpinia aquatica	*Elettariopsis latiflora*	*Intsia bijuga*
Amomum xanthophlebium	*Etlingera maingayi*	*Stachyphrynium latifolium*
Centotheca lappacea	*Fagraea auriculata*	*Stachyphrynium sumatranum*
Cheilocostus globosus	*Hornstedtia conica*	*Zingiber puberulum*

One noteworthy ongoing project is the conservation, propagation and reintroduction of the native orchids of Singapore. Since 1995, more than 10,000 plants from 18 orchid species have been reintroduced successfully at more than 20 locations in Singapore such as parks, Nature Areas and roadside trees (Yam, T. W., pers. comm. 8 Oct 2013). These orchids bloom occasionally, giving character, colour and variety to the streetscape planting.

Improving habitat connectivity

There have been several initiatives that are being implemented with the intention of improving habitat connectivity in the medium to long term. In the 2011 National Day Rally speech, Singapore's Prime Minister, Mr Lee Hsien Loong, highlighted the vision to transform Singapore into a City in a Garden (CIAG, see section 3.2.2 below), which includes creating ecological connections between urban green areas such as parks with Nature Reserves (MND, 2011). As part of the CIAG vision, green spaces such as Nature Areas and parks will also be enhanced to provide a lush living environment for Singaporeans.

One initiative announced in 2012 was the Round Island Route (RIR), which is a 150km long recreational and green corridor that runs around the entire island of Singapore. It will link up with sections of the Park Connector Network (PCN) and will feature an eco-discovery trail (Toh, 2012). The PCN (highlighted in the 4th National Report), RIR and Rail Corridor (please see section below) improve connectivity between parks and complements our network of parks to achieve the goal of having a park or green space within 400m (or walking distance) of up to 90% of homes in Singapore (Urban Redevelopment Authority, URA, 2013).

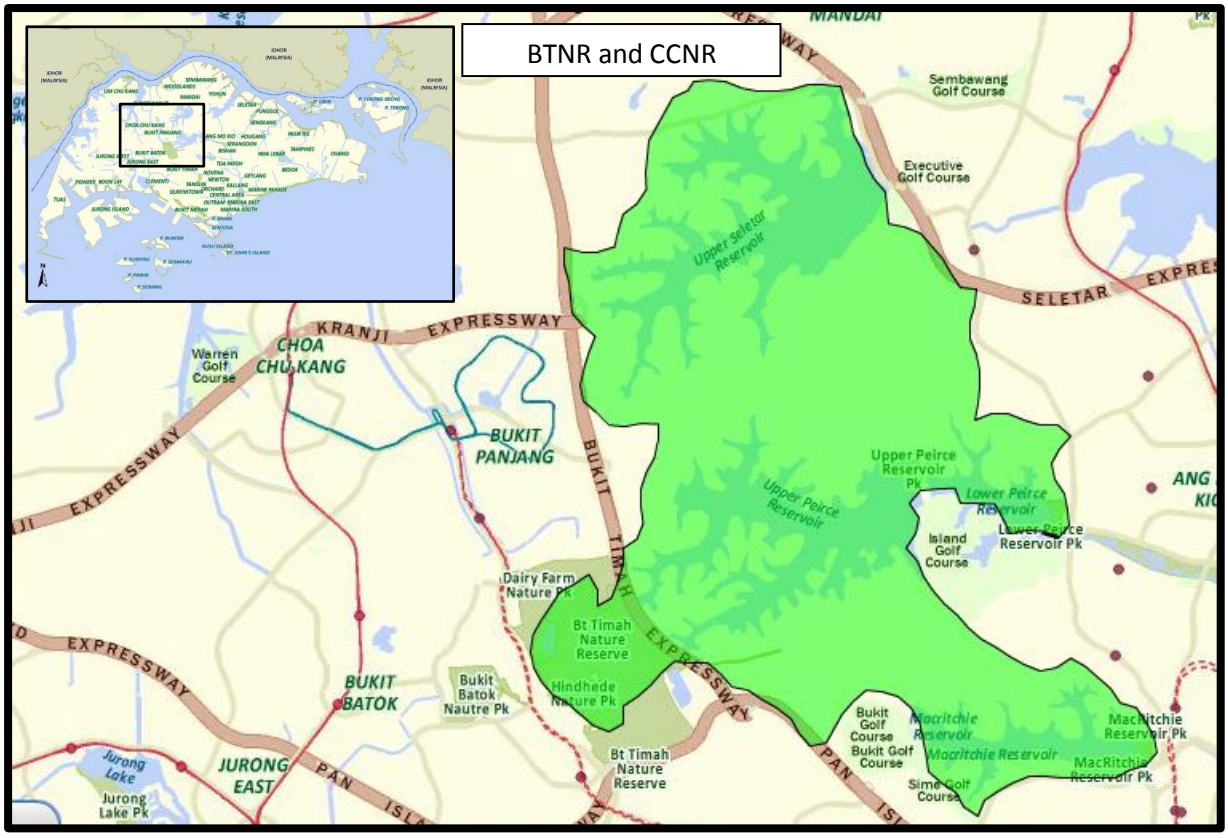
Another initiative has been the development of "Nature Ways" which are linear green corridors along roadsides that have been developed to connect areas of high biodiversity. Designed based on the natural structure of forests, these corridors are intended to have similar community structures as natural forests with emergents, a canopy layer, an understorey layer and an undergrowth layer. These Nature Ways would act as green corridors connecting patches of forest to encourage movement of animals and gene flow between these patches. For example, the Tengah Nature Way project spans 13 km and connects the Bukit Timah Nature Reserve to the Western Catchment forest (Ministry of the Environment and Water Resources, MEWR and MND, 2014). Various small patches of forest and parks exist between these two larger patches, and the Tengah Nature Way will link these up through smaller gardens planted along its length with butterfly and bird attracting plants. Numerous community groups have been involved in this initiative and this would enhance the sustainability of this effort as well as promote its success as an ecological corridor. Schools are also engaged to document the diversity of animals that are seen using the Nature Ways, which has the added benefit of exposing younger children to nature as well. Island-wide, there will be a total of 60 km of Nature Ways by 2015.

Eco-Link@BKE:

One of the major efforts that have taken place in recent years to improve biodiversity conservation was the Eco-Link@BKE bridge that served to connect two Nature Reserves, the Bukit Timah Nature Reserve (BTNR) and the Central Catchment Nature Reserve (CCNR), which harbour the richest diversity of Singapore's forests (see 4th National Report to the CBD). Prior to 1983, the two Nature Reserves were contiguous, but that year marked the start of construction of the Bukit Timah Expressway (BKE) that ran in between the two reserves, effectively cutting them off from each other. In 2011, construction began on the Eco-Link@BKE, an hourglass-shaped overhead ecological corridor 50 m wide at its narrowest point, and this was completed in 2013 at a total cost of S$17 million. Native plants have been planted on the bridge to encourage its use by the fauna on either side.

Public access will be minimised for the initial few years to reduce the disturbance and assess its effectiveness as a wildlife corridor and in restoration of gene flow between the two sites. Monitoring programmes that began prior to the construction of the Eco-Link will enable us to compare if there have been changes in the communities on either side. It is hoped that eventually animals such as the banded-leaf monkey that were once found in Bukit Timah Nature Reserve will cross the Eco-Link to take advantage of the habitats on that side. Apart from physical crossings, the Eco-Link would also assist with the exchange of genetic materials between the two Nature Reserves, particularly for some rare native plants such as the Singapore durian (*Durio singaporensis*) and the Singapore walking stick palm (*Rhapaloblaste singaporensis*) which are pollinated and dispersed by animals.

Figure 1: Bukit Timah Nature Reserve and the Central Catchment Nature Reserve



Rail Corridor:

The Rail Corridor is a 24 km long stretch of land that used to be a functioning railway line known as the Keretapi Tanah Melayu (KTM) Railway Line (URA, 2015). The land was previously controlled by Malaysia's railway operator, but was returned to Singapore in 2011 after bilateral negotiations with Malaysia. This stretch of land is subsequently known as the Rail Corridor.

Figure 2: Route of the Rail Corridor

The Rail Corridor connects key green areas (see table 4) from the north to the south of Singapore and is a green corridor with natural vegetation on both sides of the tracks, providing community space where many residents can enjoy recreational activities.

Table 4: Areas of biodiversity significance along the Rail Corridor (NSS, 2010).

Green areas	Significance
Southern sector	The southern sector includes the Southern Ridges, Singapore Botanical Gardens, One North Park and the Ulu Pandan Park Connector. The Rail Corridor links all of these places up by intersecting with the existing PCN, improving movement between the parks. Also, the Rail Corridor currently skirts along the Ayer Rajah Expressway and can be a green cycling route into the city. The Rail Corridor has also been acting as a green buffer to adjacent light factories in the southern sector.
Clementi Woodlands	Clementi Woodlands is an area of significant secondary growth forest. This large patch of green is also intersected by the disused Jurong Line.
Jurong Line	The remains of a railway line disused some 20 years ago, the Jurong line has developed unique micro-climates that have become sanctuaries for

	many rare plants such as giant tree ferns. Due to the cool and humid climate in that area, many rare species of ferns and orchids thrive there. Rare birds such as the buffy fish owl and changeable hawk eagle have also been recorded in its woodlands area.
Bukit Timah Nature Reserve (BTNR)	BTNR is an important ecological site in Singapore and a popular nature reserve frequented by both locals and foreigners alike. The railway land runs close to BTNR and Bukit Batok Nature Park and converting the railway land into nature trails can help make BTNR more accessible.
Kranji / Mandai Mangrove & Mudflats	This coastal strip between the railway line and the sea consists of extensive areas of mangroves and intertidal mudflats, forming a river estuarine system. The site contains one of the best examples of mixed mangrove stands and is rich in biodiversity.

Given the importance and heritage of the Rail Corridor, many nature interest groups have encouraged the preservation of the stretch as a "Green Corridor" to connect communities, and natural areas together (NSS,2010). While we are cognisant that the Rail Corridor presents a unique opportunity to meet our development needs, we are also aware that many desire to keep this as a green space and a respite from the urban environment. We believe that both objectives can be met. Since the return of the land, the government has been actively engaging the public on various platforms to shape our common aspirations for the Rail Corridor.

Restoration, reforestation and enhancement initiatives

Reforestation programmes at Nature Reserves:

Singapore is constantly seeking to improve the conditions of the Nature Reserves. NParks' reforestation programme consists of collecting seeds of native species and growing them in nurseries before planting them at sites that have been selected for rehabilitation, in particular some of the degraded peripheral habitats.

Some mangrove species such as *Avicennia alba*, *Rhizophora apiculata*, *R. mucronata* have also been used in replanting schemes at Sungei Buloh Wetland Reserve (SBWR). The plants are propagated from propagules and grown in the in-house nursery before being planted by volunteers at sites where restoration work is being carried out.

Bukit Timah Nature Reserve closure:

Existing habitats under NParks' management are also constantly monitored for signs of degradation. BTNR is well known to Singaporeans as a haven for nature. BTNR is a small forest (1.63 km^2, or 0.2% of Singapore's land area) within an urban setting with unique biodiversity that contains a large proportion of Singapore's native flora and fauna (Tan, 2014). These include the Singapore freshwater crab (*Johora singaporensis*, see pg 16) which is endemic to Singapore and rare native species like the straw-headed Bulbul (*Pycnonotus zeylanicus*). However, increased visitorship of nearly 400,000 users annually and heavy rainfall have caused some of the walking trails at BTNR to become degraded, leading to exposed roots which might hinder forest regeneration. Young saplings are also damaged

through trampling before they can establish themselves. Also, as some park users do not keep to the designated paths; new tracks have been formed in some parts of this pristine forest, leading to greater fragmentation of the habitat (See & Lin, 2014). Thus, a decision was made to fully close BTNR to the public for six months from September 2014 in order to undertake slope stabilisation works, and partial closure over the subsequent two years for the construction of boardwalks and railings, upgrading of the visitor's centre and other restoration work. The closure will allow some time for the biodiversity of the Nature Reserve to recover from any impact from visitors.

Figure 3: Bukit Timah Nature Reserve

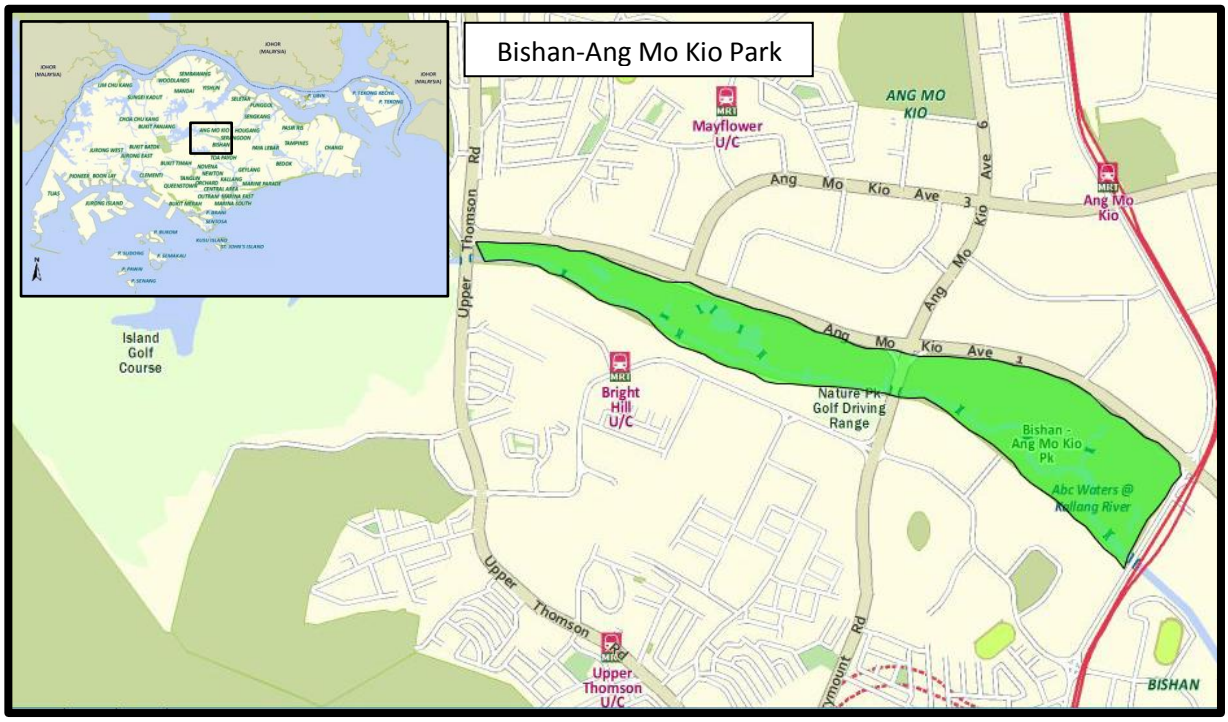
Bishan-Ang Mo Kio Park river rehabilitation:

One of the most successful examples of habitat rehabilitation was in the redevelopment of Bishan-Ang Mo Kio Park, which originally had a concrete canal that ran its entire length. A joint collaboration between PUB (Singapore's national water agency) and NParks, the concrete canal was redeveloped under the Active, Beautiful, Clean (ABC) Waters Programme into a meandering naturalised river that is integrated with the park, with the use of natural materials to shore up the river bank. The efforts have paid off, with a large variety of native birds spotted visiting the river and occasional otters travelling upstream into the park, which is located quite deep inland.

ABC Waters design features (comprising only plants and planting media) have also been incorporated into the design to maintain the water quality in the ponds and the river naturally, without the use of chemicals. An example is the cleansing biotope, which consists of carefully selected plants to filter and absorb pollutants. Located upstream in the park, the water is also recycled for use in the water playground after it undergoes UV treatment. The park has also been

developed to encourage the public to interact with the naturalised river and to get closer to nature and the river, and the landscape surrounding the river is designed to accommodate increases in water levels.

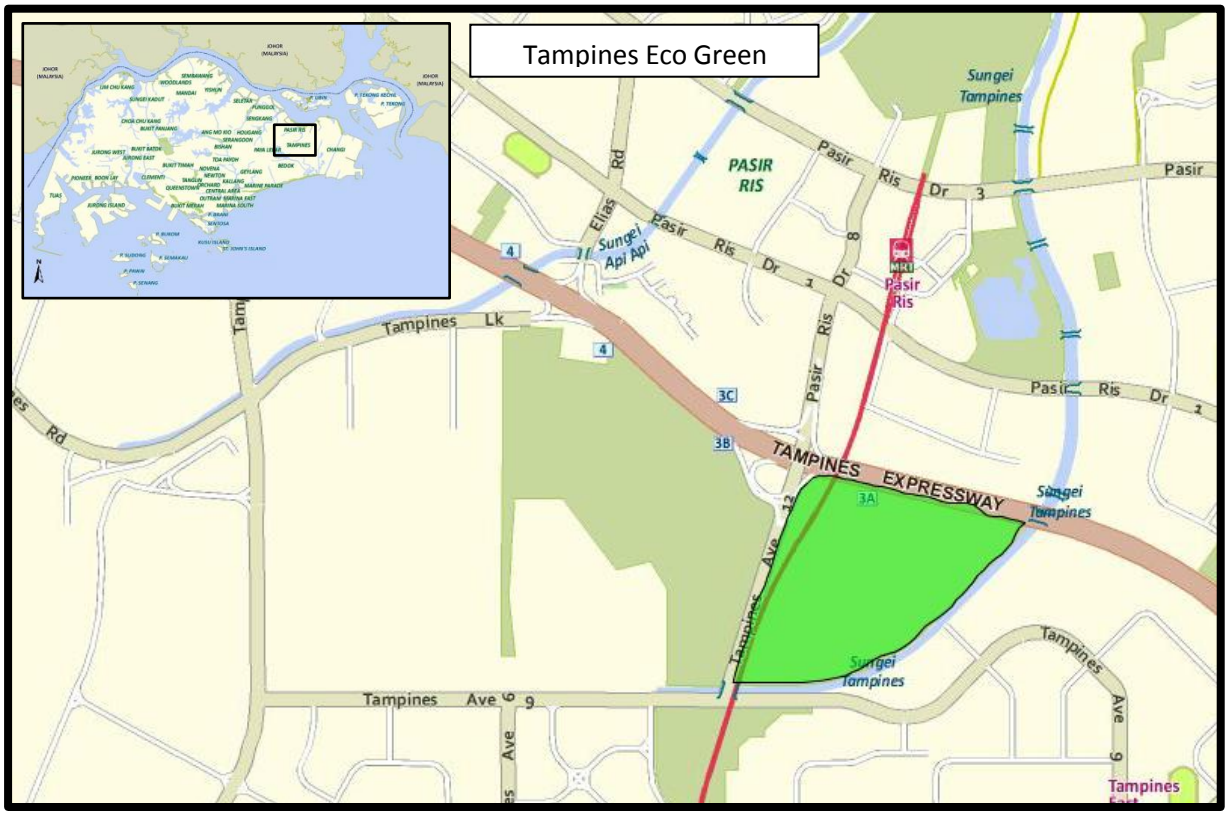
Figure 4: Bishan-Ang Mo Kio Park



Tampines Eco Green:

Tampines Eco Green, an eco-friendly park, was opened in 2011. The $3 million, 2.5 ha park was established incorporating various habitats such as secondary forest, marshlands and freshwater ponds, with much of the original habitats and vegetation being retained in its development (Huang, 2011). Eco-friendly measures and features were implemented in the development of this park, such as using grass for the footpaths rather than concrete. Dead trees were also retained within the park, as these serve as perches or nesting sites for birds such as woodpeckers. Wood collected from NParks' pruning operations and other horticultural waste were also recycled to create the signage, benches and bird hides along the trails. Tampines Eco Green also boasts a viewing platform, vegetated swales (natural drainage system that traps particulate pollutants), green roofs on all the rest shelters and washrooms, and the first-ever flush-free public eco-toilet. In order to increase the diversity of animals, over 200 butterfly attracting plants were planted with the help of volunteers. Tampines Eco Green will potentially serve as a model for future recreational parks, leaving ecosystems as intact as possible while remaining enjoyable for visitors to the park.

Figure 5: Tampines Eco Green



Sungei Pandan project:

In 2010, the Sungei Pandan corridor project was launched by NSS with the aim of creating a wildlife corridor along the Pandan river through the enhancement or expansion of existing patches of woodland, mangroves and riverine habitats. The Southwest Community Development Council (SWCDC)'s One Million Tree Planting Programme, together with various NSS Special Interest Groups, PUB and NParks have been making efforts to plant native plants that will support local bird and butterfly populations along the Sungei Pandan corridor. This project aims to be an ongoing project with monitoring surveys that will hopefully help to guide future projects in other parts of Singapore (NSS, undated).

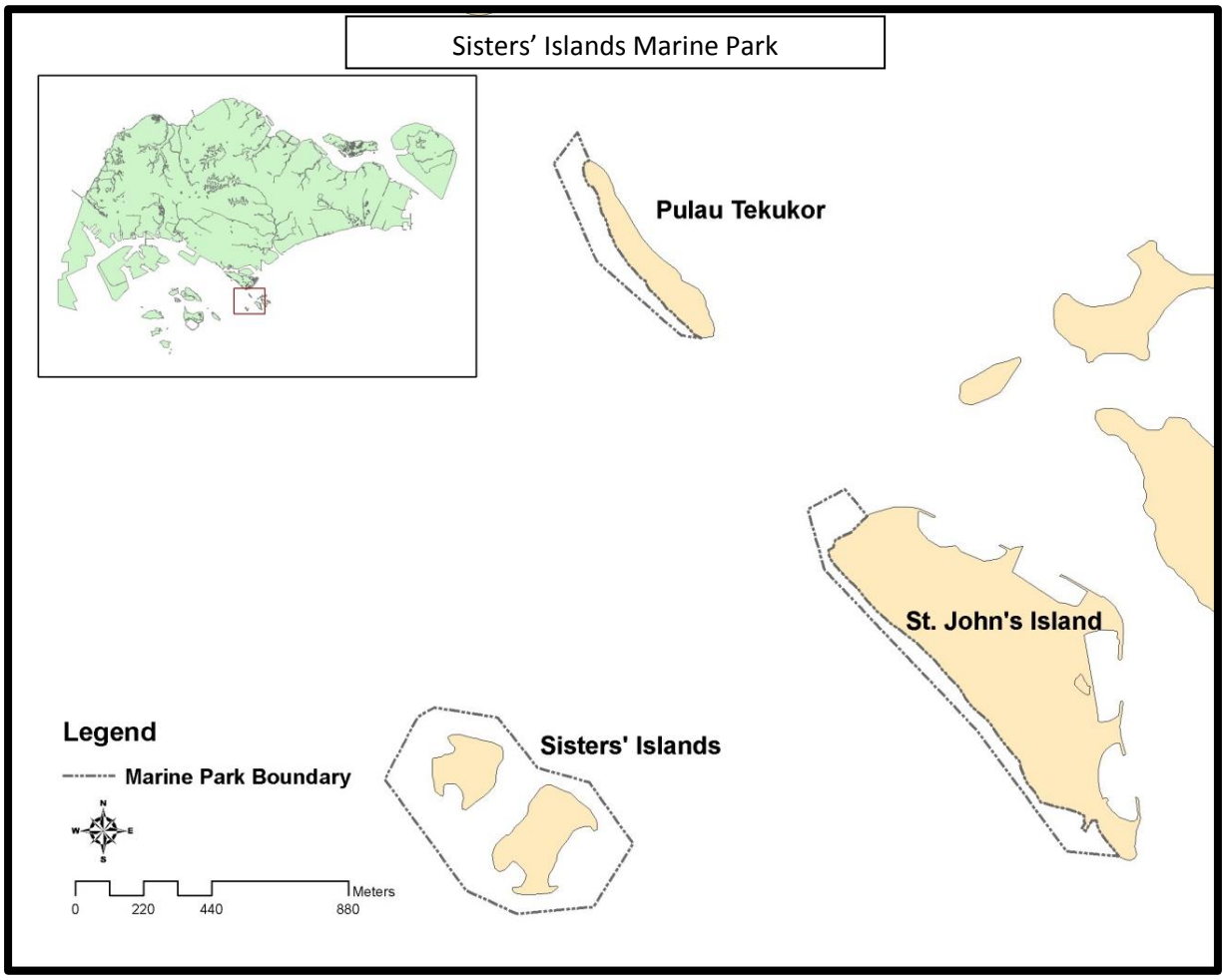
<u>Other efforts on safeguarding biodiversity</u>

Sisters' Islands Marine Park:

Singapore's first marine park, encompassing Sisters' Islands and the western reefs of Pulau Tekukor and St. John's Island, was announced during the Festival of Biodiversity (FOB) in July 2014. The establishment of this 40 ha park will help protect a variety of Singapore's marine habitats such as coral reefs, sandy shores and seagrass meadows, which are inhabited by various rare and endangered species of marine life. The Sisters' Islands Marine Park is managed by NParks, and involved several NGOs, universities, schools and other marine nature interest groups in its establishment. It will also help serve multiple roles and functions, particularly outreach, education, conservation and research. The marine park will give Singaporeans a first-hand experience of our

rich coastal and marine biodiversity through guided tours and volunteer programmes. Educational programmes such as talks and remote monitoring programmes for schools will also be provided for interested parties to learn more about marine life. Conservation and research will tie in together with in depth studies and regular monitoring of Singapore's marine environment, providing scientific data which will facilitate the implementation of habitat enhancement activities. Restoration activities such as nurseries for iconic marine organisms are also in place, such as the reintroduction of giant clams (see pg 15). In 2014, when some lagoons off Pulau Semakau landfill were closed to accommodate future landfill needs, corals from the lagoons were salvaged and transplanted to Sisters' Islands where they are now thriving.

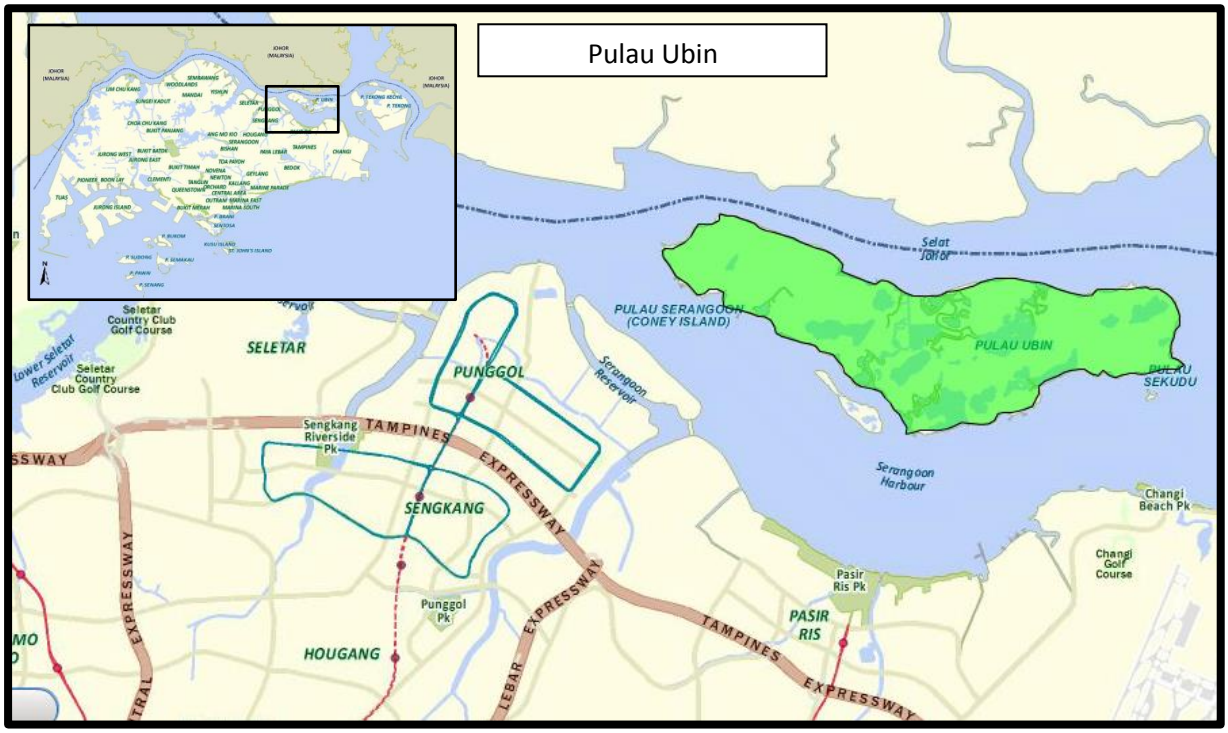
Figure 6: Sisters' Islands Marine Park



Ubin Project:

Pulau Ubin is the second largest island off mainland Singapore, covering 1,020 ha in total (Tan, 2003) and the island is where Chek Jawa wetland is found, one of Singapore's richest ecosystems. Chek Jawa is the largest natural intertidal flat in northern Singapore and houses many different biodiversity rich habitats including a coastal forest, mangroves, rocky shores, sandy shores, seagrass lagoons and coral rubble areas.

Figure 7: Pulau Ubin



Recognising the importance of protecting the biodiversity at Pulau Ubin, the government started the Ubin Project in 2014 to consult citizens on ways to retain the rustic and natural character of the island for future generations to experience. The Friends of Ubin Network (FUN) was set up to guide the project. The members of FUN include socio-anthropologists, students, Ubin community leaders, residents, and volunteers from various heritage and nature groups. The public expressed and discussed their myriad views for Pulau Ubin through various platforms such as workshops, symposiums, exhibitions and an online portal. The ideas generated from the consultation are being implemented with multi-agency participation.

Table 5: Projects generated from the Ubin project (MND, 2015).

No.	Programme	Details
1	Ubin Living Lab	An integrated facility for field studies, education research and community outreach. The current plan is to convert a former resort site to house the facilities.
2	Species recovery programmes	- Bats The programme aims to increase the diversity of bats and bring back uncommon species such as ashy roundleaf bats (*Hipposideros cineraceus*) and lesser false vampire bats (*Megaderma spasma*) through the installation of bat houses or roosts - Birds Birds such as red-wattled lapwings (*Vanellus indicus*), baya weavers (*Ploceus philippinus*) and blue-throated bee-eaters (*Merops viridis*) have been identified for the species recovery programme. Baseline Information gathering has commenced in December 2014 and prototype set ups are being developed.

3	Habitat enhancement	- Floating wetland prototype at Pekan Quarry. To enhance the heron habitat, floating wetlands will be installed to provide nesting and roosting sites. A prototype of the floating wetland will be installed by end 2015 - Mangrove restoration The Restore Ubin Mangroves (RUM) group will be piloting a restoration project at the south-eastern part of Pulau Ubin. RUM is a ground-up initiative supported by NParks.
4	Cultural mapping and heritage	NParks has commissioned a book on the cultural and natural heritage of Pulau Ubin, and launched the Ubin Oral History Project that will record personal life histories and experiences about Ubin's past and present, culminating in a documentary to be produced.
5	Design Guidelines for Restoring/Rebuilding on Pulau Ubin	A set of design guidelines for restoring or rebuilding buildings and structures on the island will be worked out together with stakeholders. This is so as to retain the rustic quality and heritage of Pulau Ubin and ensure the safety of the inhabitants.

Oil spill impact mitigation:

One aspect of safeguarding biodiversity is the ability to mitigate impacts of events with the potential to harm the environment. As mentioned in the section on threats to Singapore's biodiversity (see section 2.2.6), oil spills are a concern when it comes to protecting biodiversity in close proximity to major ports and busy sea lanes. MPA works closely with NParks and other relevant government agencies to prevent, or minimise the effects of oil spills by containing and clearing the spilled oil in an environmentally-safe and expedient manner. MPA, in consultation with the relevant stakeholders, has developed the Marine Emergency Action Procedure (MEAP) to deal with oil and chemical spills as well as other marine incidents. The MEAP contains detailed procedures and establishes clear channels of authority so that MPA can tap on a large pool of resources and expertise quickly in the event of an incident. These response plans are tested and sharpened through cross agency exercises such as the annual Joint Oil Spill Exercise (JOSE). Apart from this overarching response plan, agencies such as NParks have drawn up site-specific oil spill response plans and measures, for example, the deployment of oil booms. The Singapore government also invests in technology to prevent and mitigate oil spills. For example, NParks and NUS have jointly-developed an oil-spill motion prediction resource, with a focus on sites of high biodiversity, to allow managers on the ground to react expediently to spills, thereby complementing MPA's full-scale oil spill modelling capabilities.

NParks engages with the major oil companies, their response vendors, and academia regularly to highlight the areas of concern vis-à-vis oil spills in Singapore. NParks also involves nature interest groups in post-spill activities, such as reconnaissance and surveys.

3.2.2 Strategy 2: Consider biodiversity issues in policy and decision-making

City in a Garden vision

The National Day Rally is an annual speech given by the Prime Minister of Singapore that outlines the key challenges and directions for the country in the upcoming year, and provides a sense of the priorities of the government at the highest level. At the 2011 National Day Rally, the Prime Minister, Mr Lee Hsien Loong, highlighted Singapore's plan to have parks in all parts of the country and then link them up to turn Singapore into a City in a Garden in order "to keep Singapore special and exceptional". NParks is a statutory board whose primary purpose is to maintain and enhance the greenery in Singapore. Within NParks, the detailed implementation of making Singapore a City in a Garden is carried out through six key areas, one of which is "enriching biodiversity in our urban environment".

Singapore's Land Use Planning

MND released a Land Use Plan (MND, 2013) which articulated various strategies to "ensure a high quality living environment for all Singaporeans", including an entire chapter of plans on how Singapore can maintain its City in a Garden vision. The Land Use Plan was then translated into detailed plans in the URA Master Plan 2014 (URA, 2014).

URA is Singapore's land use planning and conservation authority, tasked to develop medium to long term plans for the sustainable development of Singapore[2]. URA recently published their most recent Master Plan in 2014, having conducted a land use consultation exercise in 2013 and incorporating MND's 2013 Land Use Plan. Recreation is a key focus of the 2014 Master Plan, which has a heavy emphasis on safeguarding and enhancing nature and biodiversity. For example, some of the strategies adopted include the creation of ecological corridors, and the enhancement of existing natural areas (URA, 2014).

In addition to the 4 Nature Reserves that are legally gazetted under Singapore's Parks and Trees Act (2005), URA also recognises another 18 areas with significant biodiversity termed Nature Areas in the Parks and Waterbodies Plan of its 2003 Master Plan for Singapore (URA, 2003). On 31 January 2013, MND announced the addition of two more Nature Areas, Jalan Gemala; and Pulau Unum and Beting Bronok in its Land Use Plan (MND, 2013). Beting Bronok is a submerged reef on the northern coast of Singapore that gets exposed during low spring tides that has significant marine biodiversity, partially due to its proximity to military training areas which restricts access to the area. To the east of Beting Bronok is Pulau Unum, a small island that has a relatively healthy mangrove habitat with two species of locally-endangered mangrove plants. Jalan Gemala has varied habitats such as wet grassland, freshwater marshes, as well as tall secondary woodland and a freshwater reservoir. The wetland habitats here are home to two species of rare plants and also support the nearby Kranji Marshes and Sungei Buloh Wetland Reserve in terms of ecological connectivity.

[2] URA's planning process is covered in greater detail in the 4th National Report to the CBD.

This is a significant announcement, given the premium on land area in Singapore, and is a demonstration of the commitment of the government towards biodiversity conservation. It is also the first time that new Nature Areas have been demarcated ever since the 2003 Masterplan. These areas will be protected through administrative measures that require any development near these areas to undergo consultations that will minimise impact to the habitats or require the conduct of impact assessments.

Integrated Urban Coastal Management

Singapore adapted the Integrated Coastal Management (ICM) framework, developed by the Partnerships in the Environmental Management for the Seas of East Asia (PEMSEA), to our highly urbanised context where our coastal and marine environment (CME) are closely tied to urban development. The resulting framework is known as Integrated Urban Coastal Management (see section 3.2.5.2 on Singapore's partnership with PEMSEA on IUCM), and it is used by Singapore to sustainably manage the coastal and marine environment and biodiversity in a consultative manner, which involves stakeholders from the government, private and public sectors.

IUCM has three objectives: to enhance coordination between all stakeholders in coastal and marine land use and planning; to conserve sensitive coastal habitats and biodiversity or natural resources amidst coastal development; and to optimise the use of coastal resources, including coastal space, in a sustainable manner. To achieve these, the IUCM process has four guiding principles:

1. Proactive planning and management
2. Whole-of-Government approach
3. Active partnerships
4. Science-based management

Using the IUCM framework, Singapore has integrated marine biodiversity conservation and coastal resource management into decision-making processes and into the implementation of national policies. The adoption and implementation of the IUCM framework has been endorsed by the Coastal and Marine Environment Policy Committee (CMEPC), an inter-ministerial committee formed to provide policy direction for CME issues. The CMEPC is supported by the Technical Committee on Coastal and Marine Environment (TCCME), which is co-chaired by NParks and the National Environment Agency (NEA) and is the implementing body for IUCM. Comprising technical experts from government agencies as well as academics and researchers in marine environmental sciences, it is responsible for driving research in Singapore's marine environment that provides sound scientific findings for the formulation of effective policies and management solutions.

Sustainable Singapore Blueprint 2015

The Sustainable Singapore Blueprint 2015 (SSB 2015) lays out Singapore's vision and plans for a more sustainable living environment. The first version of SSB was released in 2009 which detailed the findings and recommendations of the Inter-Ministerial Committee on Sustainable Development (IMCSD, see 4th National Report to the CBD). The current SSB 2015 (MEWR and MND, 2014) was announced in Nov 2014 by the Prime Minister, Mr Lee Hsien Loong. SSB 2015 goes beyond the scope of SSB 2009 to take into account future challenges and developments that Singapore will face and

takes stock of Singapore's achievements over the last five years in reference to the targets set out in the 2009 version of the SSB, as presented in the table below.

Table 6: SSB 2015 update on the progress towards the targets set out in SSB 2009.

Key SSB 2009 targets and recommendations	Status in SSB 2015 (figures as of 2013)
• Increase the green park space by 9 km^2 to 42 km^2 by 2020, and reach a park provision of 0.008 km^2 per 1,000 population by 2030	• 40.4 km^2 of green space have been developed.
• Increase the length of park connectors from 100 km in 2007 to 360 km by 2020	• 216 km of park connectors have been developed.
• Introduce 0.3 km^2 of skyrise greenery by 2020 and 0.5 km^2 of skyrise greenery by 2030	• 0.61 km^2 of skyrise greenery had been implemented, exceeding the target set for 2030.
• Open 8.2 km^2 of reservoirs and 90 km of waterways for recreational activities by 2020 and have 9 km^2 of reservoirs and 100 km of waterways open for recreational activities by 2030	• 9.59 km^2 of reservoirs open for recreational activities, exceeding the target set for 2030. • 93 km of waterways open for recreational activities, exceeding the target set for 2020.
• Implement a National Biodiversity Strategy and Action Plan to research, document and conserve biodiversity in Singapore.	• NBSAP has been implemented, and is being reviewed.
• Develop a City Biodiversity Index with international partners to promote biodiversity conservation efforts among cities globally.	• The Singapore Index has been developed and is currently in use (see section 4.1 and Annex C).

The SSB 2015 also set new targets for the various sectors that contribute to sustainability, to be achieved by 2030. The following targets are the ones most relevant to greenery and biodiversity.

Table 7: SSB 2030 targets on greenery and biodiversity.

SSB 2015 Targets for Green and Blue Spaces			
Indicator		2013 Levels	Targets for 2030
1	Amount of skyrise greenery	61 ha	200 ha
2	Amount of park space and waterbodies open to recreational activities a) Parks b) Waterbodies	 4,040 ha 959 ha	 Park Provision Ratio of 0.008 km^2 / 1,000 population 1,039 ha
3	Length of Park Connectors and waterways open to recreational activity a) Park Connectors b) Waterbodies	 216 km 93 km	 400 km 100 km
4	Length of Nature Ways	21 km	180 km
5	Proportion of households within 10 min walk of a park	80%	90%

Greening of Urban Infrastructure

50 years of Greening:

In 2013, NParks celebrated 50 years since the start of efforts to improve the quality of life and make Singapore distinctive and attractive through greenery (NParks, 2013a). On 16 June 1963, Singapore's first Prime Minister, Mr Lee Kuan Yew planted a Mempat tree at Farrer Circus, signifying the start of Singapore's greening campaign. To commemorate the 50th Anniversary, Mr Lee planted a rain tree at Holland Village Park on 16 June 2013 (NParks, 2013b). Mr Lee was largely considered to be responsible for the campaign to green Singapore, and continued to oversee greening efforts throughout the years since its inception through the Garden City Action Committee (GCAC) that was set up by him in 1970. The GCAC was tasked to oversee policies for greening the whole island and coordinates the activities of the various government agencies in this respect. Over the years, these efforts have evolved from the original focus of just providing greenery island-wide to incorporating greenery and nature throughout Singapore, and the associated shift from the vision of Singapore being a Garden City to becoming a City in a Garden (CIAG, see section above). As part of the CIAG implementation, the greening of Singapore's urban infrastructure has shifted to more natural plantings, such as the Nature Ways (see section 3.2.1) and there is a greater emphasis on planting insect or bird attracting plants.

The planting along the streets of Singapore is being guided by the Streetscape Greenery Master Plan (Tee et al., 2009) which is a blueprint to optimise available green spaces along the roads for lush, densely planted treatments using a wide variety of native species contributing to our City in a Garden vision.

3.2.3 Strategy 3: Improve knowledge of our biodiversity and the natural environment

Biodiversity research and access and benefit sharing (ABS)

NParks has tried, wherever possible, to facilitate research on local biodiversity and habitats by coordinating access to these habitats with various landowning agencies for researchers. NParks collaborates with academics, schools, amateurs and nature interest groups to obtain information on native habitats and species. The information obtained from these surveys is consolidated in a central information portal that will be elaborated under the section on biodiversity information management below.

Singapore has always encouraged research on native biodiversity and habitats, with the primary returns consisting of information about the habitat or taxa being studied. For non-commercial or academic research, access to local habitats is administered through the issuing of research permits by NParks, with the agreement that the researcher should provide all stakeholders with a copy of the research outcomes.

As local expertise is limited, there is a need for researchers with more in-depth expertise to come and study the local biodiversity. Their access to local habitats is provided on the condition that they share their findings with Singapore; and where feasible, to conduct training on specific topics to boost capacity in these areas. Some examples of foreign researchers coming here to conduct field work and training include the Singapore Mangrove Insect Project (2012-2015), where the Royal Belgian Institute of Natural Sciences, NUS and NParks conducted surveys of the insects found in local mangroves and from which at least ten new species were discovered. In 2011, TMSI and the then Raffles Museum of Biodiversity Research (RMBR, now known as Lee Kong Chian Natural History Museum or LKCNHM) invited Dr Daphne Fautin to conduct a sea anemone identification workshop over the course of a week, which greatly boosted the local ability to properly classify these animals.

Singapore is currently in the process of developing a framework for commercial research and bioprospecting in local habitats that would allow greater investments in this sector.

In addition to facilitating research, NParks also has a research plan that forms part of the Nature Conservation Master Plan under development (NCMP, see section 3.1), which outlines the direction that biodiversity and conservation research in Singapore should take to complement the NCMP.

NParks established the Centre for Urban Greenery and Ecology (CUGE) in conjunction with the Singapore Workforce Development Agency to share and advance expertise on urban greenery and ecology to the landscape industry; as well as to conduct multidisciplinary research on the greenery and ecology of cities. Biodiversity related research include the development of ecological guidelines for aquatic systems, enhancing biodiversity in skyrise greenery, ecological networks and more recently, the concept of “park prescriptions” which aims to explicitly demonstrate the physical and health benefits of exposure to nature and greenery. In addition to biodiversity research, CUGE conducts workshops, seminars and talks on topics such as understanding ecological habitats, ecological designs and urban biodiversity conservation.

Monitoring ecosystems

Singapore conducts constant monitoring of the most important habitats and ecosystems found in the country. Monitoring takes place in the form of both scientific surveys as well as observations by Rangers or Park Managers who are tasked with managing the Nature Reserves or parks, as well as volunteers. In addition to this, biodiversity research conducted in local habitats requires a research permit (see section above, on biodiversity research and ABS in Singapore). As such, researchers from local institutions are able to provide reports and feedback on the condition of the habitats that they are working on.

Biodiversity information management

One of the most basic prerequisites for proper management of habitats and conservation of biodiversity in any country would be the way in which biodiversity information is processed and applied. NParks has developed a system to manage biodiversity data that facilitates science-based decision making on conservation management issues.

Data acquisition:

NParks works in partnership with various nature interest groups, research/educational institutions as well as government agencies to monitor key habitats in Singapore. For example, TeamSeaGrass is a group of volunteers that monitors seagrass habitats at numerous intertidal areas, and another group, the Blue Water Volunteers (BWV), monitor the status of hard corals, mobile invertebrates and reef fish in local waters. Information on species and habitats is also obtained in reports for research work conducted under the NParks research permit system (see pg 27). NParks also collaborates with research institutions for various projects and surveys, most notably the CMBS (see section 2.2), to take stock of our biodiversity and to monitor the health of intertidal habitats and marine organisms. Even members of the public can submit sighting records for animals that they have seen, usually in the form of a photograph together with information on where it was sighted (see section 3.2.4.2).

In addition, NParks also works with development agencies in order to collect data for impact assessment. As part of the impact assessment, consultants are engaged for biodiversity monitoring work around Singapore.

Data management:

The information is then fed into BIOME – Biodiversity and Environment Database System, NParks Flora & Fauna Web and the NParks website to organise, store and maintain these data. This allows systematic organisation and secure storage of the information while also facilitating easy search and retrieval of relevant information. For example, BIOME allows users to search for information using keywords and incorporates a geographical information system within that allows users to search based on locality. NParks Flora & Fauna Web allows users to browse and search for information and pictures relating to a particular species of flora or fauna.

Data application:

The data can be used as a review of existing research information, or repackaged into posters and publications for outreach programmes and education. For example, NParks has published books on our biodiversity such as “Dragonflies of our Parks and Gardens” and supplied the information for exhibits such as the Festival of Biodiversity (FOB) and other paraphernalia. Researchers might also use the data for reference and analysis, build their work on existing knowledge in the database, or create new knowledge. We also share our knowledge through public engagement platforms, events, seminars and exhibitions such as FOB (see section 3.2.4.1), Biodiversity Research Symposium, CMBS exhibitions and many more. Most importantly, the scientific data is used to make policy and management decisions: BIOME incorporates tools designed to generate reports from data which provide summaries or snapshots of the current state of biodiversity that can be useful to policymakers.

Such a system of data acquisition, management and application enables us to continue building on our existing knowledge and manage our biodiversity and natural environment better.

3.2.4 Strategy 4: Enhance education and public awareness

In Singapore, many different organisations and nature interest groups have been conducting outreach activities targeted at the community. These include guided walks, seminars, workshops, exhibitions and competitions to engage the public and increase appreciation of biodiversity among Singaporeans. Guided walks at many natural areas such as Nature Reserves and the Sisters’ Islands Marine Park are available for both adults and children to get closer to nature. The demand for tours is high, especially for the Sisters’ Islands Marine Park where the available slots are filled within minutes of opening the registration for tours.

The public can also participate in biodiversity-related seminars and educational workshops conducted by NParks or interest groups such as NSS, Cicada Tree Eco-place and The Leafmonkey Workshop among others. One such event is the Biodiversity of Singapore Symposium (BoSS) which was first started in 2003 and has taken place every four years since. Organised by LKCNHM and NParks, the symposium is open to the public and invites speakers working on various aspects of biodiversity to showcase their work to the public and hopefully inspire others to go into biodiversity research or work on conservation.

Community in Nature:

Launched in September 2011, the Community in Nature (CIN) initiative is an NParks initiated movement to engage different groups in the community to conserve Singapore's biodiversity. The objectives of the initiative are:

- To connect, educate and inspire diverse communities to actively conserve and celebrate Singapore's natural heritage.
- To nurture and form partnerships to achieve better biodiversity and social outcomes.

CIN brings together all of NParks' nature-related events, activities and programmes under a single umbrella. These activities all have sound science, ecological knowledge and a passion for nature as their bases. The groups that NParks hopes to engage include educational and research institutions, private sector companies, NGOs, government agencies, families and passionate individuals.

A large number of the programmes under CIN rely heavily on volunteer efforts. For example, events such as FOB (see section 3.2.4.1 below) have volunteers as the majority of the exhibitors; scientific surveys such as the CMBS (see section 2.2) and the monitoring conducted by TeamSeaGrass are almost exclusively conducted by volunteers; and guided walks are also conducted by various teams of volunteers such as Ecolife by the River Plains.

CIN strives to engage the community at various levels, from outreach to individuals who are unaware of local biodiversity, to participants at events or programmes who are keen on contributing their efforts to local biodiversity. Additionally, CIN engages volunteers not only to help run the programmes, but to develop volunteer leaders that will champion such programmes.

3.2.4.1 Events and Exhibitions

Festival of Biodiversity:

The annual Festival of Biodiversity (FOB) is conducted as a flagship outreach event inaugurated in 2012 by Singapore's President Tony Tan Keng Yam. It is an annual signature community outreach event organised by NParks in collaboration with the Biodiversity Roundtable (a group comprising local NGOs involved in local biodiversity issues, see section 3.2.5.1) for the conservation of Singapore's natural heritage.

The Festival's main aim is to communicate the importance of biodiversity and its conservation to the members of the public that are least likely to have contact with it, in a setting that maximises exposure to the target demographic. It brings together government, private sector, academia and nature interest groups to showcase native biodiversity over the course of one weekend every year. The two-day event typically involves approximately 100 volunteers from about 40 partner organisations comprising nature groups, biodiversity experts, schools, corporate organisations and government agencies, each contributing to the Festival's programme and exhibits.

The biodiversity community also takes the opportunity to launch and profile their new biodiversity mobile applications, exhibitions and books to the public during the Festival. In addition to exhibits that highlight the biodiversity that exists locally, various activities are organised throughout the day

that appeal to different audiences. For example, storytelling and children's activities such as animal themed face painting or clay workshops are conducted for the younger visitors, or more serious biodiversity talks for the other age groups. The Biodiversity Passport, which involves participants going on a treasure hunt for information on various native species, is an activity that might appeal to slightly older children.

In addition to this, each year at the Festival, NParks puts together and launches an informative and interactive exhibition based on the current year's theme for CBD's International Day for Biological Diversity to enhance local understanding of biodiversity issues. This educational exhibition is subsequently showcased at various heartland areas in Singapore to further reach out and spread the message to people who might not be familiar with local biodiversity.

Exhibitions:

Exhibitions such as the "Forests, People, Environment" held in 2011 at the Singapore Botanic Gardens highlight the rich biodiversity found in forests, their importance to people, and their relevance in the Singapore context. In the same year, the exhibit "A Decade of Biodiversity Conservation and Discoveries in Singapore" showcased the amazing discoveries of flora and fauna in Singapore over the last 10 years.

Nature photography competitions are also popular, like the City in a Garden photography competition in 2012 and the BiodiverCity photo competition in 2010, where the winning entries were showcased in exhibitions such as the Singapore Garden Festival and the Festival of Biodiversity.

3.2.4.2 Programmes

Community in Bloom programme:

The NParks Community in Bloom (CIB) programme is a nationwide gardening movement which began in 2005. Today, CIB has over 800 community gardens engaging more than 20,000 garden enthusiasts and residents. They can be found across the nation; from residential neighbourhoods and schools to companies, hospitals and organisations, attracting people of all backgrounds and ages from pre-school children to senior citizens to share a common hobby of gardening and to foster community spirit.

This initiative was borne out a desire to include citizens as partners in the government's greening efforts. It was envisioned that through the cultivation of a gardening culture among the people, public and private sectors, a greater sense of ownership of our City in a Garden would emerge.

Today, community gardens also play a vital role of creating green communal spaces for people to bond with the wider community while connecting with nature. In addition to sowing edible crops, gardeners also grow flowering plants and even biodiversity attracting plants. Native birds and butterflies are becoming an increasingly common sight in the neighbourhoods, and residents are able to enjoy the sights and sounds of nature right at their doorsteps.

The CIB programme holds a biennial award ceremony to further encourage community gardeners to improve their standards and promote the gardening culture. Notably, environmental quality and biodiversity is one of the three criteria used in the judging; the others are community involvement and garden quality respectively.

A good example of a biodiversity garden is the CIB garden in Seletar Country Club. Located next to Lower Seletar Reservoir, the Club boasts rich biodiversity: it is home to 89 species of butterflies, 80 species of resident and migratory birds and over 100 species of moths. Some of the butterfly species sometimes seen in the Club are seldom found elsewhere in Singapore such as the pointed ciliate blue, conjoined swift and chocolate albatross.

The CIB garden in Metta Welfare Association is another example of a community garden rich in biodiversity. Located in the heartlands, the gardeners tend to over 200 species of shrubs and trees attracting 42 different species of birds, butterflies and other insects.

Greening Schools for Biodiversity:

The Greening Schools for Biodiversity programme was launched in July 2013, with 22 schools participating in the pilot phase. Open to all primary schools, secondary schools and junior colleges, the programme involves targeted planting of bird-, butterfly-, and dragonfly-attracting plants guided by results from biodiversity audits conducted by students. Not only are habitats for animals created in schools, bringing students and teachers closer to nature, the resulting network also has the potential to act as linkages for wildlife movement between nature areas.

The programme incorporates a training workshop to give students an appreciation of nature in Singapore and teaches them about biological classification. The students then conduct the first biodiversity audit to gather baseline data, which focusses mainly on flora. Three more audits are carried out throughout the year, focusing on fauna. Aids such as identification charts and biodiversity apps supplement students' learning about the flora and fauna within their school grounds, and on the broader scale, the biodiversity of Singapore.

Another big component of the programme is outreach. Students conceive and implement outreach efforts to increase appreciation and raise awareness of biodiversity in their school grounds among their peers and beyond.

The process of teaching students about biodiversity and having them take ownership of scientific data through self-collection is very much in tune with the objectives of citizen science. In time to come, as more schools join the programme, the collective data obtained will be an invaluable resource in learning about Singapore's urban biodiversity – such as trends in species richness in different parts of the island – from the understudied green pockets that schools almost always encompass.

Other initiatives in schools:

The "Every Child a Seed" programme was started in 2013 to enable pupils nationwide to commemorate 50 Years of Greening Singapore. This programme seeks to provide children with an

opportunity to grow their very own plant, and experience the joy of seeing their plants grow. Through this, it is hoped that the pupils learn that every Singaporean plays a part in shaping Singapore as a City in a Garden. Since 2013, NParks has distributed 40,000 plant starter kits to 200 schools annually. This has met with strong enthusiasm from school leaders, teachers and students.

The "Special projects to Understand Nature" (SUN) Club programme, sponsored by Singapore Press Holdings (SPH) Foundation and initiated by NParks is a nature appreciation programme launched in 2006 for special needs children. The SUN Club programme is founded on the idea of 'nature for everyone' and aims to bring nature appreciation to special needs students through tailor-made projects in nature areas.

Singapore schools are also participating in the Green Wave, a global biodiversity campaign held yearly on 22 May. The Green Wave was initiated by the Secretariat of the CBD (SCBD) to encourage students and youths to appreciate the value of biodiversity and the importance of protecting our natural environment. It is a yearly event held on 22 May to commemorate the International Day for Biological Diversity through planting trees. In 2013, 186 schools in Singapore participated with 91 of them participating for the first time, and 254 schools participated in 2014.

The National University of Singapore (NUS) and the Singapore Technologies Endowment Programme (STEP) initiated the STEP-NUS Sunburst Environment Programme in the hopes of nurturing future leaders in protecting the environment (NUS, 2013). This annual event brings together students from Singapore, the Association of Southeast Asian Nations (ASEAN), India and China to discuss and understand environmental issues (including biodiversity conservation) from the perspective of different countries, and share ideas on how to protect the environment. Students will also participate in workshops and environmental study visits, including nature walks conducted by NUS staff at the Sungei Buloh Wetland Reserve (SBWR) and BTNR, as well as a visit to TMSI's laboratory facilities on St John's Island.

Civil society efforts:

Numerous civil society groups such as NUS Toddycats!, NSS and WRS among others have also been active in conducting public awareness and outreach programmes in Singapore. Toddycats!, the volunteer arm of the Lee Kong Chian Natural History Museum (LKCNHM) has been coordinating International Coastal Cleanup Singapore (ICCS). This movement collects data while clearing trash along the coastline of Singapore in an annual coordinated island-wide event. For the past two decades, ICCS had an average annual participation of 1,500 volunteers from schools, government agencies, private organisations and corporate entities, making it one of Singapore's largest environmental conservation programmes. The clean ups involve an enhanced educational programme as facilitators are taught to conduct pre-cleanup briefings and post-cleanup briefings to help volunteers better relate how each person's choice can affect the trash found in oceans and make them more appreciative of unspoiled natural habitats (ICCS, undated).

NSS is the largest NGO concerned with nature conservation in Singapore. It has a membership of 1,500 with numerous sub-groups, including those concerned with birds and bird ecology, butterflies, conservation, education, marine conservation, plants and vertebrates (Khor, 2009). NSS organises

regular talks, surveys and walks which are open to the public. Its talks are well attended and cover a wide range of topics related to the biodiversity of Singapore. In 2014, NSS engaged with over 2,900 members of the public.

Biodiversity interest groups such as Toddycats!, NSS, Animal Concerns Research & Education Society (ACRES), Naked Hermit Crabs, Cicada Tree Eco-Place and Youth for Ecology have played important roles in spreading the word about nature conservation. In 2014, these groups were able to reach out to more than 22,000 people through various events, workshops and surveys. (Lai, J., 2015, pers. comm. 29 April)

Wildlife Reserves Singapore (WRS) is the holding company of several award-winning attractions: Jurong Bird Park, Night Safari, River Safari and Singapore Zoo. WRS is dedicated to fostering conservation and research while educating visitors about animals and their habitats through its WRS Living Classrooms concept which comprises interactive activities such as enrichment programmes for schools. With millions of visitors to its attractions each year, WRS hopes to create memorable wildlife experiences that inspire in their visitors a love and respect for nature.

TeamSeaGrass is another biodiversity interest group that engages the public through volunteer work. TeamSeaGrass is a collaboration that started in 2007 between NParks and the international Seagrass-Watch, the largest scientific, non-destructive, seagrass assessment and monitoring programme in the world. TeamSeaGrass surveys seagrass habitats on Singapore shores and conducts outreach efforts through public exhibitions. Even though a small team is sufficient to manage the monitoring, they decided to establish a volunteer base to give them an opportunity to experience first-hand Singapore's shores and contribute to Singapore's biodiversity conservation efforts. Currently, TeamSeaGrass has about 200 volunteers that regularly monitor the seagrass on Singapore shores.

Involving volunteers:

The NParks volunteer network started in early 1990s with 50 people but has now grown to more than 1,000 volunteers. The volunteers can choose from a wide range of activities, including leading outreach and education programmes, conducting guided walks and tours, and participating in conservation programmes or surveys, such as the recent Comprehensive Marine Biodiversity Survey (CMBS).

Volunteer opportunities are available at Singapore's various biodiversity interest groups, in the form of helping with daily operations, conducting research surveys, fund raising or outreach efforts. The Blue Water Volunteers (BWV) is an NGO that focusses on marine conservation. It seeks to raise awareness of local marine habitats and complement research activities. BWV carries out its volunteer-based work through four main programmes: ReefFriends, ReefWalk, ReefTalk and ReefExhibits. In ReefFriends, trained volunteer divers conduct surveys while non-divers can help out in the other three programmes: ReefWalk is an intertidal programme to conduct free guided tours for the public at Kusu Island; ReefTalks are seminars and talks held by marine experts and conservationists to engage members of the public on marine and biodiversity conservation issues; ReefExhibits showcases exhibition panels done up by BWV at various event booths to raise awareness on marine issues.

Toddycats! also offers many avenues for the public to contribute to biodiversity conservation, such as through ICCS (see pg 33), as museum guides, through project management and also supporting roles for their various programmes such as nature walks, talks and public exhibitions. Another example is ACRES, an animal protection organisation that focuses on wildlife trade investigation, rescue and rehabilitation, education and outreach. Volunteer opportunities are available in terms of caring for the rescued animals, carrying out rescues and fund raising. The Jane Goodall Institute (Singapore) also has its Roots & Shoots programme which is a collaboration with schools and community groups to develop projects to better protect Singapore's distinct environment.

Other activities:

The Ministry of Education (MOE) rolled out the Programme for Active Learning (PAL) in 2011 for primary schools. As part of this initiative, NParks developed Kids for Nature, a programme for lower primary school students which consists of outdoor activities to cultivate a sense of ownership for the environment, and to encourage and provide opportunities for pupils to take action to sustain Singapore as a City in a Garden. Some 5,600 pupils from 14 schools took part in 2013, an increase from 4,200 in 2011. In addition, MOE and NParks have collaborated in various other nature education programmes for children of different ages as listed in the following table.

Table 8: Ongoing educational programmes (Teo, 2011)

Name of Programme	Target age	Description
Young Nature Explorers	Children aged 5-6	This programme encourages children to use their five senses to learn more about nature and is conducted in partnership with the MOE's Preschool Branch.
HeART for Nature	Children aged 4-7	The programme introduces pupils to different aspects of rainforest habitats (MOE, 2010) in Singapore and explores the wonders of nature through art.
Nature Keepers	Children aged 8-12	This programme aims to build the students' knowledge of our native biodiversity.

Another education initiative, Ecolife by the River Plains, was launched in 2013 for primary and secondary students, and it received good response: within two months of its launch, 700 students from five schools had taken part in the initiative, which was aimed at encouraging students to explore the flora and fauna at Bishan-Ang Mo Kio Park.

NParks is also working with MOE to share information on flora and fauna to be included in school textbooks and assessment books, including field-based training to encourage teachers to use parks and gardens for social studies lessons. NParks also participated in about 50 roadshows, exhibitions and school assembly talks in 2013 to reach out to more than 37,000 students and educators.

In addition to long-term programmes, students also get the opportunity to learn about biodiversity through competitions and project grants offered. The Singapore Geospatial Challenge 2013 was organised by the Singapore Land Authority (SLA) in partnership with NParks to raise awareness of Singapore's rich historical and green heritage through the use of Geospatial Information Systems

and Technology (GIST). 350 students from 40 secondary schools and institutions participated. The Singapore Geospatial Challenge is held yearly and involves different themes each year to encourage schools to use GIST to analyse environmental data from parks. Another initiative is the NSS Little Green Dot student research grant, which offers grants for secondary school and pre-university students to encourage them to learn about the environment through direct study and discovery.

Technological outreach:

With technological advances, new avenues for biodiversity outreach have arisen in the form of social media. In Singapore, there have been many blogs coming up such as the popular "Wild Singapore" website (http://www.wildsingapore.com) which was created by Ria Tan, a nature enthusiast, to provide a one-stop resource portal for Singaporeans who want to learn more about local nature areas and do more for them. Since it went online in 2007, "Wild Singapore" has attracted nearly 800,000 visitors in total, with 2,000 to 15,000 unique visitors each month.

In recent years, more Singaporeans are blogging about nature and environmental issues or have set up websites focussed on nature photography in local habitats, which can be taken as a sign of growing awareness for nature conservation. Blogs such as The Annotated Budak (http://budak.blogs.com/), Nature in a Concrete Jungle (https://ourlittleurbaneden.wordpress.com/) and Psychedelic Nature (http://psychedelic-nature.blogspot.sg/) have all greatly increased the profile of local biodiversity in the public eye. Nature photography is another good tool to showcase local biodiversity to large parts of the population that would be unlikely to visit natural areas. The Nature Photographic Society, Singapore is an organisation that features local flora and fauna very prominently. ClubSNAP is a local photography community that has a forum dedicated to nature photography (http://www.clubsnap.com), and some individuals are also very actively involved in photographing and identifying animals in local habitats such as Nicky Bay (http://sgmacro.blogspot.sg/). The NParks Facebook page and Twitter account are also well read with 54,000 likes and 10,200 followers respectively. This trend shows that not only are ordinary Singaporeans taking a deeper interest in our natural heritage, they are also building a community of people who care about and act on these issues.

NParks has also been collaborating and releasing technological tools to help Singaporeans better appreciate nature. One of the tools developed specifically to monitor biodiversity is the SGBioAtlas mobile application, a citizen science-based application for everyone to share their sightings of local flora and fauna. It uses crowd-sourced information to map the distribution of biodiversity throughout Singapore. All uploaded sightings which have been verified are then plotted on an atlas in NParks' online database, BIOME (see section 3.2.3). The application also comes with photo identification guides on commonly seen fauna such as birds, butterflies, dragonflies and amphibians.

Other mobile applications such as sParks have been designed for the public to access information on local parks, gardens and Nature Reserves. There is also the Singapore Botanic Gardens navigator mobile application that helps visitors to find their way around the 74 ha grounds; and a Healing Garden mobile application that allows visitors to have self-guided tours and provides information and images of plants used as traditional cures and remedies.

The NParks Flora & Fauna Web is a one-stop information website for all who are interested in plants and animals in Singapore, featuring cultivated and native plants as well as a variety of animal life in Singapore. The portal is updated regularly with new photos and information such as species conservation status, to cater to the growing horticultural interest and wildlife awareness in Singapore.

3.2.5 Strategy 5: Strengthen partnerships with all stakeholders and promote international collaboration

3.2.5.1 National collaborations

Corporate partnerships:

The Garden City Fund (GCF) is a registered charity managed by NParks. The GCF provides a platform for organisations and individuals to be involved in conservation, research, outreach and education initiatives. Corporate sponsors can contribute and support biodiversity related projects not only financially but also hands-on as volunteers to the projects. Higlighted below are some examples of biodiversity related corporate partnerships.

The SPH Walk of Giants in the Singapore Botanic Gardens is an elevated boardwalk that will bring visitors close to mature trees and new forest emergent species that will be planted as part of the Gardens' botanical and conservation collection. Made possible through support from the Singapore Press Holdings (SPH), it will give visitors an unobstructed view of the forest floor, mid-forest level and canopy. Key attractions that can be enjoyed from this boardwalk include views of the fissured trunks and fragrant flowers of the giant Tembusu, and crown shyness of the Kapur.

Visitors to the Southern Ridges can learn more about a special collection of giant trees native to the region. Named the Sembcorp Forest of Giants in appreciation of the donation from Sembcorp Industries, the arboretum - a living gallery of trees for education and research, is part of NParks' initiative to enhance biodiversity within urban areas. The Sembcorp Forest of Giants collection comprises trees that originally dominated our regional landscape before the advent of urbanisation. Some of the species selected for the collection can attain heights of over 80 m in the wild.

The Singing Forest is a bird-friendly forest using trees sponsored by STMicroelectronics. The Singing Forest project aims to intensify the already high diversity of native bird species in the Southern Ridges. Care has been taken to select native tree species from four botanical families that will provide a wide variety of suitable food sources as well as shelter and nesting areas for native birds. When established, the additional planting of suitable tree species will eventually provide an opportunity for visitors to learn about and appreciate the diversity of birds and trees in Singapore.

The Hongkong and Shanghai Banking Corporation (HSBC) has been a long-time supporter of greening and biodiversity initiatives in Singapore, and has supported numerous projects such as the HSBC Tree Top Walk in the CCNR, the Ubin and HSBC volunteer hub on Pulau Ubin, NParks' Heritage Tree Scheme, and the Comprehensive Survey of BTNR. HSBC also sponsors the annual National Youth Achievement Awards (NYAA) Youth Environmental Award, which gives recognition to youth that have contributed actively towards environmental protection and nature conservation in Singapore.

In addition to monetary contribution, HSBC staff volunteers have dedicated their time, immersed in the forest and marine environment of Singapore to document and monitor our flora and fauna for various surveys such as the Climate Change Partnership at CCNR, CMBS (see section 2.2), Comprehensive Survey of BTNR, and tree planting activities.

Nature Nurtures is a successful ongoing mentorship programme for secondary school students sponsored by Shell. The programme brings mentors and mentees on a journey of discovery through nature-based activities. The programme aims to motivate teens to contribute positively to society, through skills that physically and mentally challenge them, and activities that are based on confidence and team building in a natural setting. Students have participated in various activities such as archery, coastal clean-ups, mangrove salvaging and water parameter testing.

Initiated in 2014, the Marine Eco-toxicity Biomonitoring Programme aims to monitor the levels of eco-toxicity in the coastal areas in Singapore using physiological, behavioural and DNA tests on green mussels (*Perna viridis*) and other coastal organisms. Changes in these parameters over time will indicate changes to the water conditions, and hopefully serve as a warning system for pollutants and contamination. This biomonitoring programme is sponsored by Kosé Singapore and done in partnership with various schools around Singapore. It is facilitated by trainers from the National Institute of Education (NIE) and NParks for both lab and field components. Students will thus be able to participate in active research, learn more about the marine environment in Singapore, and contribute towards the protection of vulnerable coastal habitats.

Led by NParks, and supported by partners from various tertiary institutions, non-governmental organisations and individual enthusiasts, the CMBS (see section 2.2) is sponsored by Asia Pacific Breweries Singapore, Care-for-Nature Trust Fund, Keppel Care Foundation, Shell Companies in Singapore and The Air Liquide Group.

The Festival of Biodiversity (see section 3.2.4.1) is a celebration of the community's efforts to conserve Singapore's natural heritage, to educate and enthuse the general public to be more proactive in conserving biodiversity. Sponsors included Kingsmen, VivoCity, IKEA and Toshiba.

Over the years, Garden City Fund and NParks have also received strong recurring support from various companies, such as Ricoh Asia Pacific, Shimizu Corporation, the Association of Banks in Singapore (ABS), and Panasonic Asia Pacific (Panasonic) in support of biodiversity initiatives such as tree planting efforts. Panasonic also worked with NParks on a mangrove biodiversity monitoring study in Pasir Ris Park's mangrove forest.

Biodiversity Roundtable of Singapore:

The Biodiversity Roundtable of Singapore is a collaboration between NUS and NParks that gathers representatives from academia, schools, nature interest groups, government and other stakeholders in regular meetings to discuss current topics of interest to the biodiversity community. The Roundtable is also responsible for the organisation of the Festival of Biodiversity (see section 3.2.4.1) and the Biodiversity of Singapore Symposium (see section 3.2.4).

Freshwater crab conservation working group:

The Singapore freshwater crab (*Johora singaporensis*) is endemic to Singapore and has been listed as critically endangered by the IUCN as well as being among the top 100 most threatened species worldwide. In March 2014, NParks, NUS, WRS, IUCN, members of other government agencies and NGOs convened at the Freshwater Crab Conservation Roundtable meeting to develop an overall species conservation strategy for this endemic species. A working group was set up consisting of NParks, NUS and WRS, which aims to follow up on the strategies developed and update the roundtable subsequently (Ng et al., 2015).

3.2.5.2 Regional collaborations

Biodiversity conservation requires concerted actions at the different levels: national, regional and international. As a responsible global citizen, Singapore participates in key biodiversity-related regional and international fora, and fosters strategic partnerships with regional and international organisations to facilitate collaboration on the conservation of biodiversity across national boundaries and share our experience and expertise on urban biodiversity conservation.

Association of Southeast Asian Nations (ASEAN):

Singapore is a member state of ASEAN, and participates in various ASEAN Working Groups under the ASEAN Cooperation on Environment, such as the ASEAN Working Group on Nature Conservation and Biodiversity (AWGNCB), ASEAN Working Group on Coastal and Marine Environment (AWGCME) and the ASEAN Working Group on Environmentally Sustainable Cities (AWGESC). As part of the commitment to these Working Groups, Singapore hosted the AWGESC in 2013, the AWGNCB in 2014, and the AWGCME in 2015. These working groups provide a formal platform to share Singapore's experiences and knowledge on urban biodiversity conservation, as well as for exploring regional cooperation on other issues. Singapore has and continues to promote some areas of expertise such as IUCM (see section 3.2.2) and the application of the Singapore Index on Cities' Biodiversity (SI, see section 4.1) to ASEAN Member States (AMS).

Under the ASEAN Declaration on Heritage Parks and Reserves, AMS agreed to participate in the ASEAN Heritage Parks (AHPs) programme in order to generate greater awareness and appreciation for the conservation of ASEAN's rich natural heritage through a regional network of representative protected areas, and to generate greater collaboration between AMS in preserving their shared natural heritage (ASEAN Centre for Biodiversity, 2010). The AHPs are protected areas of high conservation importance within the ten AMS. Singapore currently has two AHPs: Sungei Buloh Wetland Reserve (SBWR) and BTNR. SBWR was designated as Singapore's first AHP in 2003 and it is also known as a site of international importance for migratory birds that stop over to feed along their annual migration routes. BTNR was designated an AHP on 18 October 2011.

ASEAN Centre for Biodiversity (ACB):

Singapore has worked closely with the ACB since its inception in 2005 for various programmes or events as well as being an active participant at ACB organised workshops, courses and events.

NParks is a regular contributor of articles to the ASEAN Biodiversity Magazine and provides inputs to various ACB publications, for example, the ASEAN Biodiversity Outlook, which is a flagship publication of the ACB.

Singapore also co-organises events and workshops with ACB, such as the inaugural ASEAN Conference on Biodiversity in 2009, two ASEAN workshops on the Singapore Index in 2010 and 2014, the Asia-Pacific Regional Consultation and Capacity-building Workshop on REDD+ in Developing Countries in March 2011 and 4 other events in 2009: the 5th International Hornbill Conference, ASEAN Workshop on the United Nations Convention on Law of the Sea and Marine Biodiversity, Sub-regional Capacity Building Workshop on Forest Biodiversity and Climate Change and the ASEAN Wetland Management Training Course.

Agreement between the Governments of the Member States of ASEAN and the Republic of Korea on Forest Cooperation (AFoCo):

Singapore has been a member to the "Agreement between the Governments of the Member States of ASEAN and the Republic of Korea on Forest Cooperation" or AFoCo Agreement since it entered into force in August 2012. The two-year agreement was extended in August 2014 for a further two years. The main focus of this agreement is to facilitate forest-related cooperative projects among AMS and the Republic of Korea in the context of reducing deforestation, forest degradation as well as the sustainable management of forests. NParks, through the National Biodiversity Centre (NBC), serves as the focal and implementing agency for Singapore for any activities under this agreement.

Through the agreement, capacity-building sessions for the member countries were undertaken. Training session on the use of geographic information system for forest management, seed nursery management and forest pest management are just some examples of activities that have been provided to member countries. Exchange programmes including a fellowship with the Secretariat of the agreement provides opportunities for officials from ASEAN countries to experience working in an international network.

PEMSEA on Integrated Urban Coastal Management:

Singapore has been working with the Partnerships in the Environmental Management for the Seas of East Asia (PEMSEA) since 2009 to develop an Integrated Urban Coastal Management (IUCM) framework, a proactive planning and management framework for sustainable development of the marine and coastal areas within an urban context (see section 3.2.2 on IUCM).

On 18 November 2013, Singapore and PEMSEA signed a Memorandum of Understanding (MOU) to establish Singapore as a PEMSEA Regional IUCM Demonstration Site and Learning Centre. By signing the MOU, Singapore is recognised internationally as a positive example in integrated coastal management. Experiences and best practices in Singapore's IUCM implementation will be showcased and disseminated within the Seas of East Asia and beyond.

3.2.5.3 International collaborations

Secretariat of the Convention on Biological Diversity (SCBD):

Singapore works with the SCBD on various initiatives. NParks has been in partnership with the SCBD to develop the indicators of the Singapore Index on Cities' Biodiversity (SI) since it was first proposed in 2008. NParks and the SCBD led the Technical Task Force that developed the SI and co-organised the three expert workshops that were conducted in Singapore. SCBD has been instrumental in promoting the use of the SI by cities worldwide.

Singapore has been involved in the Global Partnership on Local and Subnational Action for Biodiversity since its inception in 2008. Facilitated by the SCBD, the Global Partnership is a network of relevant UN organisations and scientific networks, key individual cities and partners working collaboratively to promote the cities and their biodiversity agenda. In addition to the SCBD, other prominent members of the Global Partnership include ICLEI's Cities Biodiversity Centre (CBC), the Urban Biodiversity and Design (URBIO) network and the Stockholm Resilience Centre. Singapore works closely with the Global Partnership as well as these partner organisations to promote the application of the SI by cities.

The Singapore Botanic Gardens is a member of the Consortium of Scientific Partners (CSP) that is a network of scientific institutions facilitated by the SCBD. The purpose of the CSP is to allow SCBD to leverage the expertise and experience of these institutions in the implementation of the CBD Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets.

In 2013, the Singapore Botanic Gardens co-hosted a regional workshop on reflecting the Global Strategy on Plant Conservation in NBSAPs together with the SCBD and the Botanic Gardens Conservation International.

CHAPTER 4:

PROGRESS TOWARDS THE 2020 AICHI BIODIVERSITY TARGETS

Singapore has been making great efforts in biodiversity conservation under the framework of the NBSAP, which was developed in 2009. The purpose of this chapter is to take stock of Singapore's efforts in this area vis-a-vis the implementation of the Strategic Plan of Action for Biodiversity 2011-2020 and the achievement of Aichi Biodiversity Targets. In addition, Singapore, as a city-state, is also able to take stock of her biodiversity conservation efforts as a city. Thus, where relevant, the assessment of Singapore's contribution towards the Aichi Biodiversity Targets will be made using the SI.

4.1 The Singapore Index on Cities' Biodiversity

In 2008, Singapore initiated the development of an index that was specifically designed to benchmark conservation efforts at the city level – the Singapore Index on Cities' Biodiversity or Singapore Index (SI, then known as the City Biodiversity Index or CBI). The SI was developed by an international Technical Task Force, led by the SCBD, and has been applied by numerous cities worldwide in order to measure their progress in biodiversity conservation. The SI provides a quantitative framework with which national governments are able to easily consolidate and obtain a broad overview of the efforts made by their cities.

The SI is divided into two parts: Part I documents the profile of the city, and provides the context for the application (e.g. climate, location, size etc.); Part II details the 23 indicators that make up the index and is comprised of three parts: Native Biodiversity in the City (ten indicators), Ecosystem Services (four indicators), and Governance and Management of Biodiversity (nine indicators). Each indicator has a maximum score of four points, and cities can score up to a total of 92 points for all 23 indicators. As the SI is intended as a self-assessment tool, some of the indicators are designed in such a way that a score can only be obtained from the second application onwards, by calculating with respect to the baseline or first year of application. The results are typically not comparable amongst cities.

4.1.1 Singapore's score for the SI

Singapore first applied the SI in 2010, and this establishes the baseline for Singapore's future applications of the SI. Singapore applied 18 out of 23 indicators and obtained a score of 55 out of 72 points (76%). The five indicators that were not applied were the ones where a score can only be obtained from the second application onwards.

Table 9: Breakdown of Singapore's SI scores for each component.
See Annex C for detailed scoring on each indicator.

SI component	Score
Native Biodiversity in the City	14 out of 20 points
Ecosystem Services	8 out of 16 points
Governance and Management of Biodiversity	33 out of 36 points
Total	**55 out of 72 points**

On the whole, Singapore scored well for the Governance and Management component, more so than the other two components. This could potentially be interpreted as the city making great efforts in terms of governance, however, there may be other factors such as lack of land preventing these efforts from being reflected as a higher score in the other components. Subsequent applications of the SI are planned for 2015 and would likely shed light on the contributing factors to this and allow for more targeted efforts; especially if consistent high scores in the governance component are not translated into quantifiable improvements in the other components.

Singapore's score on the SI provides a measure of the progress on current efforts in urban biodiversity conservation, and some of the indicators can be used to assess progress on the Aichi Biodiversity Targets.

4.2 Assessment of Singapore's progress towards the Aichi Biodiversity Targets

Table 10: Progress towards the Aichi Biodiversity Targets, with relevant SI indicators and scores as well as key NBSAP actions.

Legend

Assessment of Progress	
	Significant progress
	No significant progress
	Needs further improvement
	Lack information to assess progress

Aichi Biodiversity Targets	Relevant SI Indicators and Singapore's score (baseline year, 2010)	Relevant NBSAP Strategy and Key Actions	Progress
Target 1: By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	Indicator 14: Number of formal education visits per child below 16: 0.01, 0 points. Indicator 20: Existence of formal or informal public consultation process: routine consultation process exists (e.g.: URA Master Plan public consultation), 4 points. Indicator 21: Number of organisations with which the city is in partnership: 66, 4 points. Indicator 22: Biodiversity or elements of it are included in the school curriculum, 4 points. Indicator 23: Number of outreach or public awareness events held in the city per year: 1340, 4 points.	Strategy 4 - Enhance Education and Public Awareness Numerous efforts being made to reach out to the public. Some examples include: • Community in Nature • Festival of Biodiversity • Biodiversity related exhibitions • Nature photography competitions • Greening Schools for Biodiversity • SUN Club • Every Child a Seed • Green Wave • Kids for Nature programme • Volunteer programmes • TeamSeaGrass • International Coastal Cleanup Singapore • Community in Bloom programme • Websites, Nature Blogs and mobile applications • STEP-NUS Sunburst Environment Programme • Singapore Geospatial Challenge	
Target 2: By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and	Indicator 17: Existence of Local Biodiversity Strategy and Action Plan: Singapore's NBSAP, 4 points. Indicator 18: Institutional capacity: number of biodiversity related functions: 7, 4 points.	Strategy 2 - Consider Biodiversity issues in Policy and Decision-making: • City in a Garden vision recognised at the highest levels. • Land use planning takes biodiversity into	

planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.	Indicator 19: Institutional capacity: number of agencies involved in inter-agency co-operation: 10, 4 points. Indicator 20: Existence of formal or informal public consultation process: routine consultation process exists (e.g.: URA Master Plan public consultation), 4 points.	consideration; designation of two new Nature Areas and the Sisters' Islands Marine Park • The Sustainable Singapore Blueprint 2015 incorporates elements of biodiversity, and the targets for 2030 have biodiversity elements as well. • Administrative processes are in place for Environmental Impact Assessment (EIA)/Biodiversity Impact Assessment (BIA) required for development works near Nature Areas. • Access and benefit sharing processes for non-commercial research is well established, policy for commercial research being reviewed.	
Target 3: By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio-	Singapore does not provide any incentives and subsidies that could have harmful impact to biodiversity.		

economic conditions.			
Target 4: By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within ecological limits.	Indicator 21: Number of organisations with which the city is in partnership: 66, 4 points.	Strategy 2 - Consider Biodiversity Issues in Policy and Decision-making Singapore does not extract natural resources for commercial production, and our main role is as a consumer or transportation hub in the supply chain. Majority of efforts towards sustainable consumption are in the areas of recycling and energy use. Tentative steps have been made towards engaging with the business community in assessing the sustainability of business practices.	
Target 5: By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.	Indicator 1: Proportion of natural areas: 29%, 4 points Indicator 2: Connectivity measures - mean mesh size: 1599Ha, 4 points.	Strategy 1 - Safeguard Our Biodiversity Numerous measures have been taken to maintain natural areas and to increase habitat connectivity. For example: • Addition of two new Nature Areas and the Sisters' Islands Marine Park • Measures to improve habitat connectivity, such as Eco-Link@BKE, Nature Ways, RIR, PCN, Rail Corridor • Reforestation efforts at Nature Reserves • Habitat enhancement in parks such as Bishan-Ang Mo Kio Park, Tampines Eco Green, Sungei Pandan and Pulau Ubin • Oil spill response procedures to protect coastal habitats from oil spills	

Target 6: By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.	Not relevant for Singapore as commercial fishing is not a major sector in Singapore. We have measures in place to combat illegal, unreported and unregulated (IUU) fishing, such as prohibiting the entry of IUU fishing vessels and inspecting fishing vessels.
Target 7: By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	Not relevant for Singapore. Singapore has limited agriculture and aquaculture, and no forestry sector.
Target 8: By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem	Minimal impact in Singapore. Farming is not a major sector in Singapore. Excess nutrients from farms or industrial waste leaching into habitats are not significant, or are managed through strict regulations. Impact from pollution to native habitats is relatively minimal, barring occasional unusual situations such as oil spills, where administrative procedures are in place to prevent or mitigate impact.

function and biodiversity.			
Target 9: By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.	Indicator 10: Proportion of Invasive Alien Species (birds): 3%, 3 points.	Strategy 1 - Safeguard Our Biodiversity Various IAS are present in Singapore, but have yet to demonstrate significant impact to biodiversity. Initial steps have been taken to identify species and pathways, with some limited attempts at control measures within Nature Reserves.	
Target 10: By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.	Indicator 7: Change in number of hard coral species: 255 hard coral species, currently no SI score (baseline data).	Strategy 1 - Safeguard Our Biodiversity Various species conservation and recovery programmes are in place, such as the giant clam restocking project. Singapore designated our first Marine Park in 2014, the Sisters' Islands Marine Park, which is intended to protect marine habitats and act as a protected area for species conservation programmes. Singapore also developed the Integrated Urban Coastal Management framework together with PEMSEA to encourage sustainable development of the coastal environment within an urban context. Oil spill response procedures are in place to protect coastal habitats from oil spills	
Target 11: By 2020, at least 17 per cent of terrestrial and	Indicator 1: Proportion of natural areas: 29%, 4 points.	NParks' Nature Conservation Master Plan includes a Physical Plan that will help in management of areas with	

inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider land-scape and seascapes.	Indicator 2: Connectivity measures - mean mesh size: 1599Ha, 4 points. Indicator 9: Proportion of protected natural areas: 4.7%, 1 point.	significant biodiversity Strategy 1 - Safeguard Our Biodiversity Efforts under this strategy include identification of specific sites with biodiversity significance, such as the habitat ranges of endangered animals. Other initiatives to improve the connectivity between habitats are also important in achieving this target, e.g. Eco-Link@BKE, Nature Ways, RIR, PCN and the Rail Corridor; as well as other restoration and habitat enhancement initiatives such as the Bishan-Ang Mo Kio Park stream rehabilitation and Tampines Eco-Green. Strategy 2 - Consider Biodiversity Issues in Policy and Decision-making The Sisters' Islands Marine Park is under the management of NParks and the two new Nature Areas were designated under the URA Parks and Waterbodies Plan, providing some administrative protection for these sites.	

Target 12: By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.	Indicator 1: Proportion of Natural Areas: 29%, 4 points. Indicator 2: Connectivity measures - mean mesh size: 1599Ha, 4 points. Indicator 4: Change in number of vascular plant species: 2145 native vascular plant species, currently no SI score (baseline data). Indicator 5: Change in number of bird species: 321 bird species, currently no SI score (baseline data). Indicator 6: Change in number of butterfly species: 295 butterfly species, currently no SI score (baseline data). Indicator 7: Change in number of hard coral species: 255 hard coral species, currently no SI score (baseline data). Indicator 8: Change in number of freshwater fish species: 34 fish species, currently no SI score (baseline data). Indicator 9: Proportion of protected natural areas: 4.7%, 1 point.	Under the Species Recovery programmatic plan of NParks' Nature Conservation Master Plan, threatened species are identified and prioritised based on endemism, conservation status and habitat range. This will help to guide actions towards increasing populations of the species identified. Strategy 1 - Safeguard Our Biodiversity Various species conservation and recovery programmes are in place: • Giant clam restocking programme • Freshwater crab conservation working group, for the Singapore freshwater crab (*Johora singaporensis*) • Rare native plant propagation and reintroduction	

Target 13: By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.	Not relevant for Singapore. Plant cultivation and farming are not major sectors in Singapore.		
Target 14: By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.	Indicator 1: Proportion of Natural Areas: 29%, 4 points. Indicator 2: Connectivity measures - mean mesh size: 1599Ha, 4 points. Indicator 9: Proportion of protected natural areas: 4.7%, 1 point. Indicator 11: Regulation of Quantity of Water: 63.2%, 2 points. Indicator 12: Carbon Storage and Cooling Effect of Vegetation (extent of tree canopy cover): 31.9%, 3	Similar to Targets 5 and 11, Singapore has made great efforts to preserve native habitats intact, and to restore connectivity between patches to enhance ecosystem services. Vulnerable groups highlighted in the target are not reliant on ecosystem services for their livelihoods in Singapore.	

	points. Indicator 13: Recreational Services: Area of parks with natural areas: 0.75ha/1000 persons, 3 points.		
Target 15: By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.	Indicator 1: Proportion of Natural Areas: 29%, 4 points Indicator 2: Connectivity Measures - Mean Mesh Size: 1599Ha, 4 points. Indicator 9: Proportion of protected natural areas: 4.7%, 1 point. Indicator 12: Carbon Storage and Cooling Effect of Vegetation (extent of tree canopy cover): 31.9%, 3 points.	Report of Singapore's national communication and biennial update reporting to United Nations Framework Convention on Climate Change (UNFCCC) is currently in preparation, and will provide greater detail in this area. Strategy 1 - Safeguard Our Biodiversity Ongoing reforestation programmes at Nature Reserves not only help to improve their resilience as ecosystems by adding buffer zones to core areas, they also contribute towards sequestration of carbon. Various tree planting programmes outside of the Nature Reserves can also contribute to this target, e.g. Southwest Community Development Council (SWCDC)'s One Million Tree Planting Programme. Similarly, habitat enhancement and restoration efforts at Pulau Ubin and Tampines Eco Green would also help. Strategy 2 - Consider Biodiversity Issues in Policy and Decision-making Singapore has been very actively greening the urban infrastructure as part of the City in a Garden vision, which greatly increases the capacity of the urbanised areas to contribute to climate change mitigation.	

Target 16: By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.	No relevant SI indicator.	Strategy 2 - Consider Biodiversity Issues in Policy and Decision-making • Access and Benefit Sharing processes for non-commercial research is well established, and the policy for commercial research is currently being reviewed. • Singapore is not yet a Party to the Nagoya Protocol, but national consultations are currently ongoing to consider if Singapore should accede to the Protocol.	
Target 17: By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.	Indicator 17: Existence of Local Biodiversity Strategy and Action Plan: Singapore's NBSAP, 4 points.	Strategy 2 - Consider Biodiversity Issues in Policy and Decision-making Singapore's NBSAP is currently undergoing review and national targets are being developed, possibly to be completed before the end of 2015. In addition, NParks' Nature Conservation Master Plan is intended to support the implementation of Singapore's NBSAP.	
Target 18: By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected,	Not relevant for Singapore		

subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.			
Target 19: By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred and applied.	Indicator 18: Institutional Capacity: Number of Biodiversity Related Functions: 7, 4 points. Indicator 19: Institutional Capacity: Number of Agencies Involved in Inter-agency co-operation: 10, 4 points. Indicator 21: Number of Organisations with which the City is in partnership: 66, 4 points.	Strategy 3 - Improve Knowledge of Our Biodiversity and the Natural Environment Academic research on biodiversity in Singapore requires a permit under NParks, and one of the conditions under the permit is the submission of reports and data which is then transmitted to the relevant managing authority of each site where the studies were conducted for incorporation into their management of the site. Biodiversity related information is also collated and managed, and tools are supplied to analyse the data in order to provide timely and relevant information to policy and decision makers. Biodiversity related information is then disseminated using the various initiatives under Strategy 4 - Enhance Education and Public Awareness. Events such as the	

		Festival of Biodiversity are very useful in communicating up to date information on biodiversity to the general public.	
Target 20: By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan 2011- 2020 from all sources and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization should increase substantially from the current levels. This target will be subject to changes contingent to resources needs assessments to be developed and reported by Parties.	Not relevant for Singapore.		

4.3 Progress towards achieving the Aichi Biodiversity Targets

The preceding table provides a general assessment of Singapore's progress with respect to the Aichi Biodiversity Targets using efforts under our National Biodiversity Strategy and Action Plan as well as relevant indicators of the SI.

On the whole, Singapore has made good progress towards achieving the Aichi Biodiversity Targets, with significant progress in the majority of the targets. The unique circumstances in Singapore also create situations in which some of the Aichi Biodiversity Targets are either not relevant for Singapore, or only partially relevant. There were three targets where progress was marginal and showed room for improvement: Target 4 on sustainable production is only marginally relevant as Singapore does not extract natural resources for commercial production and can only work indirectly through businesses that administer their operations from here; Target 9 on IAS is also only partially relevant in that Singapore does not have substantial agriculture where IAS impact is typically most obviously demonstrated; and finally, Target 16 on the Nagoya Protocol is currently undergoing national consultations as to whether Singapore should become a Party.

4.4 Moving forward

Singapore has done fairly well to conserve local species and habitats - surveys have shown that the number of species has increased for numerous groups of plants and animals and many species once thought lost have been found again in local habitats. Home ranges of some rare species have expanded, and where particularly vulnerable species are identified, species recovery programmes are initiated. There have been numerous events, initiatives, projects and programmes that were carried out to achieve the objectives of Singapore's NBSAP, and in turn, contribute towards achieving the Aichi Biodiversity Targets.

In the immediate future, Singapore is currently revising its NBSAP to include national targets in line with the Aichi Biodiversity Targets, which would facilitate better tracking of our efforts on biodiversity conservation and the implementation of the Convention. Singapore will also be conducting the second application of the Singapore Index, which will provide additional perspectives on Singapore's efforts in this area. The Nature Conservation Master Plan under development will also help to guide efforts in Singapore towards implementing our NBSAP, contributing to the achievement of our national targets and the broader Aichi Biodiversity Targets.

Despite Singapore's small size, great efforts have been made in biodiversity conservation and the implementation of the Convention in Singapore. The atypical circumstances here present fairly unique opportunities for Singapore in conserving our biodiversity, such as finding new ways to enhance urban biodiversity. Singapore will continue our efforts towards ensuring that biodiversity is conserved, in order to keep Singapore as green and natural as possible in the future. These efforts contribute significantly to make Singapore a livable and sustainable city.

ANNEXES

Annex A - References for Table 2

	Taxonomic group	No. of species	Changes in number	Source	Comments
Plants and others	Vascular Plants	3604	54	Baseline: Chong et al. (2009) 21 New records: Ang et al. (2010, 2011), Neo et al. (2013, 2014), Rodda & Ang (2012a), Tan et al. (2011), Tan (2013), Yeo et. al. (2012, 2012a), NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec, NParks Plant Information Unit (2013), pers. comm. 13 Dec. 33 Rediscoveries: Ang (2010), Ang, Lok & Chong et al. (2010), Ang, Lok & Tan (2010), Ang, Lok & Yeo et al. (2010, 2011), Ang, Lok, Yeo & Angkasa et al. (2012), Ang & Yeo et al. (2012), Hassan Ibrahim et al. (2011), Lim et al. (2014), Lok et al. (2010, 2011, 2011a, 2012), Loo (2011), Rodda et al. (2012), Tan & Yeo (2012), Yam et al. (2012), Leong & Yam (2013), Yeo et al. (2013, 2013a, 2013b), Yeo, Ang & Lok (2012a, b), NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec, NParks Plant Information Unit (2013), pers. comm. 13 Dec.	Baseline of 3550 is based on Chong (2009). Only extant species were counted. Chong et al. (2009) had a total of 4192 plants recorded. Subtracting the 642 presumed extinct species gave a total of 3550 extant vascular plants.
	Algae	1054	0	Baseline: Pham et al. (2010)	
	Fungi	950	0	Baseline: Wee & Ng (1994)	
	Lichens	376	0	Baseline: Ng et al. (2011)	80 are unknown species, 296 are known species.
	Bryophytes	232	1	1 New record: Ho (2013) Baseline: Ho, B. C. (2014) pers. comm. 30 April, Piippo et al. (2002a, 2002b), Tan & Ho (2008), Yong et al. (2013).	

Vertebrates	Mammals	93*	2	Baseline: Baker & Lim (2008), Nature Society (Singapore) (2014). Includes species of indeterminate status. 1 New record: Lim & Leong (2014). 1 Rediscovery: Cai (2010)	Baseline changed as transient animals are counted
	Birds	384	20	Baseline: Wang & Hails(2007) 18 New records, 3 Rediscovery, 1 Extirpation: Nature Society (Singapore) Bird Group Records Committee (2013)	
	Reptiles	152*	4	Baseline: Baker & Lim (2008), Nature Society (Singapore) (2014). Includes species of indeterminate status. 4 New records: Lim (2009), Lim & Cheong (2011), Tan & Lim (2012), Thomas et al. (2014).	Baseline changed as 5NR includes marine turtles and marine snakes but 4NR did not.
	Amphibians	29	0	Baseline: Baker & Lim (2008)	
	Freshwater fishes	106*	2	Baseline: Baker & Lim (2008), Nature Society (Singapore) (2014). Includes species of indeterminate status. 2 New records: Tan et al. (2013)	
	Marine fishes	585	13	Baseline: Froese & Pauly (2014), Ng (2012a, b). 12 New records: Low (2013), Jaafar & Ng (2012), Ng (2012), Jaafar et al. (2012). 1 Rediscovery: Ng (2012a)	

Insects and Arachnids	Butterflies	317	22	Baseline: Khew (2014)	
	Beetles	10000+	10	Estimate based on Ng et al. (2011) 5 New species: Jäch et al. (2013) 3 New records: Jäch et al. (2013) 1 Rediscovery: Ong et al. (2013)	
	Dipterans	910	42	Baseline: Ng et al. (2011) 42 New species: Ng et al. (2011), Grootaert (2013), Grootaert & Shamshev (2012)	
	Hymenopterans	540	1	Baseline: Ng et al. (2011) 1 New Species: Pauly (2012) 1 New record: Lee, J. X. Q. pers. comm. 28 Oct 2013 1 possible Extirpation: John X. Q. Lee pers. comm. 28 Oct 2013	
	Myriapods	55	0	Baseline: Decker (2013)	
	Odonates	127	15	Baseline: Norma-Rashid et al. (2008). 15 New records: Tang et al. (2010), Ngiam, W. J. (2014), pers. comm. 6 Feb	
	Orthopterans	200+	18	Baseline estimate based on Ng et al. (2011). 16 New Species: Gorochov & Tan (2011, 2012), Ingrisch & Tan (2012), Robillard & Tan (2013), Tan (2011, 2012a, 2012b), Tan & Ingrisch (2013), Tan & Robillard (2012) 1 New record: Tan & Wang (2012) 1 Rediscovery: Tan (2011)	

	Spiders	425	26	Baseline: Court, D. J., (2009), pers. comm. 6 Oct. 1 New species: Wang & Li (2010) 25 New records: Baehr et al. (2012), Bayer (2011), Dankittipakul et al. (2012), Eichenberger et al. (2012), Huber (2011), Koh & Leong (2013), Platnick et al. (2012), Yoshida & Koh (2011), Zabka & Waldock (2012).	
Other invertebrates	Crustaceans	1000+	8	Baseline: Ng et al. (2011) 3 New species: Naruse & Ng (2010), Mendoza & Ng (2011), Cai & Teo (2012) 4 New records: Low & Tan (2012), Lee & Ng (2012), Cai & Teo (2012) 1 Rediscovery: Tan (2012)	
	Molluscs	1291	6	Baseline: Tan & Woo (2010), Wong (2011). 1 New species: Tan & Chan et al. (2011). 5 New records: Ang & Tan (2013), Tan & Low (2013a, b), Ng et al. (2014). 1 Rediscovery: Tan & Tan et al. (2011) 1 Extirpation: Neo & Todd (2013).	Baseline formed by adding 1264 from Tan & Woo (2010) to 21 species from Wong (2011)
	Octocorallia (Soft Corals + Gorgonians)	63	32	Baseline: Goh & Chou (1996). 2 New species: Benayahu & Chou (2010), Benayahu & Ofwegen (2011) 30 New records: Benayahu & Chou (2010), Benayahu & Ofwegen (2011)	
	Hard corals	255	0	Baseline: Huang et al. (2009)	

	Ascidians	32	14	Baseline: Ng et al. (2011). 14 New records: Lee et al. (2013), Su et al. (2013)	
	Sponges	228	3	Baseline: Lim, De Voogd & Tan (2012), Lim et al. (2009), De Voogd & Cleary (2009). 1 New species: Lim, De Voogd & Tan (2012). 1 New record: Lim & Tan (2013). 1 Rediscovery: Lim, Tun & Goh (2012)	
	Echinoderms	120	1	Baseline: Ng et al. (2011). 1 New record: Teo et al. (2010)	
	Marine mites	39	0	Baseline: Bartsch (2009)	

* - Figures for these taxa include species of indeterminate status.

Annex B - Species lists of new species, new records, rediscoveries and extinctions

Plants and Others

Vascular Plants

S/N	Species name	Status	Source
1	*Blechum pyramidatum*	New record	Neo et al. (2014)
2	*Cayratia japonica*	New record	Yeo et. al. (2012)
3	*Cryptocarya nitens*	New record	Neo et al. (2014)
4	*Dioscorea alata*	New record	Neo et al. (2013)
5	*Diplazium bantamense*	New record	NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec
6	*Dischidia acutifolia*	New record	NParks SBWR Branch (2013), pers. comm. 3 Dec
7	*Dracaena trachystachys*	New record	NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec
8	*Eleutherococcus trifoliatus*	New record	Neo et al. (2014)
9	*Eulophia graminea*	New record	Ang et al.(2011)
10	*Ficus stricta*	New record	Yeo et al. (2012)
11	*Halophila decipiens*	New record	Siti M. Yaakub et al. (2013)
12	*Hoya caudata*	New record	Rodda & Ang (2012a)
13	*Hoya imperialis*	New record	NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec
14	*Merremia vitifolia*	New record	Neo et al. (2013)
15	*Neoscortechinia sumatrensis*	New record	Ang et al. (2010)
16	*Paraderris elliptica*	New record	Neo et al. (2014)
17	*Plectocomiopsis geminiflora*	New record	Tan et al. (2011)
18	*Pleocnemia conjugata*	New record	NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec
19	*Rhizophora x larmarckii*	New record	NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec
20	*Tectaria incisa*	New record	Neo et al. (2014)
21	*Thottea praetermissa*	New record	NParks Plant Information Unit (2013), pers. comm. 13 Dec
22	*Amomum hastilabium*	Rediscovery	Leong-Skornickova, J. (2013), pers. comm. 10 Oct
23	*Ampelocissus thyrsiflora*	Rediscovery	Yeo et. al. (2013)
24	*Aralidium pinnatifidum*	Rediscovery	NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec
25	*Athyrium accedens*	Rediscovery	Lai (2010)
26	*Bromheadia alticola*	Rediscovery	Yam et. al. (2012)
27	*Bulbophyllum pulchellum*	Rediscovery	NParks Plant Information Unit (2013), pers. comm. 13 Dec
28	*Calamus javensis*	Rediscovery	NParks Plant Information Unit (2013), pers. comm. 13 Dec
29	*Callostylis pulchella* (= *Eria pulchella*)	Rediscovery	Lok et. al. (2012)

30	*Coelogyne rochussenii*	Rediscovery	Lok et. al. (2011)
31	*Coptosapelta tomentosa*	Rediscovery	Ang (2010)
32	*Cyrstachys renda*	Rediscovery	NParks Plant Information Unit (2013), pers. comm. 13 Dec
33	*Dendrobium aloifolium*	Rediscovery	Ang, Lok & Yeo et al. (2010)
34	*Dienia ophrydis*	Rediscovery	Hassan Ibrahim et al. (2011)
35	*Dischidia hirsuta*	Rediscovery	Rodda et al. (2012)
36	*Fagraea ridleyi*	Rediscovery	NParks Pulau Ubin Branch (2013), pers. comm. 11 Dec
37	*Freycinetia javanica*	Rediscovery	Ang, Lok, Yeo & Angkasa et al. (2012)
38	*Hetaeria obliqua*	Rediscovery	Leong & Yam (2013)
39	*Hoya coronaria*	Rediscovery	NParks Plant Information Unit (2013), pers. comm. 13 Dec
40	*Lindsaea divergens*	Rediscovery	Tan & Yeo (2012)
41	*Liparis barbata*	Rediscovery	Lok et al. (2010)
42	*Marsdenia maingayi*	Rediscovery	Yeoh et al. (2013)
43	*Myrmecodia tuberosa*	Rediscovery	NParks Plant Information Unit (2013), pers. comm. 13 Dec
44	*Pholidocarpus kingianus*	Rediscovery	NParks Plant Information Unit (2013), pers. comm. 13 Dec
45	*Pinanga simplicifrons*	Rediscovery	Ang, Lok & Tan (2010)
46	*Polystachya concreta*	Rediscovery	Lok et al. (2011a)
47	*Pterisanthes cissoides*	Rediscovery	Yeo, Ang & Lok (2012a)
48	*Renanthera elongate*	Rediscovery	Ang et al. (2011)
49	*Rubus moluccanus* L. var. *angulosus*	Rediscovery	Ang et al. (2010)
50	*Salacca affinis*	Rediscovery	Loo (2011)
51	*Tetrastigma dichotomum*	Rediscovery	Yeo, Ang & Lok (2012b)
52	*Trichotosia velutina*	Rediscovery	Ang et al. (2012)
53	*Uvaria curtisii*	Rediscovery	Ang (2010)
54	*Vrydagzynea lancifolia*	Rediscovery	Lim et al. (2014)
	Cystorchis variegata var. *purpurea*	Extinct*	Lok et al. (2011b)
Baseline	3550 species		Chong et al. (2009)

* - This record was not included in the count, as it involved a swap of status between *Cystorchis variegata* var. *variegata* and *Cystorchis variegata* var. *purpurea* so no change to total number, and no actual extinction.

Algae

S/N	Species name	Status	Source
Baseline	1054 species		Pham et al. (2010)

Fungi

S/N	Species name	Status	Source
Baseline	950 species		Wee & Ng (1994)

Lichens

S/N	Species name	Status	Source
Baseline	Estimated 376 species		Ng et al. (2011)

Bryophytes

S/N	Species name	Status	Source
1	*Marchantia emarginata*	New record	Ho (2013)
Baseline	232 species		Ho, B. C. (2014), pers. comm. 30 April

Vertebrates

Mammals

S/N	Species name	Status	Source
1	*Myotis horsfieldi*	New record	Lim & Leong (2014)
2	*Cervus unicolour*	Rediscovery	Cai (2010)
Baseline	91 species (includes species of indeterminate status)		Baker & Lim (2008), Miller (1991), Chew (2009), Nature Society (Singapore) (2014)

Birds

S/N	Species name	Status	Source
1	*Amandava amandava*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
2	*Anastomus oscitans*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
3	*Anthus hodgsoni*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
4	*Chrysococcyx maculatus*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
5	*Ducula badia*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
6	*Falco amurensis*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
7	*Hemipus hirundinaceus*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
8	*Hirundapus caudacutus*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
9	*Larus heuglini*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
10	*Leptoptilos javanicus*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
11	*Lonchura ferruginosa*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
12	*Padda oryzivora*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
13	*Phylloscopus tenellipes*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)

14	*Puffinus tenuirostris*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
15	*Stercorarius longicaudus*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
16	*Stercorarius pomarinus*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
17	*Strix leptogrammica*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
18	*Sula sula*	New record	Nature Society (Singapore) Bird Group Records Committee (2013)
19	*Bubo sumatranus*	Rediscovery	Nature Society (Singapore) Bird Group Records Committee (2013)
20	*Meiglyptes tristis*	Rediscovery	Nature Society (Singapore) Bird Group Records Committee (2013)
21	*Pycnonotus melanoleucos*	Rediscovery	Nature Society (Singapore) Bird Group Records Committee (2013)
	Mulleripicus pulverulentus	Extinct	Wang & Hails (2007)
Baseline	363 species		Wang & Hails (2007)

Reptiles

S/N	Species name	Status	Source
1	*Asthenodipsas laevis*	New record	Lim (2009)
2	*Dendrelaphis haasi*	New record	Lim & Cheong (2011)
3	*Norops sageri*	New record	Tan & Lim (2012)
4	*Phytolopsis punctata*	New record	Thomas et al. (2014)
Baseline	148 species (includes species of indeterminate status)		Baker & Lim (2008) Nature Society (Singapore) (2014)

Amphibians

S/N	Species name	Status	Source
Baseline	29 species		Baker & Lim (2008)

Freshwater Fishes

S/N	Species name	Status	Source
1	*Danio rerio*	New record	Tan et al. (2013)
2	*Macropodus opercularis*	New record	Tan et al. (2013)
Baseline	104 species (includes species of indeterminate status)		Baker & Lim (2008) Nature Society (Singapore) (2014)

Marine Fish

S/N	Species name	Status	Source
1	*Arius* cf. *gagora*	New record	Ng (2012)
2	*Chaetodon adiergastos*	New record	Low (2013)
3	*Dascyllus trimaculatus*	New record	Low (2013)
4	*Diademichthys lineatus*	New record	Low (2013)
5	*Myripristis amaena*	New record	Low (2013)
6	*Netuma bilineata*	New record	Ng (2012)

7	*Pomacentrus moluccensis*	New record	Low (2013)
8	*Ptereleotris hanae*	New record	Jaafar & Ng (2012)
9	*Scarus ghobban*	New record	Low (2013)
10	*Scarus rivulatus*	New record	Low (2013)
11	*Sphaeramia nematoptera*	New record	Low (2013)
12	*Yongeichthys virgatulus*	New record	Jaafar et al. (2012)
13	*Hemiarius sona*	Rediscovery	Ng (2012)
Baseline	572 species		Froese & Pauly (2014)

Insects and Arachnids

Butterflies

S/N	Species name	Status	Source
1	*Appias indra plana*	New record	Khew (2014)
2	*Appias paulina distanti*	New record	Khew (2014)
3	*Ariadne ariadne ariadne*	New record	Khew (2014)
4	*Cirrochroa emalea emalea*	New record	Khew (2014)
5	*Graphium bathycles bathycloides*	New record	Khew (2014)
6	*Graphium euryplus mecisteus*	New record	Khew (2014)
7	*Ideopsis juventa sitah*	New record	Khew (2014)
8	*Mooreana trichoneura trichoneura*	New record	Khew (2014)
9	*Oriens paragola*	New record	Khew (2014)
10	*Papiliio helenus helenus*	New record	Khew (2014)
11	*Polyura moori moori*	New record	Khew (2014)
12	*Prioneris philonome themana*	New record	Khew (2014)
13	*Prosotas aluta nanda*	New record	Khew (2014)
14	*Prosotas lutea sivoka*	New record	Khew (2014)
15	*Salanoemia tavoyana*	New record	Khew (2014)
16	*Saletara panda distanti*	New record	Khew (2014)
17	*Symbrenthia hippoclus selangorana*	New record	Khew (2014)
18	*Celaenorrhinus asmara asmara*	Rediscovery	Khew (2014)
19	*Pareronia valeria lutescens*	Rediscovery	Khew (2014)
20	*Potanthus trachala tytleri*	Rediscovery	Khew (2014)
21	*Troides amphrysus ruficollis*	Rediscovery	Khew (2014)
22	*Vagrans sinha sinha*	Rediscovery	Khew (2014)
Baseline	295 species		Khew (2014)

Beetles

S/N	Species name	Status	Source
1	*Hydraena hendrichi*	New species	Jäch et al. (2013)
2	*Hydraena michaelbalkei*	New species	Jäch et al. (2013)
3	*Hydraena paulmoritz*	New species	Jäch et al. (2013)
4	*Hydraena singaporensis*	New species	Jäch et al. (2013)
5	*Hydraena yangae*	New species	Jäch et al. (2013)

6	*Aulacochthebius asiaticus*	New record	Jäch et al. (2013)
7	*Hydraena* (*Hydraenopsis*) *formula*	New record	Jäch et al. (2013)
8	*Hydraena* (*Hydraenopsis*) *jacobsoni*	New record	Jäch et al. (2013)
9	*Catharsius molossus*	Rediscovery	Ong et al. (2013)
Baseline	Estimated 10,000 species		Ng et al. (2011)

Dipterans

S/N	Species name	Status	Source
1	*Chersodromia sylvicola*	New species	Grootaert & Shamshev (2012)
2	*Crossopalpus temasek*	New species	Grootaert & Shamshev (2012)
3	*Drapetis bakau*	New species	Grootaert & Shamshev (2012)
4	*Chersodromia bulohensis*	New species	Grootaert & Shamshev (2012)
5	*Chersodromia glandula*	New species	Grootaert & Shamshev (2012)
6	*Chersodromia malaysiana*	New species	Grootaert & Shamshev (2012)
7	*Drapetis hutan*	New species	Grootaert & Shamshev (2012)
8	*Drapetis laut*	New species	Grootaert & Shamshev (2012)
9	*Drapetis mandai*	New species	Grootaert & Shamshev (2012)
10	*Drapetis pantai*	New species	Grootaert & Shamshev (2012)
11	*Elaphropeza chanae*	New species	Grootaert & Shamshev (2012)
12	*Elaphropeza collini*	New species	Grootaert & Shamshev (2012)
13	*Elaphropeza gohae*	New species	Grootaert & Shamshev (2012)
14	*Elaphropeza kranjiensis*	New species	Grootaert & Shamshev (2012)
15	*Elaphropeza lowi*	New species	Grootaert & Shamshev (2012)
16	*Elaphropeza semakau*	New species	Grootaert & Shamshev (2012)
17	*Elaphropeza shufenae*	New species	Grootaert & Shamshev (2012)
18	*Nanodromia hutan*	New species	Grootaert & Shamshev (2012)
19	*Nanodromia spinulosa*	New species	Grootaert & Shamshev (2012)
20	*Nepalomyia negrobovi*	New species	Grootaert (2013)
21	*Nepalomyia priapus*	New species	Grootaert (2013)
22	*Nepalomyia singaporenis*	New species	Grootaert (2013)
23	*Nepalomyia spinata*	New species	Grootaert (2013)
24	*Nepalomyia temasek*	New species	Grootaert (2013)
25	*Nepalomyia yangi*	New species	Grootaert (2013)
26	*Platypalpus singaporensis*	New species	Grootaert & Shamshev (2012)
27	*Pontodromia pantai*	New species	Grootaert & Shamshev (2012)
28	*Stilpon arcuatum*	New species	Grootaert & Shamshev (2012)
29	*Stilpon neesoonensis*	New species	Grootaert & Shamshev (2012)
30	*Stilpon nigripennis*	New species	Grootaert & Shamshev (2012)
31	*Stilpon singaporensis*	New species	Grootaert & Shamshev (2012)
32	*Stilpon weilingae*	New species	Grootaert & Shamshev (2012)
Baseline	Estimated 910 species		Ng et al. (2011)

Hymenopterans

S/N	Species name	Status	Source
1	*Eupetersia* (*Nesoeupetersia*) *singaporensis*	New species	Pauly (2012)
2	*Polistes tenebricosus*	New record	Lee, J. X. Q. (2013), pers. comm. 28 Oct
	Polybioides raphigastra	Extinct	Lee, J. X. Q. (2013), pers. comm. 28 Oct
Baseline	Estimated 540 species		Ng et al. (2011)

Myriapods

S/N	Species name	Status	Source
Baseline	55 species		Decker (2013)

Odonates

S/N	Species name	Status	Source
1	*Acrogomphus malayanus*	New record	Ngiam, W. J. (2014), pers. comm. 6 Feb
2	*Agriocnemis minima*	New record	Ngiam, W. J. (2014), pers. comm. 6 Feb
3	*Amphicnemis bebar*	New record	Ngiam, W. J. (2014), pers. comm. 6 Feb
4	*Archibasis rebeccae*	New record	Tang et al. (2010)
5	*Burmagomphus arthuri*	New record	Ngiam, W. J. (2014), pers. comm. 6 Feb
6	*Coeliccia didyma*	New record	Tang et al. (2010)
7	*Echo modesta*	New record	Ngiam, W. J. (2014), pers. comm. 6 Feb
8	*Libellago lineata*	New record	Tang et al. (2010)
9	*Macromia cincta*	New record	Tang et al. (2010)
10	*Macromia cydippe*	New record	Tang et al. (2010)
11	*Mortonagrion arthuri*	New record	Tang et al. (2010)
12	*Oligoaeschna foliacea*	New record	Tang et al. (2010)
13	*Teinobasis cryptica*	New record	Ngiam, W. J. (2014), pers. comm. 6 Feb
14	*Vestalis gracilis*	New record	Ngiam, W. J. (2014), pers. comm. 6 Feb
15	*Zyxomma obtusum*	New record	Ngiam, W. J. (2014), pers. comm. 6 Feb
Baseline	112 species		Norma-Rashid et al. (2008)

Orthopterans

S/N	Species name	Status	Source
1	*Asiophlugis temasek*	New species	Gorochov & Tan (2011)
2	*Glenophisis singapura*	New species	Tan (2012b)
3	*Gryllotalpa nymphicus*	New species	Tan (2012a)
4	*Gryllotalpa wallace*	New species	Tan (2012a)
5	*Jambiliara selita*	New species	Ingrisch & Tan (2012)
6	*Lebinthus luae*	New species	Robillard & Tan (2013)
7	*Micrornebius kopisua*	New species	Tan & Ingrisch (2013)
8	*Nahlaksia bidadari*	New species	Ingrisch & Tan (2012)
9	*Ornebius insculpta*	New species	Tan & Ingrisch (2013)
10	*Ornebius tampines*	New species	Tan & Robillard (2012)
11	*Oxylakis singaporensis*	New species	Ingrisch & Tan (2012)
12	*Phaloria jerelynae*	New species	Gorochov & Tan (2012)

13	*Singapuriola separata*	New species	Gorochov & Tan (2012)
14	*Svistella chekjawa*	New species	Tan & Robillard (2012)
15	*Trellius neesoon*	New species	Gorochov & Tan (2012)
16	*Tremellia timah*	New species	Gorochov & Tan (2012)
17	*Gonista* cf. *bicolor*	New record	Tan & Wang (2012)
18	*Asiophlugis thaumasia*	Rediscovery	Tan (2011)
Baseline	Estimated 200 species		Ng et al. (2011)

Spiders

S/N	Species name	Status	Source
1	*Telema fabata*	New species	Wang & Li (2010)
2	*Argiope catenulata*	New record	Koh & Leong (2013)
3	*Calapnita phyllicolla*	New record	Huber (2011)
4	*Cosmophasis lami*	New record	Zabka & Waldock (2012)
5	*Eriovixia pseudocentrodes*	New record	Koh & Leong (2013)
6	*Fecenia protensa*	New record	Bayer (2011)
7	*Gamasomorpha insomnia*	New record	Eichenberger et al. (2012)
8	*Gamasomorpha squalens*	New record	Eichenberger et al. (2012)
9	*Hamataliwa incompta*	New record	Koh & Leong (2013)
10	*Heliconilla globularis*	New record	Dankittipakul et al. (2012)
11	*Hersilia deelemanae*	New record	Koh & Leong (2013)
12	*Hersilia sumatrana*	New record	Koh & Leong (2013)
13	*Heteropoda boiei*	New record	Koh & Leong (2013)
14	*Ischnothyreus peltifer*	New record	Platnick et al. (2012)
15	*Janula triangularis*	New record	Yoshida & Koh (2011)
16	*Lipocrea fusiformis*	New record	Koh & Leong (2013)
17	*Mallinella allorostrata*	New record	Dankittipakul et al. (2012)
18	*Miagrammopes oblongus*	New record	Koh & Leong (2013)
19	*Micropholcus fauroti*	New record	Huber (2011)
20	*Orsima ichneumon*	New record	Koh & Leong (2013)
21	*Pholcus kohi*	New record	Huber (2011)
22	*Prethopalpus pahang*	New record	Baehr et al. (2012)
23	*Prethopalpus schwendingeri*	New record	Baehr et al. (2012)
24	*Theridion zebrinum*	New record	Koh & Leong (2013)
25	*Uthina luzonica*	New record	Huber (2011)
26	*Workmania botuliformis*	New record	Dankittipakul et al. (2012)
Baseline	399 species		Court, D. J. (2009), pers. comm. 6 Oct

Other invertebrates

Crustaceans

S/N	Species name	Status	Source
1	*Leelumnus radium*	New species	Mendoza & Ng (2011)
2	*Synidotea poorei*	New species	Cai & Teo (2012)
3	*Tritodynamia yeoi*	New species	Naruse & Ng (2010)
4	*Cirolana willeyi*	New record	Cai & Teo (2012)
5	*Heteropilumnus sasekumari*	New record	Lee & Ng (2012)
6	*Notopus dorsipes*	New record	Low & Tan (2012)
7	*Sphaeroma walkeri*	New record	Cai & Teo (2012)
8	*Harrovia longipes*	Rediscovery	Tan (2012)
Baseline	Estimated 1000 + species		Ng et al. (2011)

Molluscs

S/N	Species name	Status	Source
1	*Amphidromus atricallosus temasek*	New species	Tan & Chan et al. (2011)
2	*Babylonia spirata*	New record	Tan & Low (2013b)
3	*Falcidens* sp.	New record	Ang & Tan (2013)
4	*Glossocardia obesa*	New record	Tan & Low (2013a)
5	*Pomacea maculata*	New record	Ng et al. (2014)
6	*Solenogastres* sp.	New record	Ang & Tan (2013)
7	*Verpa penis*	Rediscovery	Tan & Tan et al. (2011)
	Hippopus hippopus	Extinct	Neo & Todd (2012)
Baseline	1284 species		Tan & Woo (2010), Wong (2011)

Octocorallia (Soft Corals + Gorgonians)

S/N	Species name	Status	Source
1	*Cladiella hartogi*	New species	Benayahu & Chou (2010)
2	*Sinularia choui*	New species	Benayahu & Ofwegen (2011)
3	*Heliopora coerulea*	New record	Benayahu & Chou (2010)
4	*Briareum excavatum*	New record	Benayahu & Chou (2010)
5	*Cladiella pachyclados*	New record	Benayahu & Chou (2010)
6	*Lobophytum crassum*	New record	Benayahu & Chou (2010)
7	*Lobophytum pauciflorum*	New record	Benayahu & Chou (2010)
8	*Lobophytum sarcophytoides*	New record	Benayahu & Chou (2010)
9	*Sansibia flava*	New record	Benayahu & Chou (2010)
10	*Sarcophyton crassocaule*	New record	Benayahu & Chou (2010)
11	*Sarcophyton ehrenbergi*	New record	Benayahu & Chou (2010)
12	*Sarcophyton glaucum*	New record	Benayahu & Chou (2010)
13	*Sarcophyton tenuispiculatum*	New record	Benayahu & Chou (2010)
14	*Sarcophyton trocheliophorum*	New record	Benayahu & Chou (2010)
15	*Sinularia abrupta*	New record	Benayahu & Chou (2010)
16	*Sinularia acuta*	New record	Benayahu & Ofwegen (2011)

17	*Sinularia brassica*	New record	Benayahu & Chou (2010)
18	*Sinularia capillosa*	New record	Benayahu & Chou (2010)
19	*Sinularia compressa*	New record	Benayahu & Chou (2010)
20	*Sinularia depressa*	New record	Benayahu & Chou (2010)
21	*Sinularia erecta*	New record	Benayahu & Chou (2010)
22	*Sinularia exilis*	New record	Benayahu & Chou (2010)
23	*Sinularia gibberosa*	New record	Benayahu & Chou (2010)
24	*Sinularia hirta*	New record	Benayahu & Chou (2010)
25	*Sinularia lochmodes*	New record	Benayahu & Chou (2010)
26	*Sinularia maxima*	New record	Benayahu & Ofwegen (2011)
27	*Sinularia microclavata*	New record	Benayahu & Chou (2010)
28	*Sinularia molesta*	New record	Benayahu & Ofwegen (2011)
29	*Sinularia polydactyla*	New record	Benayahu & Ofwegen (2011)
30	*Sinularia triangula*	New record	Benayahu & Chou (2010)
31	*Sinularia verseveldti*	New record	Benayahu & Ofwegen (2011)
32	*Studeriotes spinosa*	New record	Benayahu & Chou (2010)
Baseline	31 species		Goh & Chou (1996)

Hard Corals

S/N	Species name	Status	Source
Baseline	255 species		Huang et al. (2009)

Ascidians

S/N	Species name	Status	Source
1	*Ascidia gemmata*	New record	Lee et al. (2013)
2	*Herdmania pallida*	New record	Lee et al. (2013)
3	*Lissoclinum timorense*	New record	Su et al. (2013)
4	*Phallusia arabica*	New record	Lee et al. (2013)
5	*Phallusia nigra*	New record	Lee et al. (2013)
6	*Polycarpa argentata*	New record	Lee et al. (2013)
7	*Polycarpa aurita*	New record	Lee et al. (2013)
8	*Polycarpa captiosa*	New record	Lee et al. (2013)
9	*Polycarpa olitoria*	New record	Lee et al. (2013)
10	*Pyura curvigona*	New record	Lee et al. (2013)
11	*Rhodosoma turcicum*	New record	Lee et al. (2013)
12	*Rhopalaea crassa*	New record	Lee et al. (2013)
13	*Styela canopus*	New record	Lee et al. (2013)
14	*Tridemnum cyclops*	New record	Su et al. (2013)
Baseline	18 species		Ng et al. (2011)

Sponges

S/N	Species name	Status	Source
1	*Forcepia (Forcepia) vansoesti*	New species	Lim, De Voogd & Tan (2012)
2	*Eunapius conifer*	New record	Lim & Tan (2013)
3	*Cliona patera*	Rediscovery	Lim, Tun & Goh (2012)
Baseline	225 species		Lim, De Voogd & Tan (2008, 2009, 2012), De Voogd & Cleary (2009)

Echinoderms

S/N	Species name	Status	Source
1	*Holothuria* (*Stauropora*) *fuscocinerea*	New record	Teo et al. (2010)
Baseline	Estimated 120 species		Ng et al. (2011)

Marine Mites

S/N	Species name	Status	Source
Baseline	39 species		Bartsch (2009)

Annex C - Singapore's score for the Singapore Index on Cities' Biodiversity

The following tables provide more details on Singapore's scores for each indicator. Please download the Singapore Index User's Manual for a complete description of how these figures are calculated: https://www.cbd.int/authorities/doc/Singapore-Index-User-Manual-20140730-en.pdf

Component 1: Native Biodiversity in the City

Indicator	Raw value	Score
1. Proportion of Natural Areas	29%	4
2. Connectivity Measures	Mean Mesh Size = 1599ha	4
3. Native Biodiversity in Built-up area (Birds)	30 bird species	2
4. Change in no. of vascular plant species	2145 plant species	NA
5. Change in no. of bird species	321 bird species	NA
6. Change in number of butterfly species	295 butterfly species	NA
7. Change in number of hard coral species	255 hard coral species	NA
8. Change in number of freshwater fish species	34 fish species	NA
9. Proportion of protected natural areas	4.7%	1
10. Proportion of invasive alien species (birds)	3%	3

Component 2: Ecosystem Services

Indicator	Raw value	Score
11. Regulation of Quantity of Water	63.2%	2
12. Carbon Storage and Cooling Effect of Vegetation	31.9%	3
13. Recreational Services	Area of parks with natural areas and protected or secured natural areas = 0.75ha/1000 persons	3
14. Number of formal educational visits per child below 16 years to parks with natural areas or protected or secured natural areas per year	0.01 visits/child/year	0

Component 3: Governance and Management of Biodiversity

Indicator	Raw value	Score
15. Budget Allocated to Biodiversity	0.6%	1
16. Number of Biodiversity Projects Implemented by the City Annually	79 projects	4
17. Existence of Local Biodiversity Strategy and Action Plan	Singapore's NBSAP was launched in September 2009 and an update is currently being prepared.	4
18. Number of essential biodiversity related functions that the city uses	7 functions	4
19. Number of city or local government agencies involved in inter-agency co-operation pertaining to biodiversity matters	10 agencies	4
20. Existence and state of formal or informal public consultation process pertaining to biodiversity related matters	Formal or informal process exists as part of the routine process (e.g.: URA Master Plan public consultation)	4
21. Number of agencies/private companies/NGOs/academic institutions/international organisations with which they city is partnering in biodiversity activities, projects and programmes	66 partners	4
22. Is biodiversity or nature awareness included in the school curriculum?	Yes, biodiversity or elements of it are included in the school curriculum.	4
23. Number of outreach or public awareness events held in the city per year	1340 outreach or public awareness events per year	4

Annex D - References

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