

Mai Po Nature Reserve

Management Plan: 2019-2024



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(Mid-term version)

Prepared by WWF-Hong Kong

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EXECUTIVE SUMMARY

The 380 ha Mai Po Nature Reserve (MPNR) is part of the Mai Po Marshes Site of Special Scientific Interest (SSSI), nested within the Mai Po Inner Deep Bay Ramsar Site on the southern bank of the Pearl River estuary. MPNR is separated into seven Biodiversity Management Zones (BMZ) managed under controlled hydrological regimes as shallow and deep open water areas, reedbed dominated ponds, rain-fed ponds, and traditionally operated shrimp ponds (*gei wai*) to provide a range of habitat for waterbird and passerines and allow their conservation. MPNR is extensively used for nature education and wetland management training, including of regional wetland managers. WWF-Hong Kong also manages a 45 ha area of mudflat as bird habitat in Inner Deep Bay, adjacent to the reserve under annual application to the District Land Office of the Hong Kong SAR Government.

MPNR has been managed by the World Wide Fund for Nature Hong Kong (WWF-Hong Kong) since 1983, with support from the Agriculture, Fisheries and Conservation Department (AFCD) of the Hong Kong SAR Government, which oversees the overall conservation management of the Mai Po Inner Deep Bay Ramsar Site. A conservation strategy and management plan for the Ramsar Site is prepared and implemented by AFCD, and this plan sets out the context of the management of MPNR. WWF-Hong Kong develops five-year management plans for MPNR under advice of the Mai Po Management Committee.

MPNR and the larger Ramsar site is an important staging area and wintering ground along the East Asian-Australasian Flyway (EAAF) for many species of migratory waterbirds among which are globally threatened species such as the Black-faced spoonbill (*Platalea minor*), Saunders's gull (*Larus saundersi*), and Nordmann's greenshank (*Tringa guttifer*). Nearly 7% of the entire global population of Black-faced spoonbill uses Mai Po and the Inner Deep Bay as a wintering ground. As such, MPNR has both regional and global significance for migratory waterbird conservation and is an integral area along the 13,000 km long EAAF 'landscape'. In addition to its role conserving migratory waterbirds, Mai Po is a refuge for biodiversity, especially wetland and mangrove species, such as the Eurasian otter (*Lutra lutra*), four-spot midget (*Mortonagrion hirosei*), and Hong Kong bent-winged firefly (*Pteroptyx maipo*). The leopard cat (*Felis bengalensis*), Hong Kong's only wild felid is also present in the reserve.

The *gei wai* represent a traditional, sustainable practice of wetland management for aquaculture. It's a disappearing traditional, cultural practice that is showcased at the reserve.



The *gei wai* is valued in cultural and ecological aspects.
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Several conservation targets are identified for this five-year reserve management plan, including several species and species assemblages (see Table 3). Mai Po is renowned for its waterbirds and many of the conservation targets focus on waterbirds; especially migratory species.

An analysis of threats to these targets was also identified (see Table 4), along with strategies and actions to mitigate or adapt to these threats. Twelve of 17 threat drivers identified were ranked Very High for scope. But this is due to the relatively small area of the reserve in relation to the spatial extent of the impact of the threats; for instance, siltation, salinity changes,

water pollution, severe weather events, occur over large areas that go beyond the reserve, and affect all or most of the reserve area. Because of the large spatial scale of these threats – especially from siltation and salinity in the Deep Bay – and the sources being far from the reserve, the costs of reversing the threats are very high. Climate change could potentially intensify these changes, especially with rising sea levels, severe typhoons, strong wave surges and rising tides. Floods following heavy rainfall will result in large, silt-laden freshwater pulses being washed downriver into the bay. This management plan integrates the climate impacts and climate adaptation strategies.

WWF-Hong Kong implements a "One Planet Education Programme" with the overall objective of inspiring, motivating and mobilizing youth and students in Hong Kong to actively participate in the global conservation movement. This programme uses the facilities available in MPNR, and will continue to do so through educational activities for both students and teachers. Mai Po is also used for eco-visits for the general public.

The tens of millions of migratory waterbirds that use the EAAF rely on a series of wetlands along the route to breed, 'refuel', and winter. However, there is increasing loss and degradation of wetlands; for example, in China alone, as much as 70% of tidal flats have been lost between the 1950s and 2000s, which has led to serious declines in migratory waterbird populations. Securing the integrity of key habitats in priority areas within the EAAF is vital to the persistence of the migration, which is of great importance for Mai Po. The Mai Po management team has been working with regional wetland managers to share knowledge and experience of managing Mai Po through the Mai Po Wetland Management Training Programme. This programme is an important part of MPNR management and will continue to be so over the next five years. A fourth component will be to develop a research programme in MPNR relevant to wetland management.

Based on these thematic objectives, the following vision, goal, targets and strategies were identified.

Vision: The Mai Po Nature Reserve is an important staging area and wintering ground for migratory waterbirds in the EAAF; a core area that supports threatened flora and fauna of Hong Kong's wetlands; and is the regional hub for environmental education and wetland management training with support from all stakeholders.

Goal: To a) manage the Mai Po Nature Reserve as a climate-resilient and adapted staging and wintering ground for migratory waterbirds along the EAAF and for threatened indigenous biodiversity; b) sustain the practice of *gei wai* as an example of traditional wise use of wetlands; and c) be a regional centre for knowledge and awareness on wetland conservation.

Objective 1. To maintain or increase populations of priority species by managing the required habitat diversity that integrates climate adaptation strategies.

1A. Species targets

Target 1. By 2024, no decline in the black-faced spoonbill (*Platalea minor*) population from current trend.

Target 2. By 2024, the numbers and relative species composition (diversity) of the shorebird and duck assemblages remains stable, relative to past five-year trend.

Target 3. By 2024, black-winged stilt continue to nest in MPNR

Target 4. By 2024, the reedbed dependent bird assemblage maintains numbers and assemblage diversity.

Target 5. By 2024, numbers and composition of the ardeid community remains stable.

- 1.1 Strategy: Manage the habitat in selected BMZs as primary high tide roosting and feeding habitats necessary for black-faced spoonbills, ducks and shorebirds
- 1.2 Strategy: Maintain roosting areas and increase the open, deep-water foraging habitats in selected BMZs for the duck assemblage.
- 1.3 Strategy: Manage the habitat in selected BMZs as nesting sites for black-winged stilt
- 1.4 Strategy: Increase the spatial extent of wet reedbeds that have been shown to support higher numbers and diversity of reedbed-dependent birds than dry reedbeds.
- 1.5 Strategy: Maintain five traditionally-operated brackish water *gei wai* and restore total *gei wai* area in BMZ 3 as winter feeding habitats for Black-faced Spoonbill, egrets and herons.

Target 6. By 2024, the roosting population of collared crows in MPNR maintained as more than 200 individuals.

- 1.6 Strategy: Protect the pre-roosting sites, and intertidal roosting mangrove patches.

Target 7. By 2024, distribution of the Eurasian otter population mapped and estimated with a conservation management plan for MPNR in place.

- 1.7 Strategy: Research and conservation focus on breeding and raise awareness and education for otter conservation.

Target 8. By 2024, the major populations of Hong Kong bent-winged firefly and their habitat conserved and secured.

- 1.8 Strategy: Collaborate with AFCD and other stakeholders to protect and conserve the priority habitats and firefly populations in and around MPNR.

Target 9. By 2024, status of Reeves' turtle and Chinese soft-shelled turtle updated, and a recovery plan prepared.

- 1.9 Strategy: Implement species' recovery plans based on surveys to confirm presence and distributions in MPNR.

Target 10. By 2024, the distribution of four-spot midget in the reserve is stable.

- 1.10 Strategy: Conserve the breeding habitat, including the water conditions necessary for eggs and nymphs to survive, with emergent vegetation necessary for metamorphosis to become complete.

1B Threat targets

Target 11. By 2024, the spread of exotic species is under control and impacts on conservation target species and habitats is minimal.

- 1.11 Strategy: Constantly monitor the status of the exotic species and apply controls to manage the populations and prevent the spread of the relevant species.

Target 12. By 2024, a climate adaptation strategy and plan for MPNR in place.

- 1.12 Strategy: Prepare and propose to government stakeholders an adaptation plan to allow for ecosystem and habitat responses to climate change and consequent impacts to MPNR.

Target 13. Through the period up to 2024, the 45 ha area of intertidal mudflat along the western boundary of the nature reserve kept clear of encroaching mangroves, grasses, and sedges.

- 1.13 Strategy: Control mangrove seedlings and patches of grasses and sedges intruding into the mudflats in front of the floating bird hides.

Objective 2. To raise public awareness and education of the importance of wetlands and their conservation, including the provision of universal access.

- 2.1 Strategy: Use the natural environment and facilities at MPNR as a key platform to raise awareness for wetland conservation, as part of thematic outdoor learning experiences for students and teacher training through the centre-based education activities under the One Planet School programme that will complement the regular school curricula.
- 2.2 Strategy: Use the facilities at MPNR to collaborate with youth groups and tertiary student communities to engage and motivate young people for conservation and as sustainability advocates through action-based learning activities under the One Planet Youth programme.
- 2.3 Strategy: Organize education and awareness programmes for local communities, targeting families and children under the Local Communities programme.

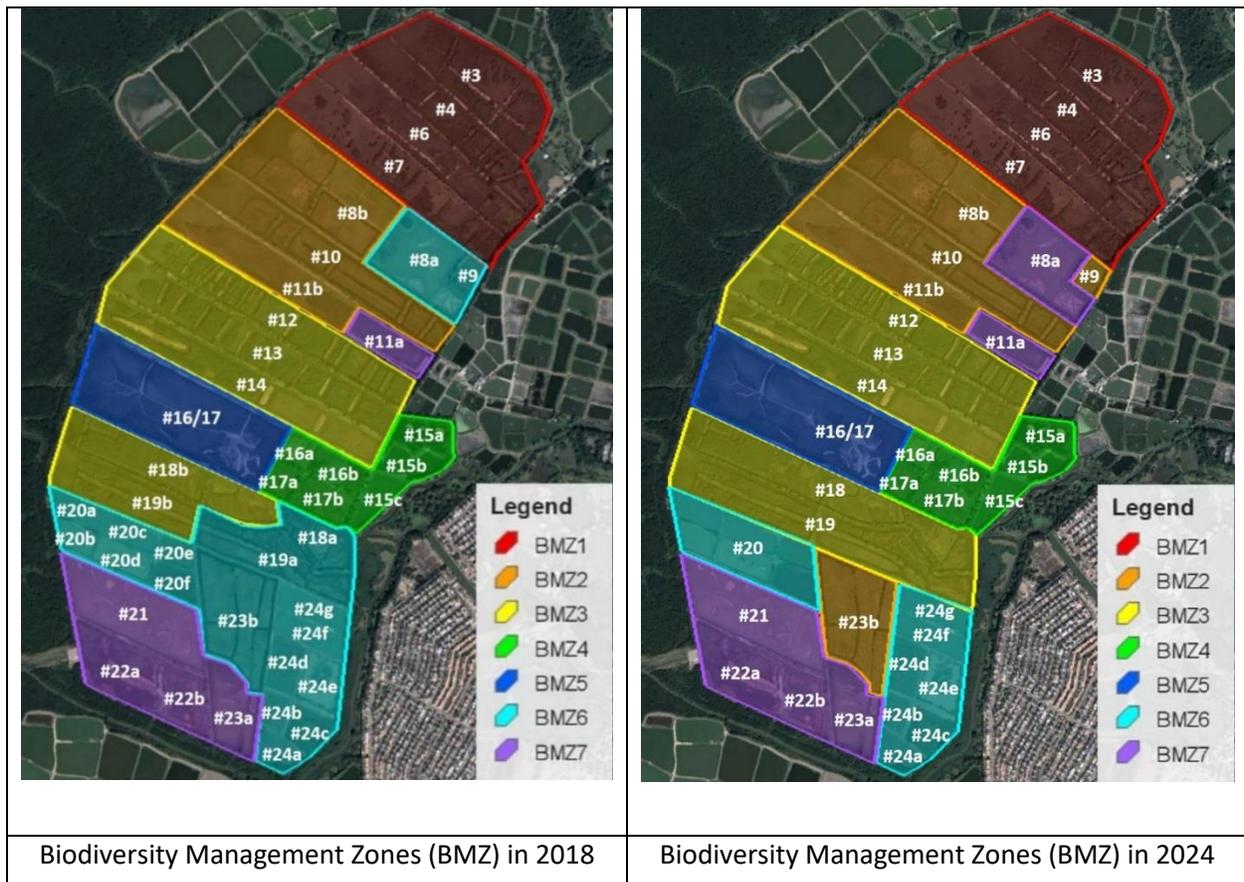
Objective 3. To share experience and knowledge with other Ramsar sites and wetlands in the EAAF for coordinated conservation and persistence of the EAAF avian landscape.

- 3.1 Strategy: Use Mai Po Nature Reserve and the Mai Po Inner Deep Bay Ramsar Site as a 'living laboratory' to demonstrate the practical application of wetland reserve management.
- 3.2 Strategy: Work with the Mai Po education and training team to support a regional awareness programme on the importance of MPNR and its contribution and role in the Ramsar Convention and EAAF Partnership.

Objective 4. To develop Mai Po as a regional centre of excellence for wetland research and monitoring.

- 4.1 Strategy: Establish a long-term monitoring programme for conservation targets and selected indicators of ecosystem change in MPNR and the Deep Bay
- 4.2 Strategy: Use new tools or technologies (created by WWF-Hong Kong or through collaboration with academics or technology companies) for better data collection and management.
- 4.3 Strategy: Conduct research that will help to improve habitat management and species conservation and recovery in the MPNR and Deep Bay
- 4.4 Strategy: Encourage local and cross-border scientific activities in the MPNR and Deep Bay to improve wetland conservation in the region.

Upon completion of the five-year work plan (2019-2024), the boundaries and major management intentions of the Biodiversity Management Zones (BMZ) will be modified as below:



The below rundown covers how the BMZs will function in 2024.

- **BMZ1** (GW #3, #4, #6, #7): Maintained as open water area to benefit wintering population of black-faced spoonbills and ducks.
- **BMZ2** (GW #8b, #9, #10, #11b, #23b): Maintained as reedbed habitats with diversifying water depths for reedbed-dependent passerine, bitterns and herons.
- **BMZ3** (GW#12, #13, #14, #18, #19): Maintained as traditionally-operated brackish water *gei wai* for the benefit of black-faced spoonbills, egrets and herons as feeding habitat in winter.
- **BMZ4** (Pond #15a-c, #16a-b, #17a-b): Maintained as a series of rain-fed ponds to facilitate the implementation of education programmes.
- **BMZ5** (GW #16/17): Maintained as shallow water high-tide roosting area with islands for the benefit of passage and wintering shorebirds and other waterbirds, particularly roosting black-faced spoonbills, ducks and breeding black-winged stilts.
- **BMZ6** (Pond #20): Maintained as an open rain-fed marsh with contouring and variable water depths;
- **BMZ6** (Pond #24a-g): Maintained as a buffalo-grazed rain-fed marsh.
- **BMZ7** (GW #8a, #11a, #21, #22a-b, #23a): Maintained as a shallow water high-tide roosting area as an alternative to BMZ5 (GW#16/17).

1. INTRODUCTION

The Mai Po Nature Reserve (MPNR) is part of the Mai Po Inner Deep Bay Ramsar Site, located in the Northwest New Territories of Hong Kong SAR, along the southern bank of the Pearl River estuary (Figure 1). While the entire Ramsar Site covers about 1,500 hectares, with more than half comprising of a shallow bay with mudflats and mangroves, the 380 ha MPNR, a part of the Mai Po Site of Special Scientific Interest (SSSI), comprises of the *gei wai* (traditionally managed shrimp ponds) that form the 212 ha Biodiversity Management Zones and some part of the intertidal mangroves. It is also situated within the Restricted Area designated under the Wild Animals Protection Ordinance (Cap 170).

The seven Biodiversity Management Zones (BMZ), designated under the Ramsar Site Management Plan, are managed primarily as shallow and deep open water areas, reedbed-dominated ponds, rain-fed ponds, and traditionally-managed *gei wai* to provide a range of habitats for waterbirds and passerines and their

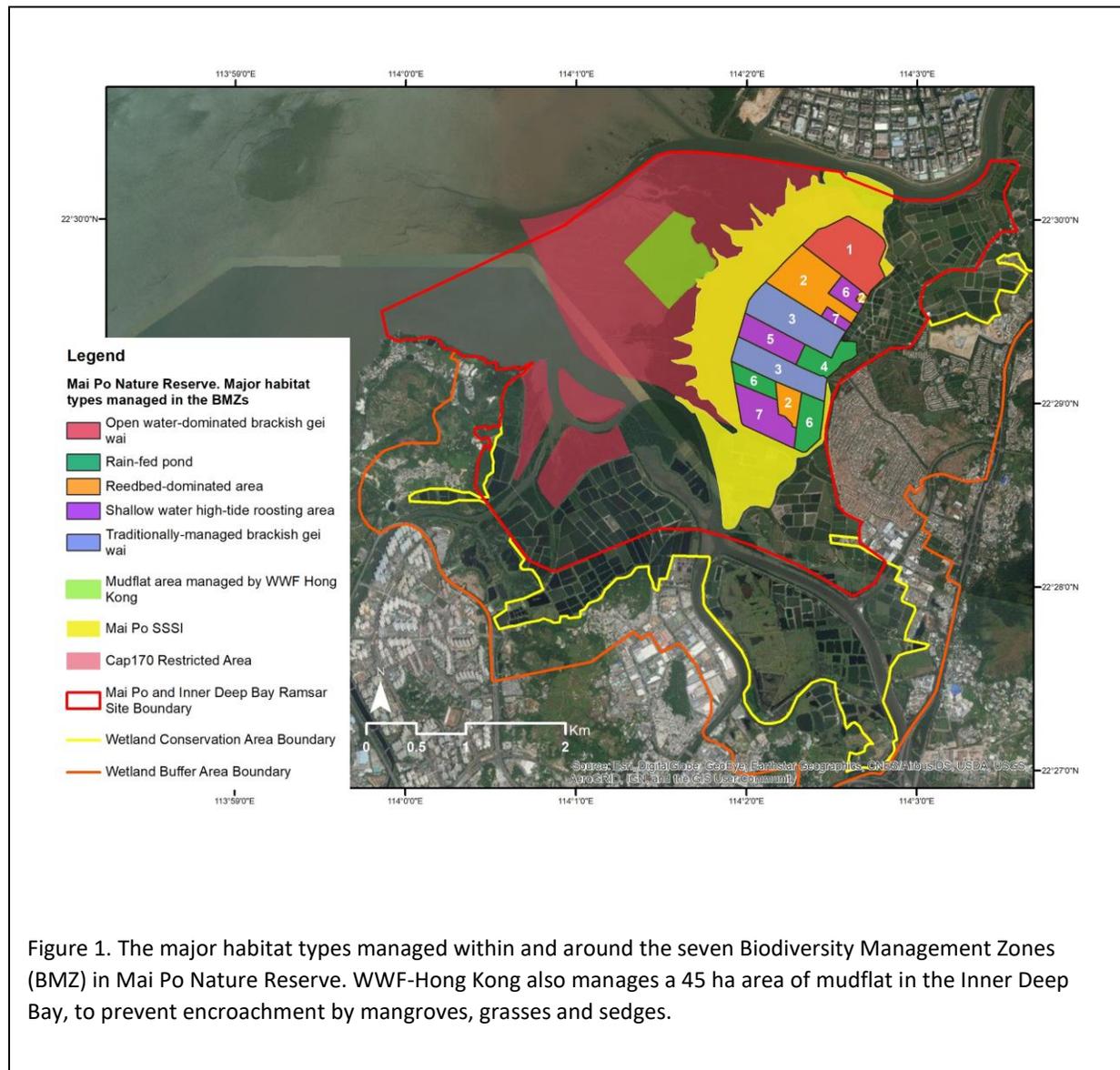


Figure 1. The major habitat types managed within and around the seven Biodiversity Management Zones (BMZ) in Mai Po Nature Reserve. WWF-Hong Kong also manages a 45 ha area of mudflat in the Inner Deep Bay, to prevent encroachment by mangroves, grasses and sedges.

conservation. The MPNR and some ponds are also extensively used for nature education and wetland management training.

The *gei wai* and ponds (Figure 2) are managed under controlled hydrological regimes to provide the range of habitat types. WWF-Hong Kong also manages and maintains a 45 ha extent of mudflat in the Inner Deep Bay (Figure 2), and periodically removes encroaching mangrove seedlings, grasses, and sedges from this area.

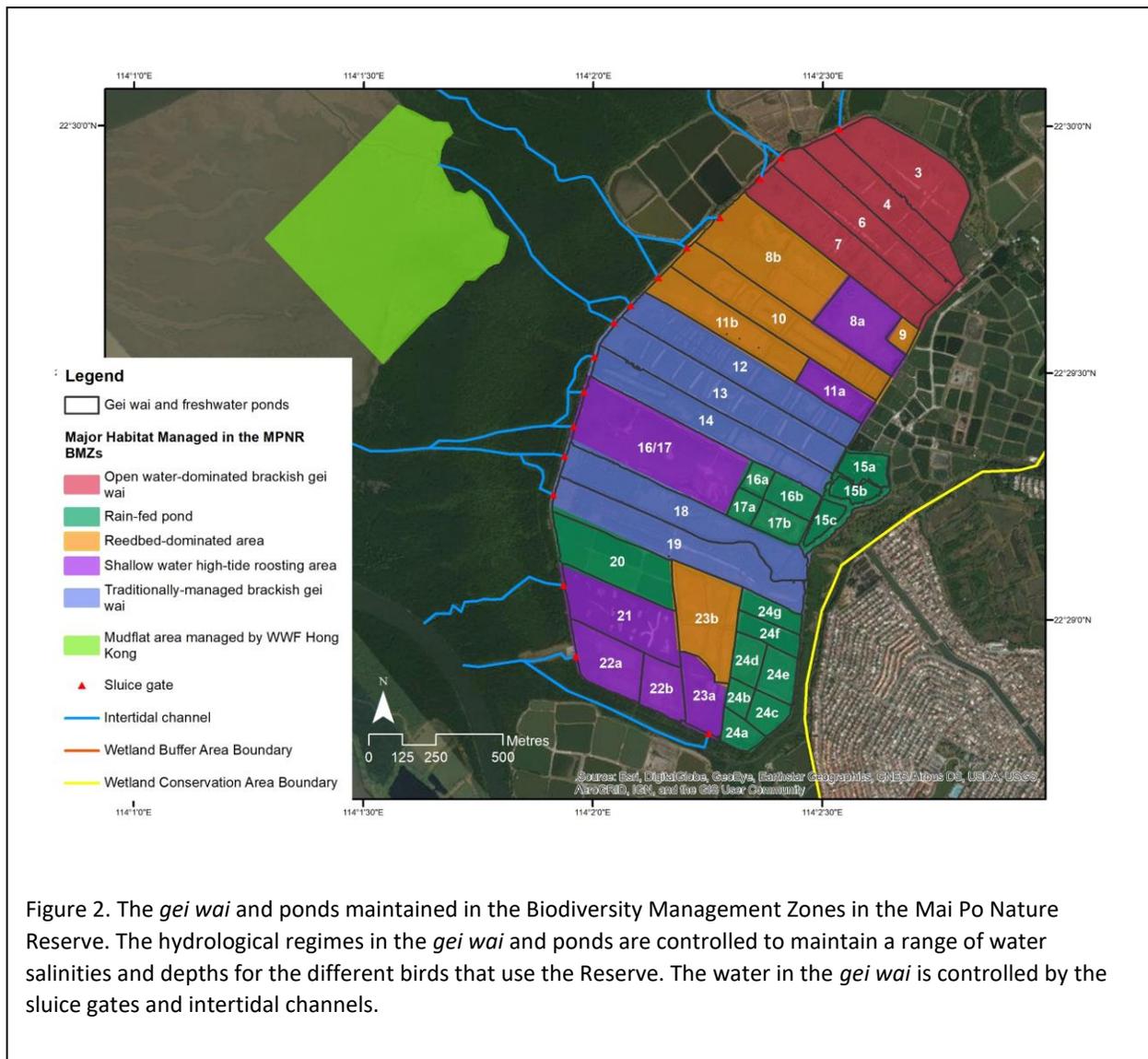
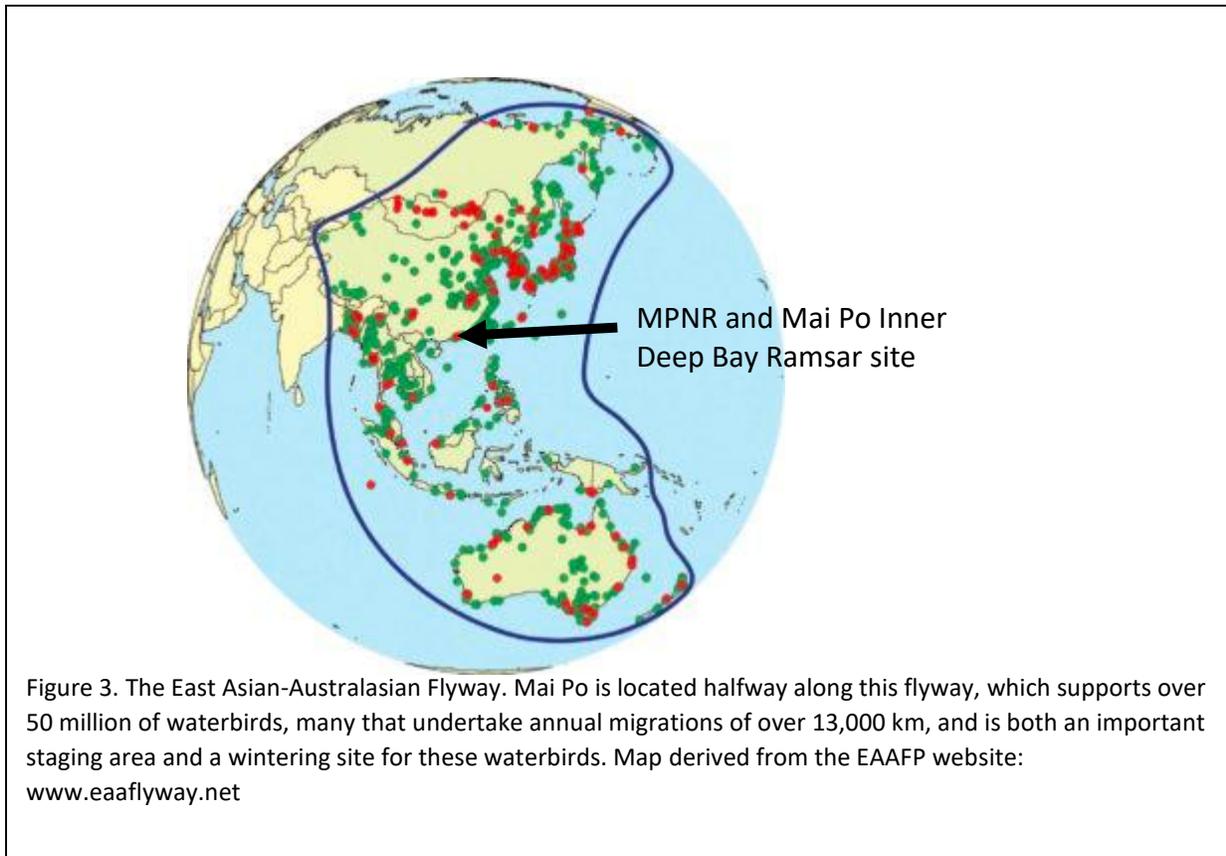


Figure 2. The *gei wai* and ponds maintained in the Biodiversity Management Zones in the Mai Po Nature Reserve. The hydrological regimes in the *gei wai* and ponds are controlled to maintain a range of water salinities and depths for the different birds that use the Reserve. The water in the *gei wai* is controlled by the sluice gates and intertidal channels.

1.1 Regional and Global Context

The MPNR, and the larger Ramsar Site is a highly important staging area and wintering ground along the East Asian-Australasian Flyway (Figure 3) for many species of migratory waterbirds, among which are threatened and endangered species such as the black-faced spoonbill (*Platalea minor*), Saunders's gull (*Larus saundersi*), Nordmann's greenshank (*Tringa guttifer*), and several passerines. Nearly 10% of the

entire global population of black-faced spoonbill uses the Deep Bay area, including MPNR as a wintering ground. As such, MPNR has regional, and even global significance for migratory waterbird conservation as an integral core area along this 13,000 km-long avian ‘landscape’.



1.2 Local Biodiversity and Wise Use

In addition to its role in conserving migratory waterbirds, Mai Po is also a refuge for Hong Kong biodiversity, especially wetland and mangrove species. Species of note are: the Eurasian otter (*Lutra lutra*); leopard cat (*Felis bengalensis*); four-spot midget (*Mortonagrion hirosei*), a damselfly restricted to the coastal wetlands of Hong Kong, Japan, South China and Taiwan; and the Hong Kong bent-winged firefly (*Pteroptyx maipo*), named after Mai Po and representing the second species to be described under this genus. Two threatened freshwater turtles, Reeves’ Turtle (*Mauremys reevesii*) and Chinese Soft-shelled Turtle (*Pelodiscus sinensis*), have been recorded at MPNR.



Eurasian otter footage captured by camera trap in MPNR.

©WWF-Hong Kong

The *gei wai* represent a traditional, sustainable practice of wetland management for aquaculture – both fish and shrimp – using the tidal fluxes to maintain water conditions. These ponds provided habitat and food for many species of waterbirds, and the livelihood of fishermen. Most *gei wai* in MPNR are now managed at varying water regimes to provide habitats for the waterbird community, but five are still managed according to traditional practices.

1.3 Geology and Geological History

The soils in the reserve are mainly clay and silt, with poor drainage and are often anaerobic. The Yuen Long Basin, where the reserve is located, has a bedrock of sedimentary carboniferous sands (from 300 million ybp) with silts metamorphosed during the Jurassic period (150 million ybp). Microfossil evidence suggests that the area was once a neritic swamp (Langford *et al.* 1989).

During the last Ice Age, about 15,000 years ago, the sea level was about 120 m below what it is today, and the current location would have been inland from the shoreline (Irving and Morton 1988); thus the landscape was very different to what it is today. But with global warming, signaling the end of the Ice Age, sea levels rose, and the Yuen Long Basin was transformed into a broad alluvial plain, and the rivers within it deposited sands and clays. The rising sea levels also deposited a thick layer of clayey marine sediments, creating the large muddy deltaic floodplain.

Today, silt and sand deposition in the estuary and adjacent shores from the Shenzhen, Shan Pui, and Pearl Rivers continue to extend the land seawards. This shoreline progradation is also facilitated by sediment entrapment by the fringing mangroves, which also keep extending outwards.

1.4 Hydrology

Four rivers, Pearl River, Shenzhen River, Yuen Long River, and Dasha River, and their tributaries flow into the Deep Bay. Heavy discharges from these rivers during the wet season causes hydrological changes in the bay, including lower salinities. These hydrological changes also affect the hydrology and water conditions in the Reserve.

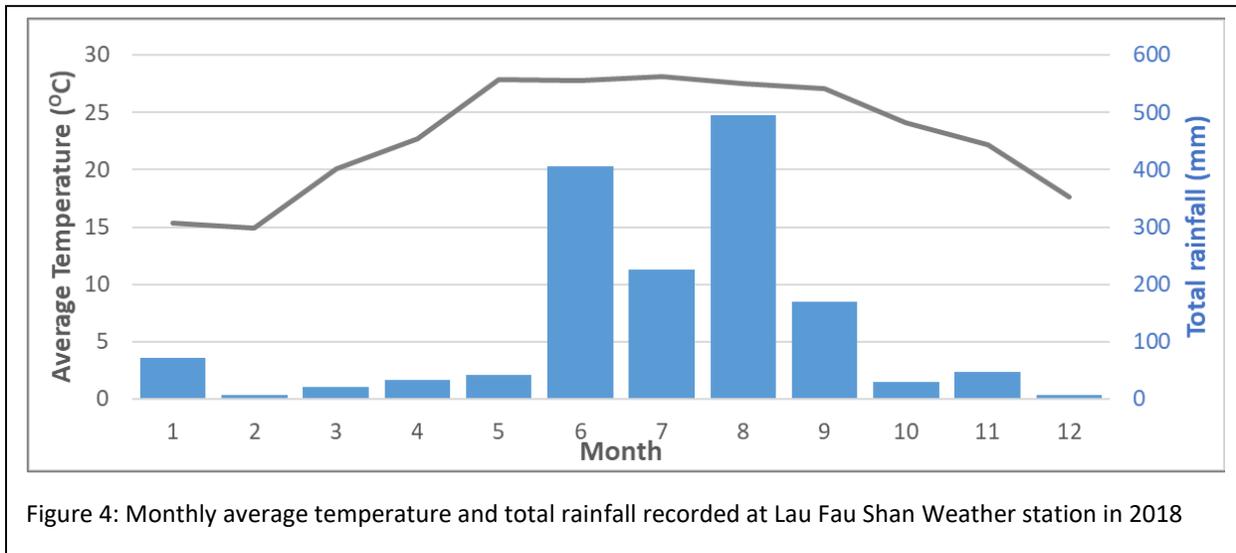
The Deep Bay has a tidal range of 3 m. Extensive mudflats are exposed during low tide, but are completely submerged at high tides of over 2.3 m above chart datum at Tsim Bei Tsui. The *gei wai* in the reserve are connected to the bay via seven intertidal channels, and regulated by 15 sluice gates (Figure 2). Water from the bay flushes into the *gei wai* when the tide is over 2.4 m above chart datum at Tsim Bei Tsui.

1.5 Climate

Overall, Hong Kong's climate is sub-tropical and humid, with almost half of the year being temperate. On average, the temperatures range from about 15 °C in the winter (December to February) to 28 °C in the summer (June to August) (Figure 4), although extreme temperatures of 1.7 °C and 36.8 °C have been recorded at the Lau Fau Shan weather station, about 5 km southwest of the Reserve (HKO, 2019).

The annual total rainfall recorded at Lau Fau Shan is usually lower (1,558 mm in 2018) compared to that recorded at the Hong Kong Observatory (2,163 mm) located about 25 km to the southeast, because the Deep Bay area is situated in the rain shadow of Tai Mo Shan. Most rainfall is recorded from June to September while December and February are the driest months (Figure 4).

Typhoons (tropical cyclones), occur from May to November, and bring extreme weather that can last for several days. The heavy rains, strong winds, storm surges and subsequent flooding impacts MPNR. In September 2018, typhoon Mangkhut, which was the most intense storm experienced in Hong Kong since records began, flooded the ponds and *gei wai* when the storm surge over-washed the mudflats and bunds along the coast. The surge and over-wash caused some sections of the seaward bunds of *gei wai* to collapse, and soil was washed into the perimeter channels of the *gei wai*, which affected the hydrological regimes. The roof and exterior walls of bird hides at GW #3, #20b and #21 were also damaged by the strong winds.



1.6 Climate Change Impacts

Climate change projections by the Hong Kong Observatory suggest that under high GHG emission scenarios the annual mean sea level in Hong Kong and its adjacent waters in 2081-2100 are expected to rise by 0.63-1.07 m relative to the average of 1986-2005 (Figure 5).¹ Rising sea levels and intrusion of salt water inland can affect MPNR. For example, the tidal mudflats and mangroves could migrate further inland, following the salinity gradient. Thus, maintaining the diversity of habitat types for the Mai Po faunal community will require management strategies that look to the future, including the possibility of managing freshwater and intertidal ponds further inland.

The Hong Kong Observatory's long-term data also shows that Hong Kong is becoming warmer (average temperature increased 0.18°C per decade in the period 1988 to 2017) and wetter (annual total rainfall increased 40 mm per decade during the period 1947 to 2017). The number of days with heavy rain (i.e., hourly rainfall greater than 30 mm) has also increased. A water height of 3.5 m that can cause serious flooding in low-lying areas, such as during Typhoon Hagupit in 2008, could become more frequent by the end of this century (HKO 2014)². Thus severe and extreme weather events due to climate change could have a bearing on many aspects of the management in the reserve.

¹ https://www.hko.gov.hk/climate_change/proj_hk_msl_e.htm downloaded 24 April, 2014

² https://www.hko.gov.hk/climate_change/proj_hk_msl_e.htm downloaded 24 April, 2014

Although there is no evidence that the numbers of typhoons have increased in recent years, warmer and wetter ocean conditions can produce more destructive tropical typhoons (Emmanuel 2005, Sun *et al.* 2017). The strong winds and storm surge from these extreme typhoons can potentially impact the MPNR ecosystems and infrastructure. Floods from typhoon Mangkhut clearly showed that there is a need to consider infrastructural changes and strengthening if maintaining the current habitat diversity remains the future goal for the reserve. If so, contingency plans for ecosystem shifts due to rising sea levels and below ground salt water intrusion should be considered now as adaptation strategies.

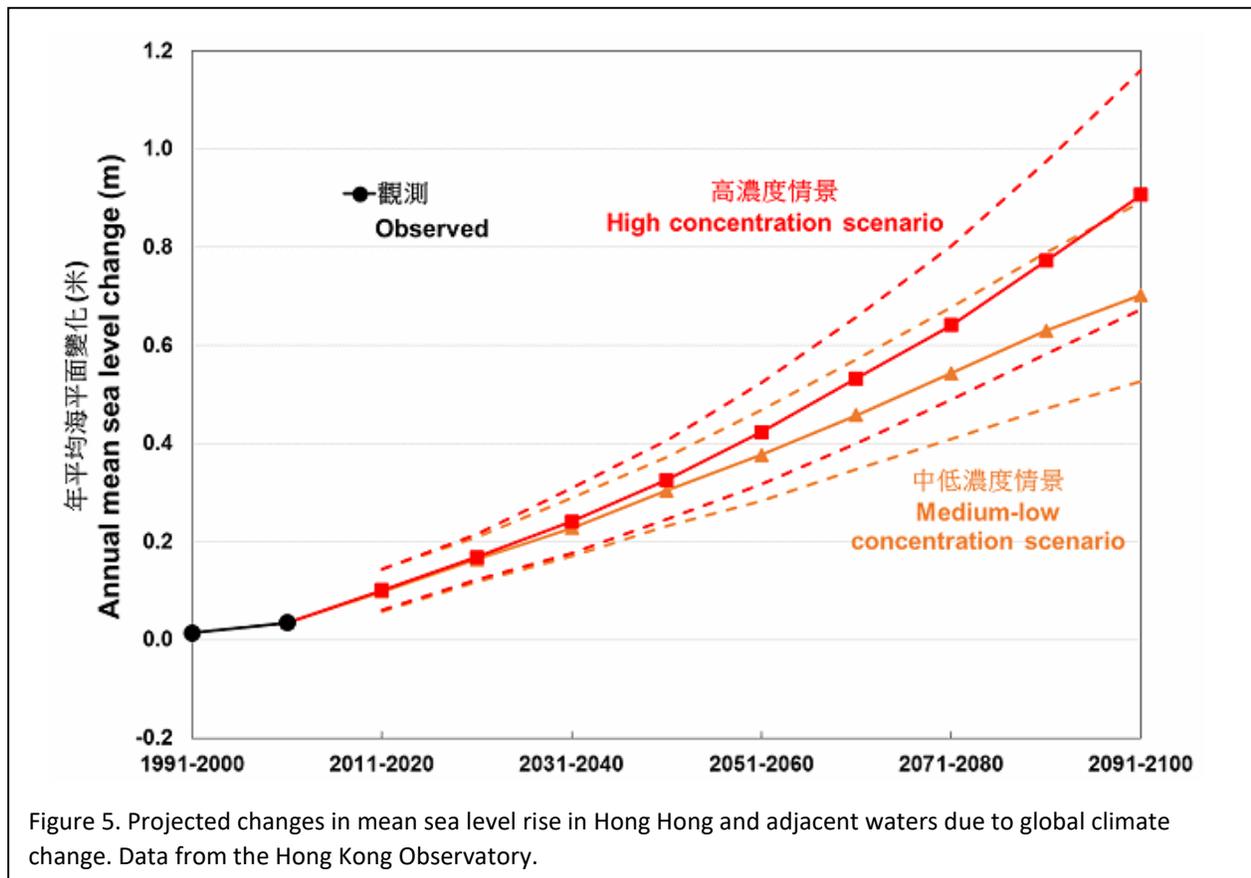


Figure 5. Projected changes in mean sea level rise in Hong Kong and adjacent waters due to global climate change. Data from the Hong Kong Observatory.

1.7 Biodiversity

Mai Po is renowned for its number and variety of birds. With 417 species (Appendix 2) recorded in the nature reserve and the Inner Deep Bay area, Mai Po and Inner Deep Bay was designated as an Important Bird Area (IBA HK001) in 2004 and declared as a Ramsar site in 1995 when it met four qualifying criteria (Table 1). In addition to birds, surveys have recorded 322 plant species, 25 indigenous mammal species, 21 indigenous reptiles, 54 fishes, and over 1,000 invertebrates (Appendices 1-5). Several of these are species of conservation importance, and protected under Hong Kong’s CAP. 170, CAP. 586 and CAP. 96.

Table 1. Mai Po Inner Deep Bay qualification criteria for Ramsar designation

Qualifying Criteria	Qualifying Target (1990-94)
Criterion 2. Support vulnerable, endangered, or critically endangered species or threatened ecological communities	13 globally threatened species
Criterion 3. Support populations of plants and/or animal species important for maintaining the biological diversity of a particular biogeographic region	Type locality for 13 endemic species (invertebrates)
Criterion 5. Regularly supports 20,000 or more waterbirds	Average of 48,500 waterbirds in Deep Bay
Criterion 6. Regularly supports 1% of individuals in a population of one species or subspecies of waterbirds	Six species having more than 1% threshold population of Eastern Asia

1.7.1 Flora

A detailed survey of the flora in the reserve was carried out from August-October 2016. Of the 322 species, 65% are indigenous, and 35% are exotic (Appendix 1). Four species are noteworthy. The small persimmon (*Diospyros vaccinioides*) is listed as Critically Endangered in the IUCN Red List (IUCN 2018), but regarded as Common to Very Common in Hong Kong. It was planted in 2006 as part of a “sensory trail” in several locations within the reserve, notably along the GW #12-#13 path, around Pond #16b, and around the rain-shelter at GW #19. The water fern (*Ceratopteris thalictroides*) is rare, listed as Vulnerable in the *Rare and Precious Plants of Hong Kong*, and is under State Protection (Category II) in China (AFCD 2017). This plant has limited distribution in the reserve (GW #7, #8b, #16/17, #18). The Hong Kong pavetta (*Pavetta hongkongensis*) is a locally protected species under Cap. 96A, and was planted in 2010 as part of a “sensory trail” along the GW #12-#13 path and around Pond #15b. Widgeon Grass (*Ruppia maritima*) is an uncommon species with a restricted distribution in Hong Kong. The species was recorded in GW #3, #4, #6, #7, #8b, #10-#13, #19b, #21 and #23a during a survey conducted from April to July 2018.



In spring, widgeon grass blooms in some gei wai, occupying water channels.

©Alex Ng/ WWF-Hong Kong

1.7.2 Fauna

Birds

The bird species in the reserve and the Deep Bay area have been systematically recorded since the 1950s. The numbers in Mai Po and Inner Deep Bay area represent about 75% of the total bird species that occur in Hong Kong. A full list of bird species is provided in Appendix 2.

Mai Po and the Inner Deep Bay regularly supports 22 species of globally threatened birds (IUCN 2018), and six additional shorebird species of regional conservation concern (WWF-Hong Kong, 2014) (Table 2). Twenty-nine other globally threatened bird species have been previously recorded and occur irregularly in the area. Fourteen waterbird species meet the 1% flyway population threshold under the Ramsar and

East Asian-Australasian Flyway Network Site criteria, and another 19 species meet the 0.25% staging threshold (Table 2).

Mai Po and the Deep Bay area supports 50,000-80,000 wintering waterbirds and another 20,000-30,000 shorebirds that pass through during their annual migration in spring and autumn. For black-faced spoonbill and the wintering duck, the peak numbers that the reserve ever supported were in 2013-2014, with over 97% and over 34%, respectively, of the total populations inhabiting the Deep Bay area (WWF-Hong Kong data). During the spring and autumn passage, the high-tide roosting sites in the reserve support about 80% and 87% of the total shorebird population in the Deep Bay area, respectively (AFCD 2015 data).

The reserve is also an important pre-roosting site for the collared crow (*Corvus torquatus*), which has recently been uplisted to Vulnerable on the IUCN Red List (IUCN, 2018). About 261 individuals have been recorded heading to roost in the intertidal mangrove adjacent to the Reserve (WWF-Hong Kong 2018 data), and this is the largest known roosting population in Hong Kong and the second most important area for the species globally (Leader *et al.* 2016).



GW #16/17, a high-tide roosting site serving thousands of waterbirds during high-tide in wintering season.

©WWF-Hong Kong

Table 2: Regularly recorded threatened bird species and bird species recorded in significant numbers

Bird species	IUCN Status	Shorebird regional red list	EAAF population	
			>1%	>0.25%
<u>Waterbirds</u>				
Northern Shoveler <i>Anas clypeata</i>				Y
Falcated Duck <i>Mareca falcata</i>	NT			
Northern Pintail <i>Anas acuta</i>				Y
Tufted Duck <i>Aythya fuligula</i>			Y	Y
Great Crested Grebe <i>Podiceps cristatus</i>				Y
Black-faced Spoonbill <i>Platalea minor</i>	EN		Y	Y
Great Egret <i>Ardea alba</i>				Y
Swinhoe's Egret <i>Egretta eulophotes</i>	VU			

Bird species	IUCN Status	Shorebird regional red list	EAAF population	
			>1%	>0.25%
Great Cormorant <i>Phalacrocorax carbo</i>			Y	Y
Black-winged Stilt <i>Himantopus himantopus</i>				Y
Pied Avocet <i>Recurvirostra avosetta</i>			Y	Y
Pacific Golden Plover <i>Pluvialis fulva</i>				Y
Grey Plover <i>Pluvialis squatarola</i>		NT		Y
Little Ringed Plover <i>Charadrius dubius</i>				Y
Kentish Plover <i>Charadrius alexandrinus</i>			Y	Y
Lesser Sand Plover <i>Charadrius mongolus</i>		EN		
Greater Sand Plover <i>Charadrius leschenaultii</i>		VU	Y	Y
Whimbrel <i>Numenius phaeopus</i>		NT		Y
Far Eastern Curlew <i>Numenius madagascariensis</i>	EN	NT		
Eurasian Curlew <i>Numenius arquata</i>	NT		Y	Y
Bar-tailed Godwit <i>Limosa lapponica</i>	NT	VU		
Black-tailed Godwit <i>Limosa limosa</i>	NT	NT	Y	Y
Ruddy Turnstone <i>Arenaria interpres</i>		NT		
Great Knot <i>Calidris tenuirostris</i>	EN	VU		
Red Knot <i>Calidris canutus</i>	NT	VU		
Broad-billed Sandpiper <i>Limicola falcinellus</i>				Y
Curlew Sandpiper <i>Calidris ferruginea</i>	NT	VU	Y	Y
Spoon-billed Sandpiper <i>Calidris pygmaea</i>	CR	CR	Y	Y
Red-necked Stint <i>Calidris ruficollis</i>	NT			Y
Dunlin <i>Calidris alpina</i>		VU		Y
Asian Dowitcher <i>Limnodromus semipalmatus</i>	NT	NT		Y
Terek Sandpiper <i>Xenus cinereus</i>				Y
Grey-tailed Tattler <i>Tringa brevipes</i>	NT	NT		
Common Redshank <i>Tringa totanus</i>			Y	Y
Marsh Sandpiper <i>Tringa stagnatilis</i>				Y
Wood Sandpiper <i>Tringa glareola</i>				Y
Spotted Redshank <i>Tringa erythropus</i>			Y	Y
Common Greenshank <i>Tringa nebularia</i>			Y	Y
Nordmann's Greenshank <i>Tringa guttifer</i>	EN	EN	Y	Y
Black-headed Gull <i>Chroicocephalus ridibundus</i>				Y
Saunders's Gull <i>Chroicocephalus saundersi</i>	VU			Y

Bird species	IUCN Status	Shorebird regional red list	EAAF population	
			>1%	>0.25%
Gull-billed Tern <i>Gelochelidon nilotica</i>				Y
Wetland dependent species				
Greater Spotted Eagle <i>Clanga clanga</i>	VU			
Eastern Imperial Eagle <i>Aquila heliaca</i>	VU			
Collared Crow <i>Corvus torquatus</i>	VU			
Manchurian Reed Warbler <i>Acrocephalus tangorum</i>	VU			
Styan's Grasshopper Warbler <i>Locustella pleskei</i>	VU			
Yellow-breasted Bunting <i>Emberiza aureola</i>	CR			

Data source: Mai Po Inner Deep Bay Ramsar Site Waterbird Monitoring Programme (2014-15, 2015-16, 2016-17 & 2017-18), AFCD data.

Mammals

Baseline surveys conducted by AFCD and WWF-Hong Kong (2015-17), have listed 25 indigenous and eight introduced mammals in the reserve (Appendix 3). Bats represent the majority of the former, with 13 species. Two species of indigenous mammals are of conservation interest; namely the Eurasian otter (*Lutra lutra*) and leopard cat (*Prionailurus bengalensis*). The former is globally red-listed as Near Threatened (Roos *et al.* 2015). Both are nocturnal carnivores and can play a significant role in structuring the ecological community of the reserve, as well as being charismatic species that can add to the reserve’s appeal among visitors.

Researchers from the University of Hong Kong have recorded evidence of otters in the brackish *gei wai* and rain-fed ponds. Camera trap photographs of a female with pups indicate a breeding population. No research has been conducted on the leopard cat.



Leopard Cat

© WWF-Hong Kong



Small Asian Mongoose

© Roger Lee



Japanese Pipistrelle

© Augustine Chung/WWF-Hong Kong

Reptiles and Amphibians

Twenty-one indigenous reptile species (two turtles, six lizards and 13 snakes) and eight indigenous amphibian species have been recorded in the reserve (Appendix 4). The former includes several globally threatened species, namely the Endangered Reeves’ turtle (*Mauremys reevesii*) and the Vulnerable Chinese soft-shelled turtle (*Pelodiscus sinensis*), Burmese python (*Python bivittatus*), Chinese cobra (*Naja*

atra), king cobra (*Ophiophagus hannah*) and mangrove water snake (*Enhydris bennettii*). The Reeves' turtle has not been recorded in the reserve since 2010 and its current status in the reserve is unknown.

Fish

Fifty-four species of fish have been recorded in the reserve (Appendix 5). Twenty are new records made during surveys conducted from 2015-17. Surveys show that brackish *gei wai* are dominated by bald glassy (*Ambassis gymnocephalus*), ladyfish (*Elops saurus*), grey mullet (*Mugil cephalus*), green-backed mullet (*M. dussumieri*) and tilapia (*Oreochromis* spp), while the rain-fed ponds are dominated by mosquito fish (*Gambusia affinis*).

Invertebrates

Surveys from 2015-17 (and before) have recorded 51 species of odonates, 105 butterflies, 316 moths, >15 ants, 155 bees and wasps, >400 beetles and weevils, >100 spiders, 12 shrimps, and 41 crabs. Many of these are still being identified. The dominant shrimps in the *gei wai* are *Metapenaeus* spp. and *Macrobrachium* sp., and the dominant crabs are *Scylla serrata* and *Varuna litterata*. The sesarmine crab, (*Perisesarma maipoensis*), which was first discovered in Mai Po in late 1970s and only recorded in Deep Bay (Hong Kong and Shenzhen), Macau and Vietnam, has not been recorded in recent years.

The four-spot midget (*Mortonagrion hirosei*) damselfly is globally listed as Near Threatened (Wilson and Reels 2011), but is common in the intertidal mangroves adjacent to the reserve. Three moths, Mai Po Jade Looper (*Thalassodes maipoensis*), *Schrankia bilineata*, and *Athetis hongkongensis* are endemic to Hong Kong. The Hong Kong bent-winged firefly (*Pteroptyx maipo*), is endemic to the Deep Bay. This firefly was first discovered in 2010, and populations seem to be highest around the water channel along the southern boundary of the reserve (WWF-Hong Kong data). *Orphinus barthelemyi* is a mangrove-associated Dermestid beetle that was discovered and described from GW #18 in 2014 (Kadej *et. al*, 2015). *Olios* sp., is a species of spider found in the mangroves and described in 2016, and now awaiting publication (Alex Ng *pers. comm*).



Olios sp.

©Alex Ng/ WWF-Hong Kong



Four-spot Midget

©Lai Nga Yee/ WWF-Hong



Hong Kong Bent-winged Firefly.

©Tony Hung

1.7.3 Habitats

MPNR consists of man-made intertidal shrimp ponds and rain-fed ponds that are now managed to provide various foraging and roosting habitats around and within the ponds by regulating the water regimes. Each pond and *gei wai* is surrounded by earth bunds that separate the water bodies. Overall, these ponds can be classified into five major habitat types based on the water levels and dominant vegetation (Figure 2). But within each pond there are several other habitats represented to support various species and their behavioural requirements (Figure 6).

The major habitats represented in the *gei wai* and ponds are:

1. **Shallow water high-tide roosting area.** Total area = 45.9 ha. Pond #8a, GW #11a, GW #16/17, GW #21, GW #22, GW #23a. These are rain-fed pond (pond #8a) or brackish *gei wai* (GW #11a, GW #16/17, GW #21 and GW #23a) where water levels are kept shallow during the operational season to provide open water habitat and low-profile islands (2.9 ha) as roosting sites for waterbirds during high-tide in Deep Bay.
2. **Reedbed-dominated area.** Total area = 43.5 ha. GW #8b, Pond #9, GW #10, GW #11b, GW #14 (landward side), GW #23b. About 20ha (46%) of the reedbed consists of the common reed (*Phragmites australis*). Stands are either fragmented by water channels or internal earth bunds. The reedbeds consist of wet reedbeds, which are always inundated and grow as emergent vegetation, and dry reedbeds that can be mixed among other terrestrial vegetation. The habitat is managed to support reedbed-dependent bird species such as *Acrocephalus* warblers, bitterns and purple heron and invertebrates, especially dragonflies and damselflies.
3. **Traditionally-operated brackish *gei wai*.** Total area = 48.2 ha. GW #12, GW #13, GW #14, GW #18b, GW #19b. Areas of dense mangroves dominated by *Kandelia obovata* and *Aegiceras corniculatum* (~20 ha) fragmented by water channels or internal earth bunds characterize this habitat. The understory is dominated by spiny bear's breech (*Acanthus ilicifolius*). Water levels are maintained at >1m in the water channels. The mangroves provide refuge for wildlife and organic matter as food for benthic organisms that forms the base of the food web. Aquatic fauna, such as shrimp and fish feed on the benthic organic matter and organisms, and the waterbirds feed on the aquatic fauna, especially when the water level is lowered with periodic draining of the ponds.
4. **Open water-dominated brackish *gei wai*.** Total area = 37.6 ha. GW #3, GW #4, GW #6, GW #7. Scattered mangroves (~8 ha) and reedbeds (0.2 ha) are interspersed in these ponds. Water levels are managed at low levels to provide shallow open water roosting habitat for waterbirds in winter (November to March). Channels provide habitat for aquatic fauna that is food for waterbirds when the water level is lowered after draining.
5. **Rain-fed ponds.** Total area = 42.4 ha. Pond #15, Pond #16a/b, Pond #17b, Pond #18a, Pond #19a, Pond #20, Pond #24. Ponds are maintained by collecting rainwater as the main freshwater source. They are managed at various water depths from 10 to 170 cm, and dominated by patches of sedges, reeds, and other herbaceous plants. Low-profile islands (0.1 ha) are maintained in some ponds. These ponds provide habitat for dragonflies, Eurasian otter, and turtles.
6. Bunds, vegetated with grass, shrubs, and trees, provide habitat for terrestrial birds. However, Guinea grass (*Panicum maximum*) and the invasive mile-a-minute weed (*Mikania micrantha*) are also common.

The current distribution and extent of these habitats are shown in Figure 6a, while Figure 6b shows the changes to these habitats proposed under this management plan.

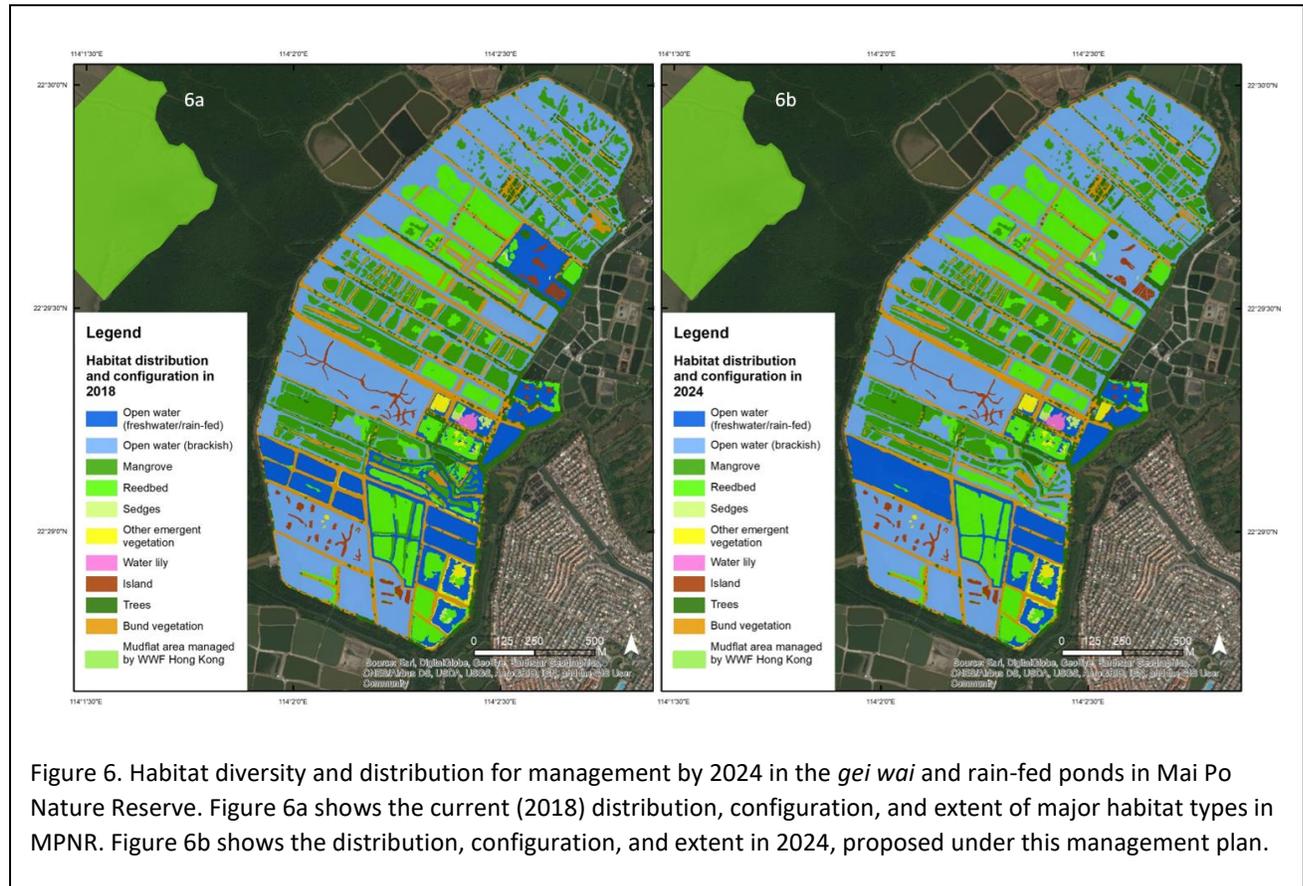


Figure 6. Habitat diversity and distribution for management by 2024 in the *gei wai* and rain-fed ponds in Mai Po Nature Reserve. Figure 6a shows the current (2018) distribution, configuration, and extent of major habitat types in MPNR. Figure 6b shows the distribution, configuration, and extent in 2024, proposed under this management plan.

1.7.4 Ecosystem Processes and Wider Ecological Links

The ponds in MPNR are adjacent to, and contiguous with, the expanse of fringing mangroves and mudflats that form the core area of the Ramsar site. These ecosystems are linked by the dynamics of tidal fluctuations. The waterbirds also use these contiguous ecosystems for feeding and roosting. On the landward side, the *gei wai* and ponds in the nature reserve are contiguous with commercial fish ponds, including a few that are non-functional. Some of the latter have now succeeded into dense stands of mature grasslands, dominated by Guinea grass. On a regional scale, MPNR is ecologically linked to other wetlands along the EAAF by bird migrations.

1.7.5 Current Wise Use and Cultural Values

The Mai Po *gei wai* have significant cultural value as the few remaining examples in Hong Kong to showcase the traditional way of farming penaeid shrimp (*gei wai* shrimp), utilizing the naturally high productivity of the estuary, and the tidal flux to regulate the condition of the water in the ponds. The first *gei wai* in Mai Po was constructed by immigrants from Mainland China who settled around Deep Bay after World War II. The peaks of Tai To Yan and Kai Kung Leng to the east of the area were used as landmarks to construct the perimeter bunds of the *gei wai* and eventually 19 *gei wai* covering 192 ha were constructed and operated by communities from both the mainland and Hong Kong sides of Deep Bay.

With the improvement in aquaculture and better economic return in the late 1960s, *gei wai* were converted to deep water ponds, including some *gei wai* at the southern end of the reserve (Pond #15, #20, #22 & #24). Although the conversion of *gei wai* at the northern end of the reserve (GW #3, #4, #6, #7, #10 and #11) was prohibited by the government, the sluice gates were still blocked, so they could be used as ponds. In 1987, these seven *gei wai* were restored to resume traditional *gei wai* operations. In the central part of the reserve, GW #12 to #19 were maintained throughout as traditional *gei wai* with no changes.

Today, most of the traditionally operated *gei wai* in Hong Kong are in MPNR and managed by WWF-Hong Kong for their biodiversity and cultural heritage value. They now showcase the “wise use of wetlands” as a practice that utilizes natural resources sustainably while benefiting wildlife. In 2014, “*Gei Wai* Operation Technique” was included in the First Intangible Cultural Heritage Inventory of Hong Kong under the “traditional craftsmanship” domain (LCSD, 2014).

1.8 Institutional Management Arrangements

MPNR is vested within the Hong Kong SAR Government and administered by the Agriculture, Fisheries and Conservation Department (AFCD). WWF-Hong Kong has been granted an annually renewable conditional license to manage MPNR, and also to manage a 45 ha extent of mangrove and mudflat in the intertidal area adjacent to the nature reserve under a service contract and permission from the District Lands Office (Figure 2).

The Mai Po Inner Deep Bay Ramsar Site Management Plan (AFCD 2011), sets out the broad context for managing the MPNR. Based on this, WWF-Hong Kong develops the management plan for the MPNR every five years, under advice of the Mai Po Management Committee, which has representation from the AFCD, local academics, wetland managers, researchers and local environmental NGOs. Committee membership is renewed every five years following the lifespan of the management plan.



Facility signages of Agriculture, Fisheries and Conservation Department and WWF-Hong Kong, located at the entrance of the Reserve.

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2 BRIEF REVIEW OF PREVIOUS MANAGEMENT PLAN AND OUTCOMES

During the previous five-year management plan (2013-2018) most (93%) of the recurrent work listed in the plan were successfully implemented (Appendix 7a). These included: controlling vegetation on bunds, islands, channels, and pathways in and along the BMZs and visitor areas; controlling invasive species; maintaining water quality and levels; and draining *gei wai* to provide feeding habitats for waterbirds as well as to remove large, predatory fishes as scheduled in accordance with management prescriptions. Activities to control feral dogs were carried out, including programmes to trap, neuter and release dogs. Equipment and infrastructure maintenance was carried out as scheduled (Appendix 7b).

Major habitat management activities are presented in Appendix 7c. These include: desilting *gei wai* channels, ponds, and reedbeds; restoring and building islands as planned to provide habitat; and renovating and strengthening bunds.

The five-year monitoring plan was also completed successfully and according to plan (Appendix 7d). Completed bird counts and surveys include: roosting lack-faced spoonbill; roosting ducks; shorebirds; terns; roosting collared crows; breeding black-winged stilt; and use of mudflats by waterbirds. Morning bird counts were conducted as specified in the plan. The use of *gei wai* by spoonbills, egrets, and herons during *gei wai* drawdown was monitored. Amphibian and adult odonate surveys were also conducted. Water levels, depths, and quality was monitored. The various habitats were mapped and records retained through fixed point photographs.

Several research projects were scheduled during this period (Appendix 7e). Two projects; i.e., a comparison of bird species richness and diversity of wet and dry reedbeds and a bird ringing programme were completed with cooperation of external parties. Proposed studies on the management of the *gei wai* mangroves and associated vegetation, the ecological value of freshwater habitats in MPNR, and a climate impact analysis were, however, not done due to lack of resources and funding.



Desilting of gei wai channel, one of the major habitat management work in summer.

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3 BIODIVERSITY CONSERVATION PROGRAMME

3.1 Biodiversity Conservation Targets

Several species and ecosystems were identified as conservation targets for MPNR (Table 3). These include threatened species, important migratory birds, endemic species, and apex predators.

Table 3. Conservation targets identified for Mai Po Nature Reserve, and the rationale for selecting these targets.

Conservation Target	Rationale for selection
Black-faced Spoonbill	An endangered species. MPNR and the Deep Bay is one of the most important wintering areas for this species along the EAAF, with up to 8.6% global population recorded in January 2019. Historically Mai Po and Inner Deep Bay has contributed significantly towards its population recovery and it remains a flagship species for the Reserve.
Shorebird assemblage	MPNR provides wintering habitat and a stop-over site along the EAAF for an assemblage of 12 threatened shorebird species, including the Critically Endangered spoon-billed sandpiper and Endangered Nordmann's greenshank
Duck assemblage	MPNR provides foraging and roosting habitat for nearly 40% of the Deep Bay duck population.
Breeding Black-winged Stilt	MPNR is one of the two breeding sites in Hong Kong for this species.
Reedbed dependent bird assemblage	Several species of threatened and/or migratory warblers for which very limited habitat is now available in south China, and other species such as Eurasian Bittern winter in MPNR and use the reedbeds.
Ardeids	The assemblage of herons and egrets are apex predators in the reserve and play an important role in maintaining ecological structure of the wetlands.
Collared Crow	The reserve is an important pre-roosting area for this species, considered to be globally vulnerable. The population is the largest known in Hong Kong, and the second most important globally.
Eurasian Otter	A small breeding population is present in the reserve. As an apex predator, otters could play an important role in maintaining ecological structure of the wetland. Mai Po and Deep Bay area is one of the few remaining sites for them in South China.
Hong Kong Bent-winged Firefly	This newly discovered species is endemic to the Deep Bay area.
Turtles	Reeves' Turtle and the Chinese Soft-shelled Turtle are both threatened species that have been recorded from the reserve. However, neither species has been recorded in recent years.
Four-spot Midget	Hong Kong is one of the few places in the world where this species can be found.

Black-faced Spoonbill: The flagship for MPNR. Trend data shows that the population of black-faced spoonbill in the Deep Bay has begun to stabilize and may even be slightly increasing (Figure 7; Sung *et al.* 2018). Between 2010 and 2014, the number of wintering spoonbills declined from 462 to 252, which could be attributed to a decline in the food availability and feeding habitats, and possibly high levels of water pollutants (see citations in Sung *et al.* 2018), the expansion of exotic mangrove species (*Sonneratia caseolaris* and *S. apetala*), and siltation and loss of fishponds (WWF-Hong Kong 2013). However, there has been an increase in arrivals since, and the trends (albeit a weak correlation) indicate an increasing population (Figure 7). Despite the net increase, the populations could be susceptible to abrupt declines, including to the threat of disease (Sung *et al.* 2018).



Black-faced Spoonbills in breeding plumage
©Caleb Choi/ WWF-Hong Kong

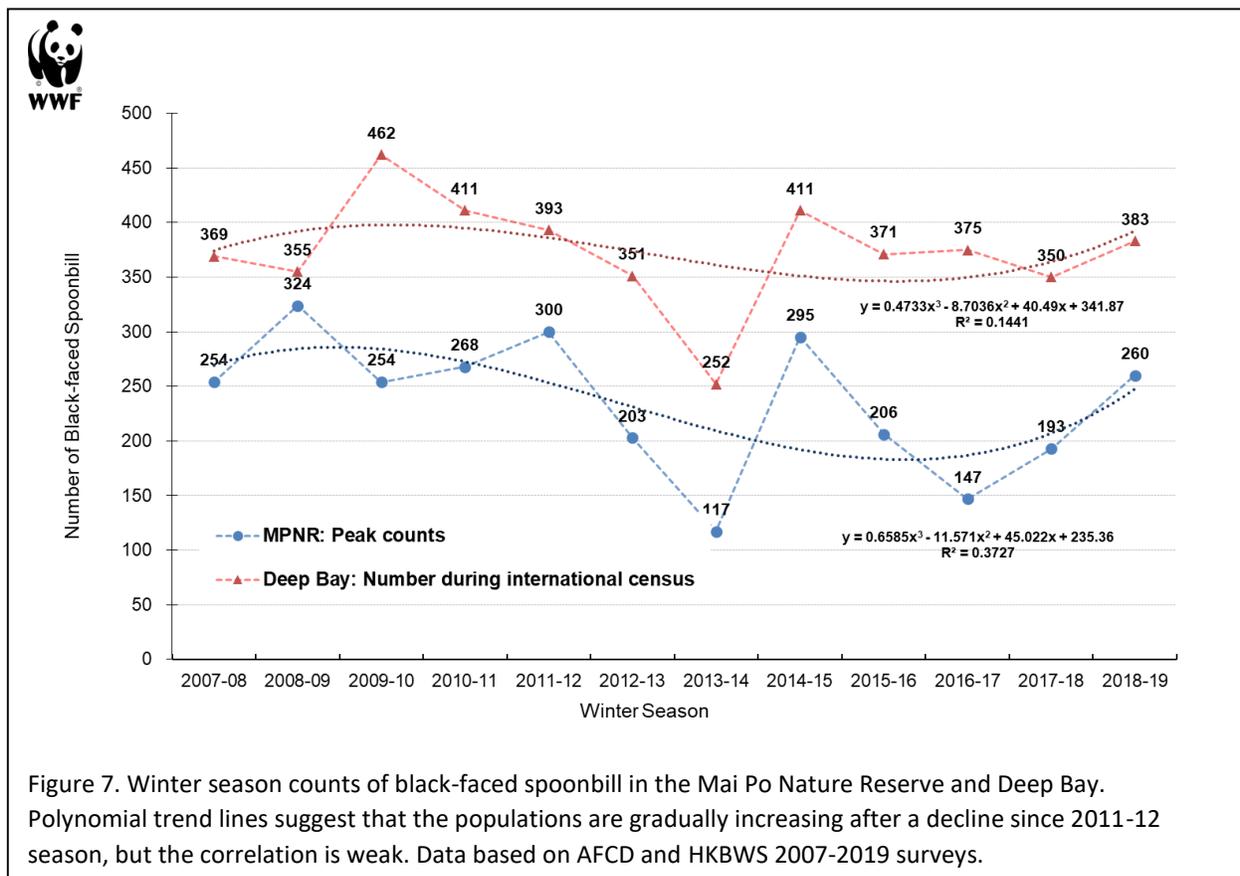


Figure 7. Winter season counts of black-faced spoonbill in the Mai Po Nature Reserve and Deep Bay. Polynomial trend lines suggest that the populations are gradually increasing after a decline since 2011-12 season, but the correlation is weak. Data based on AFCD and HKBWS 2007-2019 surveys.

Shorebird assemblage: The reserve and the Deep Bay supports 50,000-80,000 waterbirds in winter, and another 20,000-30,000 passage migrant shorebirds during spring and autumn (AFCD 1998-2018 data). The high tide roosting sites in the reserve supports over 80% of the passage migrants, especially in BMZ 5 and 7, where the shallow water and low islands provide habitat for these birds. Several species that use Mai

Po and the Inner Deep Bay as a staging area or wintering ground are threatened and endangered: namely, the Critically Endangered spoon-billed sandpiper (*Calidris pygmaea*); and the Endangered great knot (*Calidris tenuirostris*), far eastern curlew (*Numenius madagascariensis*) and Nordmann's greenshank (*Tringa guttifer*). In addition, the following species are Near Threatened: Eurasian curlew (*Numenius arquata*), bar-tailed godwit (*Limosa lapponica*), black-tailed godwit (*Limosa limosa*), red knot (*Calidris canutus*), curlew sandpiper (*Calidris ferruginea*), red-necked stint (*Calidris ruficollis*), Asian dowitcher (*Limnodromus semipalmatus*) and grey-tailed tattler (*Tringa brevipes*).

These species, together with the black-winged stilt (*Himantopus himantopus*), pied avocet (*Recurvirostra avosetta*), Pacific golden plover (*Pluvialis fulva*), grey plover (*Pluvialis squatarola*), little ringed plover (*Charadrius dubius*), Kentish plover (*Charadrius alexandrinus*), greater sand plover (*Charadrius leschenaultia*), whimbrel (*Numenius phaeopus*), broad-billed sandpiper (*Limicola falcinellus*), dunlin (*Calidris alpina*), terek sandpiper (*Xenus cinereus*), common redshank (*Tringa totanus*), marsh sandpiper (*Tringa stagnatilis*), wood sandpiper (*Tringa glareola*), spotted redshank (*Tringa erythropus*) and common greenshank (*Tringa nebularia*) are represented in Mai Po and Inner Deep Bay by >0.25% of the EAAF population, contributing to eligibility of the reserve and its surrounding wetlands as an EAAF network site.



Shorebirds forage in Deep Bay intertidal mudflat when tidal level is favourable.

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The winter populations of the shorebird assemblage increased considerably after 2004-05, but declined from 2012-13, and then increased again after 2016-17 (Figure 8). A fitted exponential regression suggests that populations may continue to increase.

Duck assemblage: Twenty-six species of ducks have been recorded from Mai Po (Appendix 2), including several threatened species and those represented by >0.25% of the EAAF population, namely, northern shoveler (*Anas clypeata*), falcated duck (*Anas falcate*), northern pintail (*Anas acuta*), and tufted duck (*Aythya fuligula*). The *gei wai* in the MPNR that are managed as roosting sites supports up to 40% of the duck population in the Deep Bay. Peak counts in BMZ 5 and BMZ7 can exceed 4,000 individuals.

The annual winter population trends fluctuate considerably, with high counts during 2006-07 and 2011-12 (Figure 8). Since then however, the populations have declined. Despite an increase between 2014-15

and 2016-17 the populations have not reached the previous high counts. A fitted exponential regression suggests that populations may continue to increase, although the correlation was relatively weak ($R^2 = 58$); thus, the populations should be closely monitored.

Ardeids: The nature reserve supports a diverse community of egrets, comprising of the eastern cattle egret (*Bubulcus coromandus*), great egret (*Ardea alba*), intermediate egret (*Ardea intermedia*), little egret (*Egretta garzetta*), black-crowned night heron (*Nycticorax nycticorax*), Chinese pond heron (*Ardeola bacchus*), grey heron (*Ardea cinerea*), purple heron, striated heron (*Butorides striata*), Pacific reef heron (*Egretta sacra*), and Chinese egret (*Egretta eulophotes*). Little egret, great egret and intermediate egret occur in large numbers and depend on the *gei wai* and ponds for foraging habitats, especially in the winter. Egrettries are present outside, but close to the reserve and these trees should be protected. Aggregations of grey heron (*Ardea cinerea*) also depend on these wetlands, along with the community of smaller herons. Winter population trends suggest that the populations are relatively stable (Figure 8).

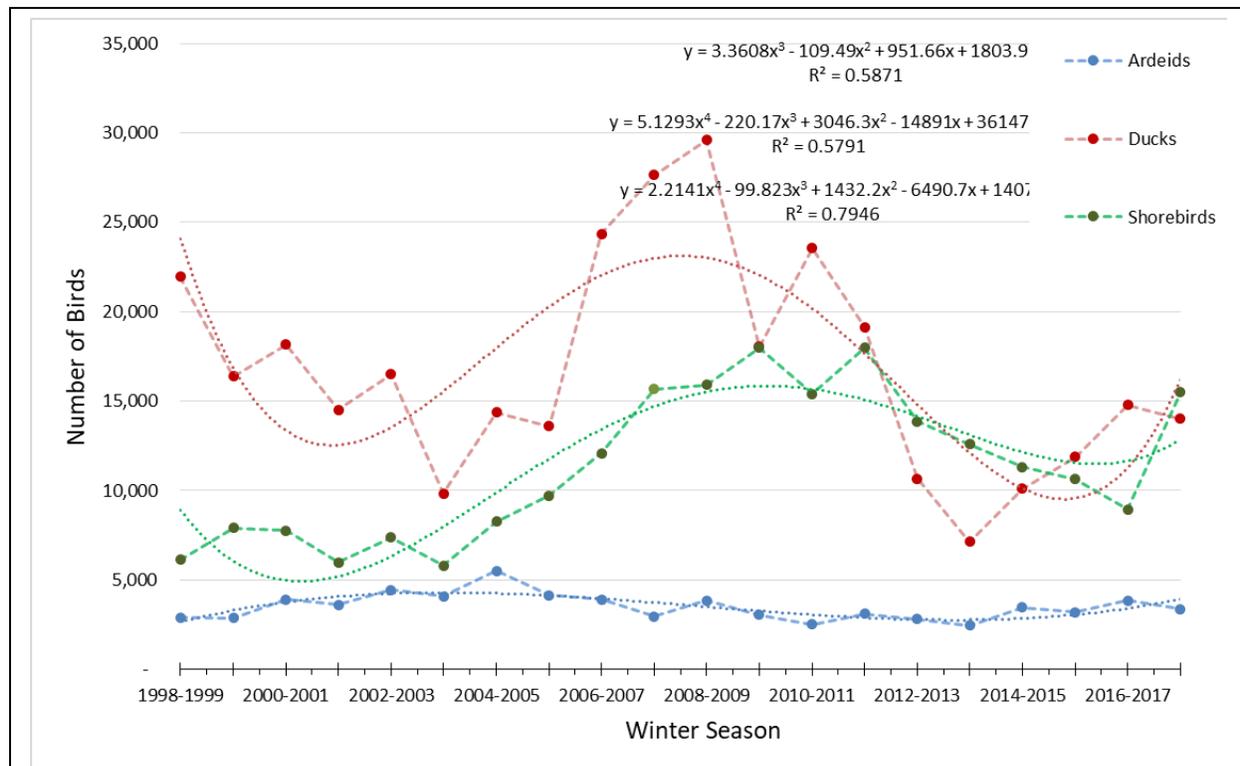
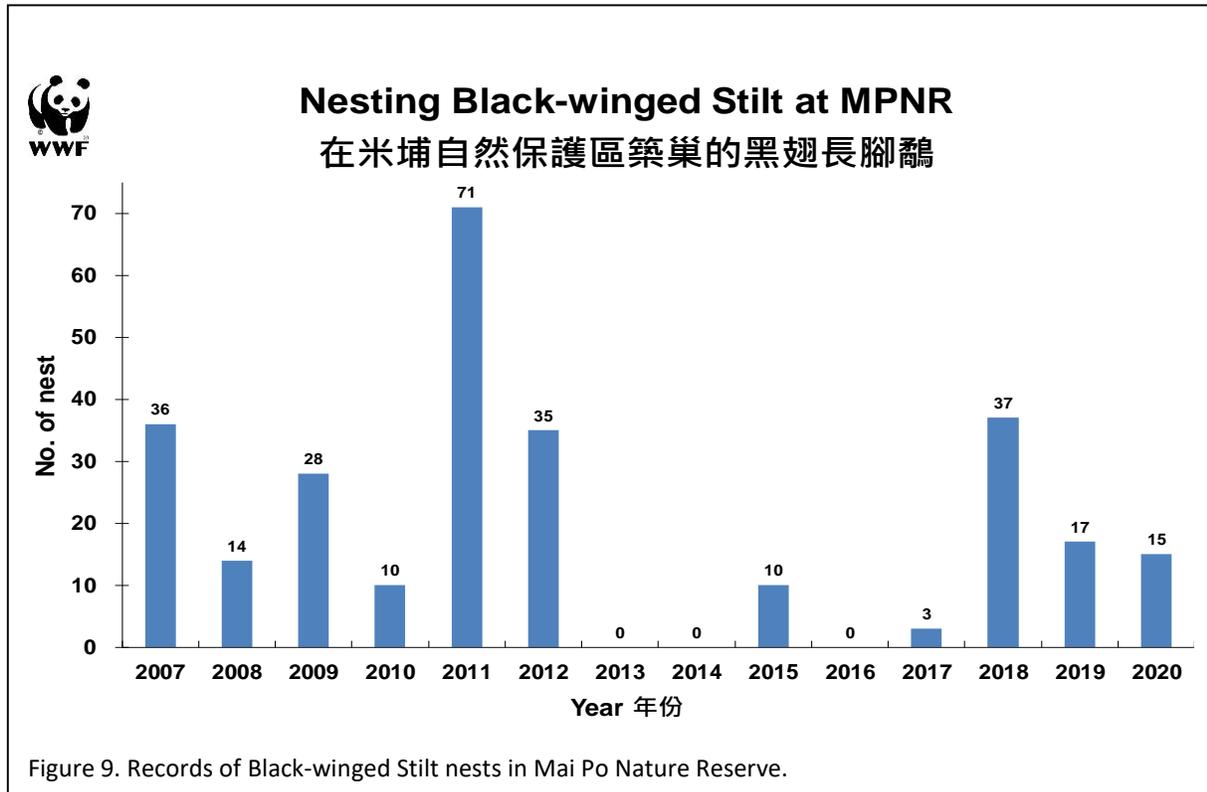


Figure 8. Population trend indicators for ardeids, ducks (the numbers include grebes and pelicans, which have been aggregated into the data), and shorebirds based on winter bird counts. The numbers represent the monthly averaged counts from November to February, considered to be the peak season for winter migrants. The data were averaged from the four month period to avoid double counts and to account for slight annual shifts in arrivals. The fitted polynomial regression lines show correlations through the years for all three groups, and suggest that the arrival of shorebirds and ducks fluctuate considerably through the years. Data from Waterbird Monitoring Programme by AFCD.

Breeding Black-winged Stilt: Black-winged stilts are usually a passage migrant and winter visitor to Deep Bay, but on occasion they also breed in the reserve. Breeding has been recorded between 2007-2012 and in 2015 and 2018. A record of 68 breeding pairs was observed in 2011 (Figure 9). Mai Po is one of only two breeding sites in Hong Kong. The black-winged stilt is also a species that is represented by >0.25 population threshold that qualifies Mai Po and Inner Deep Bay for EAAF network site status.



Reedbed-dependent bird assemblage: Reedbeds provide important feeding and roosting sites for passage and wintering passerines, but are declining habitats throughout southern China. In MPNR, the reedbed-dependent bird assemblage includes several passerine bird species, including warblers [Manchurian reed warbler (*Acrocephalus tangorum*; VU), Styan's grasshopper warbler (*Helopsaltes pleskei*; VU), Oriental reed warbler (*Acrocephalus orientalis*), black-browed reed warbler (*Acrocephalus bistrigiceps*), blunt-winged warbler (*Acrocephalus concinens*), paddyfield warbler (*Acrocephalus agricola*), baikal bush warbler (*Locustella davidi*), Middendorff's grasshopper warbler (*Helopsaltes ochotensis*), Pallas's grasshopper warbler (*Helopsaltes certhiola*)]; five buntings [yellow-breasted bunting (*Emberiza aureola*; CR), chestnut-eared bunting (*Emberiza fucata*), littleunting (*Emberiza pusilla*), black-faced bunting (*Emberiza spodocephala*), common reed bunting (*Emberiza schoeniclus*); prinias [plain prinia (*Prinia inornata*) and yellow-bellied prinia (*Prinia flaviventris*)]; Chinese penduline tit (*Remiz consobrinus*); scaly-breasted



Reedbeds support bird species such as the Purple Heron, a resident species of Mai Po.

©Anaus Lau

munia (*Lonchura punctulata*); and Siberian rubythroat (*Calliope calliope*). The reedbeds also support the largest known night roosts for the barn swallow (*Hirundo rustica*) and eastern yellow wagtail (*Motacilla flava*) in Hong Kong. Other birds that use the reedbeds for refuge, breeding, and foraging include several bitterns, namely yellow bittern (*Ixobrychus sinensis*), cinnamon bittern (*Ixobrychus cinnamomeus*), Eurasian bittern (*Botaurus stellaris*), and purple heron (*Ardea purpurea*) (Hong Kong Ringing Group unpubl. data).

In MPNR, the reedbeds consist of wet reedbeds, which are always inundated, and grow as emergent vegetation, and dry reedbeds that are mixed with other terrestrial vegetation. Recent surveys by the Hong Kong Bird Ringing Group shows that the wet reedbeds support greater numbers and diversity of birds, relative to dry reedbeds (Allcock *et al.* 2018). It is likely that the wet reedbeds provide refuge from predators, such as feral cats, mongooses, and even the Red Imported Fire Ants.

Collared Crow: The global population of this species is declining at a moderately rapid rate, likely due to prey depletion from agricultural intensification and the over-use of pesticides and rodenticides; thus the species is listed as Vulnerable (BirdLife International 2018). Mai Po has the largest known roosting population of collared crows in Hong Kong and is also considered to be the second most important area for this species globally (Leader *et al.* 2016). The population in Mai Po grew steadily over eight years between 2005 and 2013, from an estimated summer population of 81 individuals to a high of 167 in 2013 (Stanton *et al.* 2014). The population has continued to increase since then and the summer peak count in 2018 stood at 261 individuals (Figure 10). A continued increase at a similar rate should result in a population approaching 400 within the next five years (Figure 10).

The crows use the trees and snags, but also sparsely vegetated islands and bunds in the southern and southwestern *gei wai* and ponds (BMZ 5, 6, 7) as pre-roost sites where they gather before leaving for the roosting site in the dense stand of *Kandelia obovata* dominated intertidal mangrove (Stanton *et al.* 2014; Figure 11).



The MPNR supports the largest known roosting population of Collared Crows in Hong Kong.

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The population in the Deep Bay seems to be isolated, and there is no evidence of supplementation by northern migrants. The roosting flocks are comprised of birds that use the fishponds to the south of the reserve to forage; as such, loss, degradation, or conversion of these foraging habitats into other land uses could cause a population decline (Stanton *et al.* 2014). It was also reported that the species bred in the MPNR in 2019 (Leader, personal communication, 2019). Although there are similar fish ponds to the north of the Reserve, hardly any crows have been observed in them (Stanton *et al.* 2014).

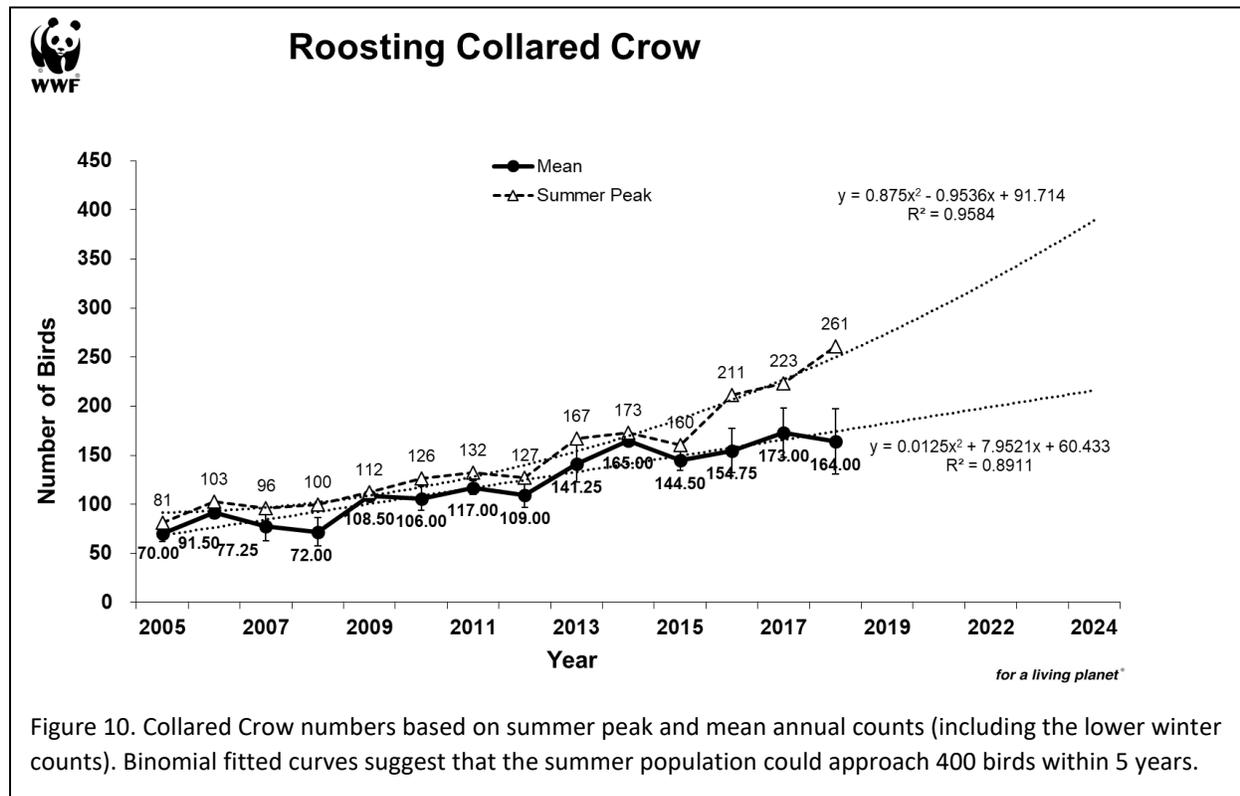


Figure 10. Collared Crow numbers based on summer peak and mean annual counts (including the lower winter counts). Binomial fitted curves suggest that the summer population could approach 400 birds within 5 years.

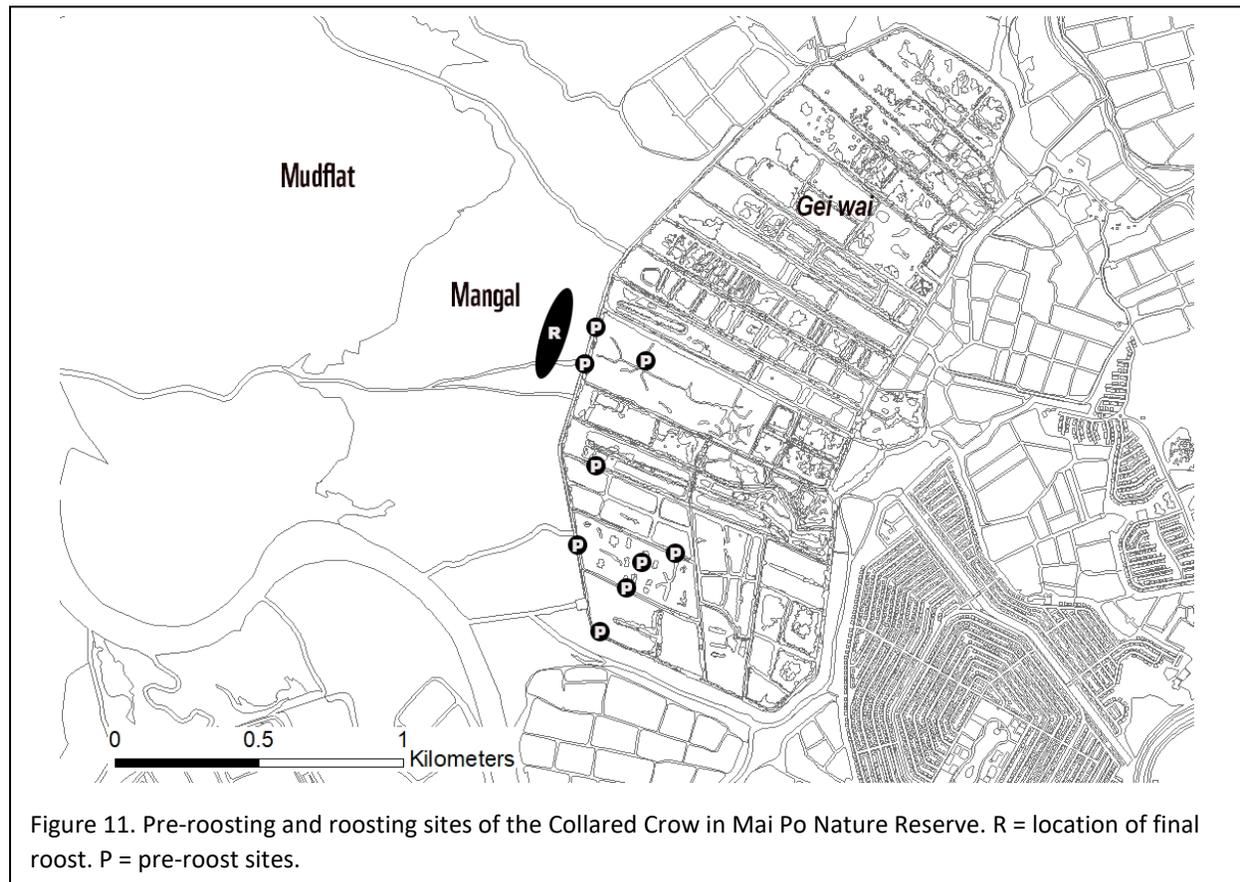


Figure 11. Pre-roosting and roosting sites of the Collared Crow in Mai Po Nature Reserve. R = location of final roost. P = pre-roost sites.

Eurasian Otter: Mai Po Nature Reserve supports a small, breeding population of otters. A limited camera trap programme implemented by WWF-Hong Kong in 2015 has confirmed presence in and around pond #15c, #16b and the sluice gate of GW #19. Previous records (2002-2009) have confirmed presence in GW #8, #10, #11, #19, #22, and #24, suggesting that otters could be – or were – much more widespread across the reserve. Yiu (2011) prepared a conservation plan for otters, which included a strategy for population recovery. This plan could be used as a guiding framework to initiate a conservation plan for otters in MPNR. Sharne Mcmillan, a PhD student from HKU, is currently conducting research to estimate the population size, habitat use and threats to otters in Deep Bay, and could be a resource to assist and inform the conservation strategy.

Hong Kong Bent-winged Firefly: First discovered and described as a new species in 2010 from the Deep Bay, *Pteroptyx maipo* is the first record of the genus *Pteroptyx* from mainland China and Hong Kong, and represents the most northerly record for this genus (Ballantyne *et al.* 2011). Surveys show that from among the known sites in the Deep Bay, MPNR supports a large population, and is thus an important site for the survival of this species. Several sites outside the reserve, including Nam Sang Wai and Tai Sang Wai also support important populations (Figure 12)

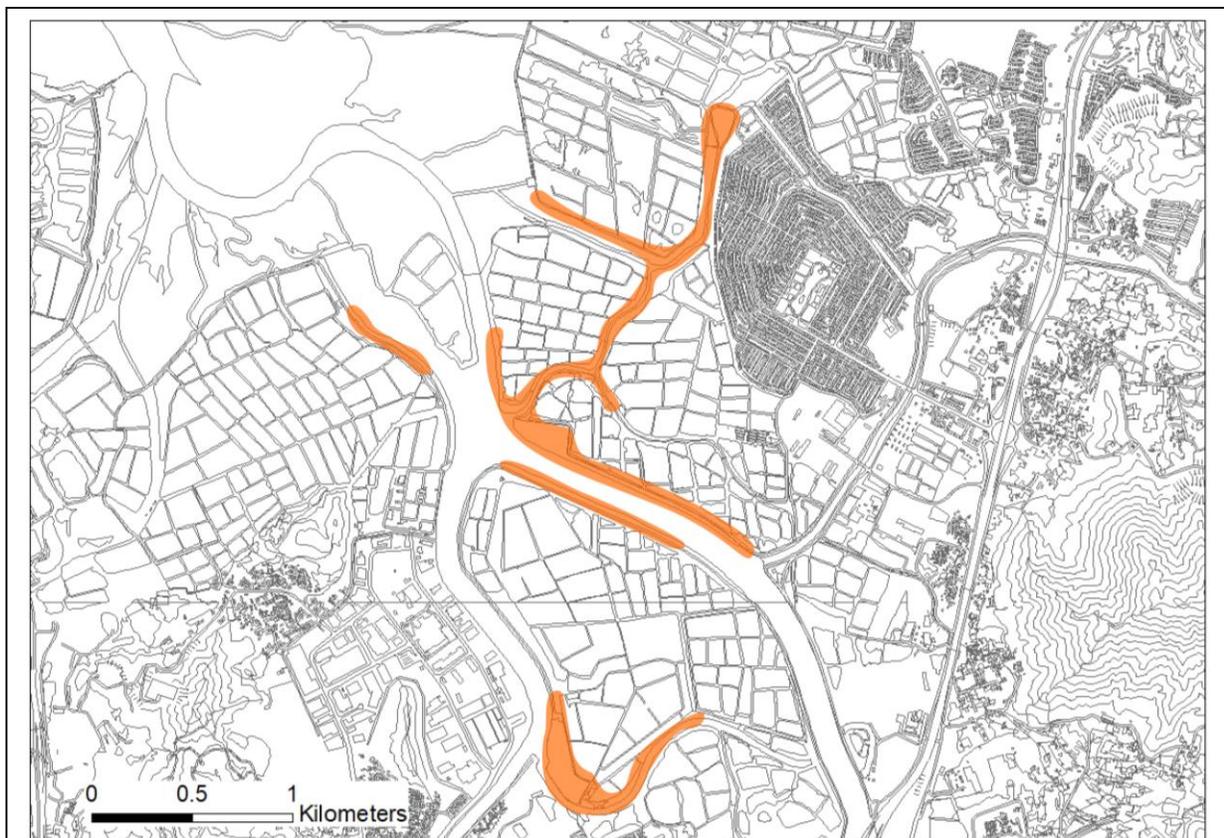


Figure 12. Distribution of Hong Kong Bent-winged Firefly (*Pteroptyx maipo*) around the Mai Po Nature Reserve. Denser populations have been recorded around Nam Sang Wai and Tai Sang Wai area.

Freshwater turtles: Four species of freshwater turtles have been recorded from the Reserve, including

two threatened species; namely Reeves' turtle (*Mauremys reevesii*), which is IUCN red-listed as Endangered and the Chinese soft-shelled turtle (*Pelodiscus sinensis*) red-listed as Vulnerable. The other two, red-eared slider (*Trachemys scripta*) and Southeast Asian box turtle (*Cuora amboinensis*), are exotic species.

The last confirmed record of Reeves' turtle is from 2010, and of the Chinese soft-shelled turtle from the 2015-17 survey conducted by WWF-Hong Kong. It is possible that the indigenous turtles are being outcompeted by the red-eared slider. Because the Reeves' turtle is known to feed on aquatic plants, especially the prolific pond weed *Hydrilla*, a survey and recovery programme, including re-introduction, could be considered to facilitate habitat management and ecological restoration, including as a biological control of *Hydrilla*.

Four-spot Midget: This damselfly (*Mortonagrion Hirosei*) is only known from five to seven highly disjunct and localized sites along the coastal areas of Japan, Taiwan, China and Hong Kong (Wilson and Reels 2011). Mai Po is one of the three sites that are protected. Preliminary studies in Mai Po suggest that the species prefers intertidal mangroves, with water depths between 0.2 and 0.5 m (Stanton and Allcock 2011). Because coastal wetlands and mangroves are under threat from clearing for coastal development, and now from climate change induced disasters, the persistence of this species in many of its known locations is uncertain. In Hong Kong, adults are commonly found in the intertidal mangroves and channels of the reserve, and historically was recorded in the reedbeds. The larval instars have not been recorded in the mangroves, but are known to have a relatively high survival rate in brackish water, with saline concentrations of up to 15% (Wilson and Reels 2011). As a habitat specialist with short generation times, this species can be used to monitor the health of mangroves.

3.2 Threats and Opportunities

A threat analysis was conducted, and identified 12 threat drivers (Table 4; Figure 13) impacting the primary management units in the MPNR; i.e., the BMZs and the 45ha tidal mudflat and mangroves adjacent to the reserve and floating hides (Figure 2). Some threats include potential future threats, especially from global climate change and mega-infrastructure projects that will require constant monitoring and horizon scanning. Three other threats that affect the key target species directly were also identified; namely, unauthorized bicycles and drones, feral cats and dogs, and light pollution (Figure 14). A conceptual model was developed to identify how the threats relate to the management units and the species and species assemblage (i.e., the conservation targets; Table 4), and is provided in Appendix 6).

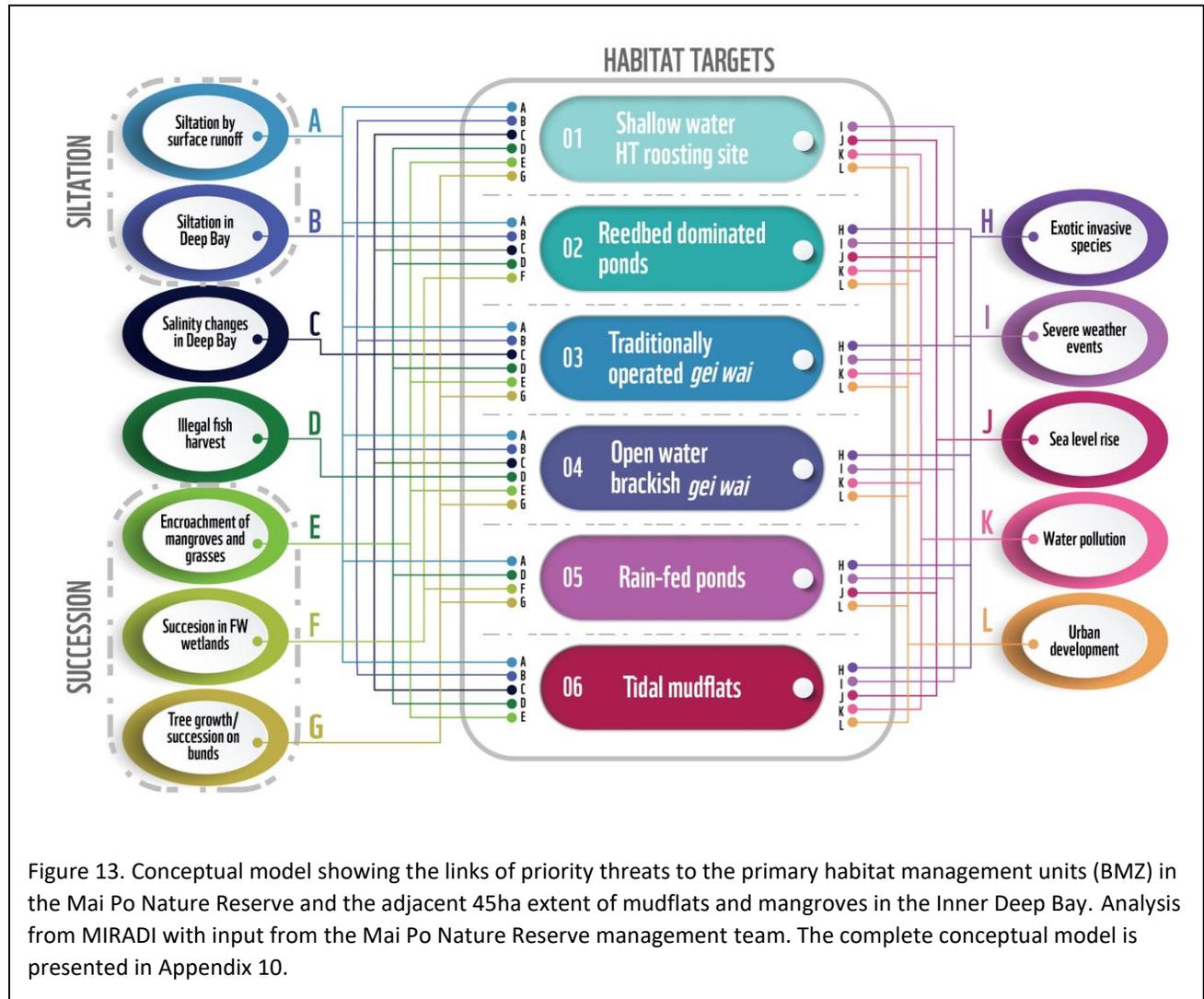


Figure 13. Conceptual model showing the links of priority threats to the primary habitat management units (BMZ) in the Mai Po Nature Reserve and the adjacent 45ha extent of mudflats and mangroves in the Inner Deep Bay. Analysis from MIRADI with input from the Mai Po Nature Reserve management team. The complete conceptual model is presented in Appendix 10.

The threats were then assessed for scope³, severity⁴, and irreversibility⁵. The rankings ranged from Very High, High, Medium to Low (Table 5).⁶

³ Scope - Most commonly defined spatially as the proportion of the target that can reasonably be expected to be affected by the threat within ten years given the continuation of current circumstances and trends. For ecosystems and ecological communities, measured as the proportion of the target's occurrence. For species, measured as the proportion of the target's population.

⁴ Severity - Within the scope, the level of damage to the target from the threat that can reasonably be expected given the continuation of current circumstances and trends. For ecosystems and ecological communities, typically measured as the degree of destruction or degradation of the target within the scope. For species, usually measured as the degree of reduction of the target population within the scope.

⁵ Irreversibility (Permanence) - The degree to which the effects of a threat can be reversed and the target affected by the threat restored.

⁶ The scoring was not done in Miradi, but were rated by the Mai Po staff based on their experience and expertise.

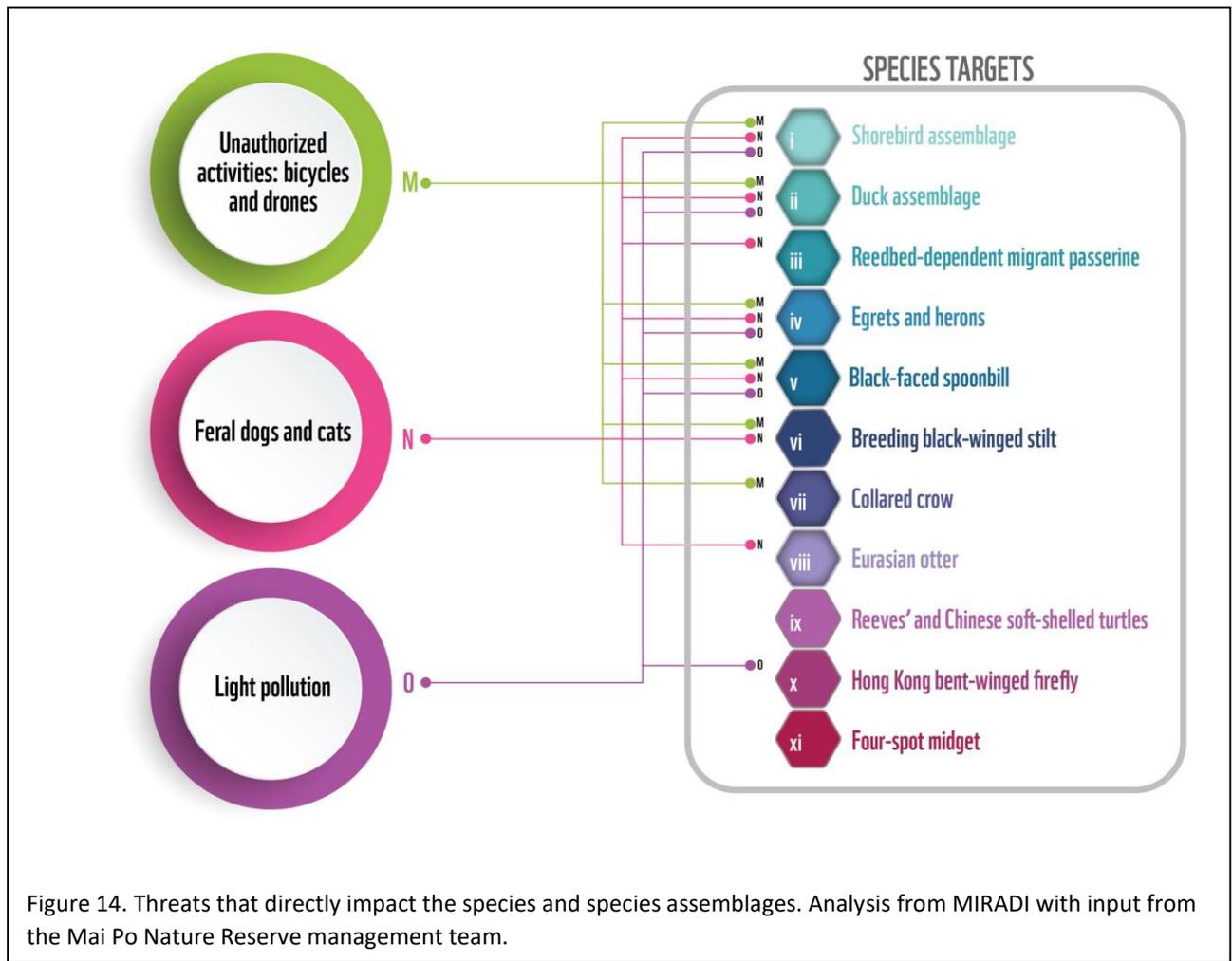


Figure 14. Threats that directly impact the species and species assemblages. Analysis from MIRADI with input from the Mai Po Nature Reserve management team.

Table 4. Priority threats that were identified in the Mai Po Nature Reserve in the left column. Shaded cells indicate the threats that apply to the primary management units and the species and species assemblage in these management zones (upper rows).

PRIMARY MANAGEMENT UNITS AND CONSERVATION TARGETS	Shallow water high tide roosting ponds (BMZ 5 –GW #16/17; BMZ 7 -- GW #8a, #11a, #21, #22, #23a)	Reedbed dominated ponds (BMZ 2—GW #8b, #9, #10, #11b, #23b; BMZ 3—GW #14)	Traditionally operated <i>gei wai</i> (BMZ 3—GW #12, #13, #14, #18, #19)	Open water brackish <i>gei wai</i> (BMZ 1-- GW #3, #4, #6, #7)	Rain fed ponds (BMZ 4—Pond #15a-c, #16a-b, #17a-b; BMZ6—Pond #20a-f, #23b, #24a-g)	Tidal mudflats
THREATS	<ul style="list-style-type: none"> - Shorebird assemblage - Duck assemblage - Egrets and herons - Black-faced spoonbill - Breeding black-winged stilt - Collared crow 	<ul style="list-style-type: none"> - Shorebird assemblage - Duck assemblage - Reedbed-dependent migrant passerine bird assemblage - Egrets and herons - Eurasian otter 	<ul style="list-style-type: none"> - Black-faced spoonbill - Duck assemblage - Egrets and herons - Hong Kong bent-winged firefly - Four-spot midget 	<ul style="list-style-type: none"> - Black-faced spoonbill - Egrets and herons - Duck assemblage 	<ul style="list-style-type: none"> - Duck assemblage - Eurasian otter - Freshwater turtles - Breeding black-winged stilt 	<ul style="list-style-type: none"> - Shorebird assemblage - Egrets and herons - Black faced spoonbill - Duck assemblage
Siltation from runoff						
Siltation in Deep Bay						
Salinity changes in Deep Bay						
Illegal fishing						
Encroachment of mangroves and grasses						
Succession in rain-fed wetlands						
Tree succession on bunds						
Exotic Invasive species						
Severe weather events						
Sea level rise						
Water pollution						
Urban development						

Table 5. Threats to conservation targets in Mai Po Nature Reserve, ranked by Scope, Severity, and Irreversibility. The definitions of ranks are from Miradi (<https://www.miradi.org/about-miradi/>); however, the ranking exercise was conducted outside of the Miradi programme, and based on the experience and expertise of the Mai Po Nature Reserve staff. Ranks are: VH = Very High, H = High, M = Medium, and L = Low. Where information was deficient, threat rankings were not assigned (blank cells).

Threats	Scope	Severity	Irreversibility
Siltation from run off	VH	M	M
Siltation in Deep Bay	VH	M	VH
Salinity changes in Deep Bay	VH		VH
Illegal fishing (in the Nature Reserve)			L
Illegal fishing (on the mudflat)	VH	M	L
Encroachment of mangroves and grasses	VH	H	L
Succession in FW wetlands	VH	H	L
Tree succession on bunds	M	M	L
Exotic Invasive species (apple snail, <i>Typha</i> , Mikania, Red Imported Fire Ant, <i>Sonnaratia</i> , Red-eared Slider)	VH		
Severe weather events – storms and floods	VH	H	VH
Sea level rise	VH	L	VH
Water pollution	VH		
Urban development (planned)	VH		M
Light pollution (on birds)	M		H
Light pollution (on fireflies)	H	H	H
Feral cats and dogs	VH	L	M
Unauthorized activities – bicycles & drones	L	L	L

Twelve of 17 threat drivers were ranked Very High (VH) for scope; but this is due to the relatively small area of the reserve in relation to the spatial extent of the impact of the threats; for instance, siltation, salinity changes, water pollution, severe weather events, occur over large areas that go beyond the reserve, and affect all or most of the reserve area. Because of the large spatial scale of these threats – especially from siltation and salinity changes in the Deep Bay – and the sources being far from the Reserve, Irreversibility is rated as Very High. Climate change could potentially intensify these changes, especially if floods following heavy rainfall will result in large, silt-laden freshwater pulses being washed downriver into the bay. These larger threats from regional and global drivers will require strategies to build adaptation and resilience within the Reserve.

Succession of rain-fed and brackish water ponds and *gei wai*, and the tidal mudflats was also ranked as Very High for Scope, and as Medium for Severity. Wetlands are highly dynamic ecosystems, and the

reserve's management units (i.e., the ponds and *gei wai*) undergo succession, with the wetlands gradually succeeding into grasslands and eventually drier, terrestrial habitats as silt and biomass begin to accumulate. Mangroves, grasses, and sedges extend into the mudflat as part of a natural successional process. Saplings of large trees colonize the larger bunds of *gei wai* and rain-fed ponds. If allowed to grow, the trees could affect the structural integrity of the bunds and also close the open spaces that waterbirds prefer. Thus, active management to reverse this succession is necessary to maintain the diversity of habitats to conserve the target species. Because reversal is relatively straightforward, the threat was rated as Low for Irreversibility.

Urban development was ranked Medium for Irreversibility because these include planned development, which can potentially be appealed and stopped. There are now plans to develop some inactive fish ponds in the Wetland Conservation Area (WCA) and Wetland Buffer Area (WBA), and build high rise buildings. If built, the infrastructure could block flight paths of migratory birds and result in fatal collisions. Light pollution from the buildings during the night could affect bird migratory behaviour and eventually lead to declines in population numbers in Mai Po. Light pollution could also affect the populations of Hong Kong bent-winged fireflies.



A view of Deep Bay intertidal mudflat from floating bird hide during night time. ©Caleb Choi/ WWF-Hong Kong

Sea level rise, higher tides, strong wave surges, and salinity intrusion are expected due to climate change that could cause the mangroves to shift inland, as well as outwards into the accreting Inner Deep Bay. Thus, the rain-fed and brackish water ponds in the reserve that now support reedbeds and other freshwater habitats could be lost in the future. Climate models applied to coastal areas and wetlands across the world show that wetlands could shift under various climate change scenarios, and hard infrastructure from development can prevent these climate responses (Passeri *et al.* 2015, Shoo *et al.* 2014, Torio and Chmura 2013). Recent studies have shown that rising tides and storms due to climate change and sea level rise could affect coastal ecological communities within the next 10 years (Von Holle *et al.* 2019). Thus, the impacts to Mai Po could happen sooner than predicted; i.e., towards the end of this century. The oceanic wave heights and wind speeds are already increasing with stronger increases under extreme conditions (Young and Ribal 2019). Coastal wetlands buffer urban areas from oceanic storm surges and high wave action during storms (Ren *et al.* 2011), and the current wetlands could be important buffers for the infrastructure landward of the MPNR.

A number of introduced flora and fauna poses threats to biodiversity in the Reserve. The invasive climber *Mikania micrantha*, which is already well established in the Hong Kong countryside, grows on drier earth bunds and smothers mangrove trees, affecting their health. *Sonneratia* spp. is a fast-growing mangrove

species that can out-compete the native mangrove species. They have been mainly recorded on the intertidal mudflat, and have begun to invade the feeding habitat of waterbirds. They grow along the water channels leading into *gei wai* in the reserve, impeding water exchange. A small number of individual trees have been recently recorded inside the reserve. Seeds of *Acacia auriculiformis* and *A. confusa* trees used to disperse into the reserve from the neighbouring residential areas but seldom do anymore. The seeds of the sedge *Typha angustifolia* are dispersed from the neighbouring fishpond areas, and grow in areas of open water. White Popinac (*Leucaena leucocephala*) can establish quickly on earth bunds. Both plants reduce the openness of the reserve landscape, which attracts waterbirds. The invasive golden apple snail (*Pomacea canaliculata*) multiplies rapidly in rain-fed ponds in the reserve and causes potential threats to native aquatic snails and marshland plants, tending to reduce their biomass and abundance. The invasive red imported fire ant (*Solenopsis invicta*) is found on dry reedbed, bunds and islands in the reserve, and poses threats to wildlife as well as hazards to reserve management staff and visitors. Since all of these invasive species can also originate from the areas surrounding the reserve, completely eradicating them from the reserve will not be possible. Instead the strategy would be to contain their spread and limit the adverse impacts on the conservation targets and habitats.

Several threats have direct impacts on the species. Feral dogs and cats roam throughout the reserve. Dogs have been observed attacking birds in the shallow ponds. Over the past few years, there have been occasional dog sightings in the reserve, including of dog attacks on birds. Feral cats may also have a greater impact on the birds, especially the smaller passerines; a phenomenon that occurs in many parts of the world, and requires investigation (Lepczyk *et al.* 2004, Loss *et al.* 2013).

Instances of illegal fishing cages/nets have been detected, especially in the mudflats of the Ramsar site core zone. While the Severity of the impacts of these cages/nets were ranked as Medium, it is possible to address and, at the very least, minimize the frequency of occurrence. Only very few instances of illegal fishing have been recorded inside the reserve.

Recreational activities, especially unauthorized bicycle riding inside the reserve were considered low impact threats, but should be controlled.



Illegal Fishing cages were found on intertidal mudflat and in gei wai occasionally

©Eddie Leung/WWFHong Kong



Invasive Golden Apple Snail multiplies rapidly in rain-fed ponds.

©Roger Lee/ WWF-Hong Kong



Feral dogs and cats populate in neighbouring area of the Reserve.

©Caleb Choi/WWF-Hong Kong

4 EDUCATION AND AWARENESS PROGRAMME

WWF-Hong Kong implements a One Planet Education Programme to create a new generation for conservation and sustainability advocates through FUN, ENGAGEMENT and REAL LIFE EXPERIENCE. The overall objective of this project, conducted in collaboration with several partners dedicated to conservation, is to inspire, motivate and mobilize youth and students in Hong Kong to actively participate in the global conservation movement to halt and reverse the decline and degradation of natural systems and associated biodiversity, in Hong Kong and across the world. The programme includes diverse initiatives that enable the next generation to act locally, regionally, and globally towards this goal.



Students engaging public visitors in the Walk For Nature annual supporter event through the One Planet Education Programme.

©Caleb Choi/ WWF-Hong Kong

The programme targets five key sectors:

1. Schools (One Planet School). To holistically integrate concepts of Education for Sustainable Development (ESD) in all aspects of formal school education in Hong Kong
2. Youth (One Planet Youth). To motivate young people (aged 15-30) to become our next generation of the conservation and sustainability constituency
3. Local Communities. To leverage expertise and experience from the education team to fulfil the organizational ambition on delivering bigger conservation impacts at local level
4. Regional Multipliers. To leverage expertise and experience from the education team to fulfil the organizational ambition on delivering bigger conservation impacts at regional level
5. WWF Global Education Community. To maintain WWF-Hong Kong as one of the champions to help facilitate implementation of the global education strategy at global, regional and local levels.

Several of these are relevant to MPNR, and will rely heavily on the facilities available in Mai Po to raise public awareness and education of the importance of biodiversity conservation, with a focus on wetlands. A comprehensive strategic plan for the education and awareness programme is available from the WWF-Hong Kong Education Programme.

5 REGIONAL TRAINING AND OUTREACH PROGRAMME

The millions of migratory waterbirds that use the East Asian-Australasian Flyway (EAAF) rely on a series of wetlands along the route to refuel. Southern wetlands are also used as wintering grounds by some species. However, there is increasing loss and degradation of wetlands; for example, in China alone, as much as 70% of tidal flat area has been lost between the 1950s and 2000s. The extent of this loss has resulted in serious declines in migratory waterbird populations. Securing the integrity of key habitats in priority areas within the EAAF is vital to the persistence of the migration, which is of great importance for Mai Po.

WWF-Hong Kong believes that the issue has to be tackled through three actions: 1) improving the management of existing coastal protected areas along the flyway; 2) securing and conserving unprotected wetlands; and 3) supporting local and regional conservation organizations that have experience, but lack financial resources. This includes extending the knowledge and experience of managing Mai Po over the past decades to regional wetlands and working with the respective wetland managers. In 1990, WWF-Hong Kong established a wetland management training programme for regional wetland managers. The bulk of the training for the programme takes place at MPNR.

This programme and outreach will continue through the next five years as the Mai Po Wetland Management Training Programme. WWF-Hong Kong uses Mai Po Nature Reserve as a living case study, to conduct this training, and to-date has trained over 5,200 wetland managers from mainland China and elsewhere in Asia. The training includes



Wetland Management Training Programme receives regional wetland managers to the MPNR since 1990.

©Caleb Choi/WWF-Hong Kong

fundamental concepts, principles and techniques of wetland conservation and environmental education, with hands-on experience in the field. WWF-Hong Kong's wetland training programme is now recognized as one of the best such programmes in Asia and the longest-running collaborative project between WWF-Hong Kong and the State Forestry and Grassland Administration of China, which is the management authority of protected areas in mainland China.

In 2005, WWF-Hong Kong initiated the China Wetlands Project to demonstrate that the management concepts of MPNR are applicable in China. Under this project, training, guidance and support was continued to managers of three coastal nature reserves that are important sites for migratory waterbirds. Training included habitat management, wise use of wetland resources, and education for sustainable development. In 2008, Zhangjiangkou National Mangrove Nature Reserve in Fujian Province and Haifeng Bird Provincial Nature Reserve in Guangdong Province were designated as Ramsar Sites. Since 2017, WWF-Hong Kong has also been partnering with various stakeholders in Luannan County of Hebei Province, which supports an important stop-over site for 350,000 migratory waterbirds in the Yellow Sea ecoregion in China, to develop and manage it as a stepping stone to support waterbirds migration in the long-term.

6 RESEARCH AND MONITORING

WWF-Hong Kong is committed to a science-based approach for conservation and management practices at MPNR. As a refuge for local biodiversity and globally threatened species in one of the most populated and urbanized areas of South China, as well as a model site of active conservation management of wetlands, WWF-Hong Kong aims to develop the MPNR and its conservation management programme into the premier local and regional hub for research on wetland ecology and conservation. A suggested research programme is provided in Appendix 8. Other projects could be added to this programme as priority requirements emerge.



MPNR research and monitoring team conducting regular morning bird count.

©Caleb Choi/WWF-Hong Kong

The research and monitoring effort is led by WWF-Hong Kong's MPNR research and monitoring team who closely collaborate with local authorities, academics, technology companies, conservation partners and the public. The programme include cutting-edge research to develop innovative and effective wetland management approaches and strategies, and fostering knowledge and experience exchange among researchers and wetland managers.

With the expertise and facilities at MPNR, WWF-Hong Kong encourages and facilitates individual and institutional researchers, both local and international, to conduct research at MPNR. To enhance public understanding of science and harness the power of collective effort in data collection and management, WWF-Hong Kong develops and supervises citizen science programmes that support research and monitoring in the MPNR.

7 MANAGEMENT GOAL, OBJECTIVES AND TARGETS

Vision: The Mai Po Nature Reserve is: an important staging area and wintering ground for migratory waterbirds in the EAAF; a core area that supports threatened flora and fauna of Hong Kong's wetlands; and will be the regional hub for environmental education and wetland management training with support from all stakeholders.

Goal: To, a) manage the Mai Po Nature Reserve as a climate resilient and adapted staging and wintering ground for migratory waterbirds along the EAAF and for threatened indigenous biodiversity; b) sustain the practice of *gei wai* as an example of traditional wise use of wetlands; and c) be a regional centre for knowledge and awareness on wetland conservation.

Four thematic areas to meet the goal were identified with the following objectives:

Objective 1. To maintain or increase populations of priority species by managing the required habitat diversity that integrates climate adaptation strategies.

Objective 2. To raise public awareness and education of the importance of wetlands and their conservation, including the provision of universal access.

Objective 3. To share experience and knowledge with other Ramsar sites and wetlands in the EAAF for coordinated conservation and persistence of the EAAF avian landscape.

Objective 4. To develop Mai Po as a regional centre of excellence for wetland research and monitoring.

7.1 Biodiversity Conservation Objective and Targets

Objective 1. To maintain or increase populations of priority species by managing the required habitat diversity that integrates climate adaptation strategies.

Thirteen targets related to priority species and habitat management were identified, with strategies and actions, to guide management over the next five years under this objective. The actions relevant to the different *gei wai* and ponds in the Reserve are also summarized in Table 6. Scheduled habitat management and species monitoring regimes are also provided in Annexes A to G.

Targets and strategies

1A Species targets

Target 1. By 2024, no decline in the black-faced spoonbill population from current trend.

Target 2. By 2024, the numbers and relative species composition (diversity) of the shorebird and duck assemblages remains stable, relative to past five-year trend.

Target 3. By 2024, black-winged stilt continue to nest in MPNR.

Target 4. By 2024, the reedbed dependent bird assemblage maintains numbers and assemblage diversity.

Target 5. By 2024, numbers and composition of the ardeid community remains stable.

1.1 Strategy: Manage the habitat in selected BMZs as primary high tide roosting and feeding habitats necessary for black-faced spoonbills, ducks and shorebirds.

Actions:

- Maintain and increase the open water area in three brackish *gei wai* in BMZ 1 (GW #3, #6, #7) primarily as roosting habitat for black-faced spoonbill.
- Maintain five traditionally-operated brackish water *gei wai* as winter feeding areas for black-faced spoonbills and ardeids.
- Desilt water channels of GW #6, #7, #12, #18, #19 to maintain deep water areas for shrimp and fish, which are the food for waterbirds.
- Re-profile islands and pond floor of GW #8a and connect #8a with #7 to restore the roosting habitats for shorebirds, ducks and ardeids.
- Reconnect landward and seaward parts of GW #18, #19 to increase the brackish water area for *gei wai* shrimp.
- Remove predatory fish to increase food quantity available for waterbirds.
- Provide feeding habitat during drain-down in the seaward side of the traditionally-operated brackish *gei wai* (GW #12, #13, #14, #18b, #19b), and open brackish water *gei wai* (GW #3, #4, #6, #7).
- Provide open, shallow water habitat in pond #17b and #24a-g by using water buffalo as “environmental engineers”.
- Maintain shallow water high-tide roosting areas with no/short grass-topped islands in BMZ 5 (GW #16/17) and BMZ 7 (GW #8a, #21, #23a) for black-faced spoonbill, shorebird and duck assemblages.
- Manage all bunds inside the Reserve as black-faced spoonbill and duck roosts.
- Re-profile BMZ 6 (pond #24f and #24g) to provide shallow water marshland for waterbirds.
- Adjust water level of all *gei wai* and ponds according to annual water level management plan (see Annex D) to provide favourable water depth for waterbirds.
- Restore overall open landscape of the reserve for black-faced spoonbill, shorebird assemblage, duck assemblage and feeding ardeids.

1.2 Strategy: Maintain roosting areas and increase the open, deep-water foraging habitats in selected BMZs for the duck assemblage.

Actions:

- Remove encroaching vegetation around edges of pond #20 and merge the six sub-ponds to create deep water open areas for foraging.

1.3 Strategy: Manage the habitat in selected BMZs as nesting sites for black-winged stilt.

Actions:

- Monitor and manage vegetation on islands in BMZ 5 and BMZ 7 for nesting black-winged stilt, and maintain low water levels in the relevant ponds until young birds fledge.
- Explore possible methods to attract black-winged stilt to breed, including artificial floating islands.

1.4 Strategy: Increase the spatial extent of wet reedbeds that have been shown to support higher numbers and diversity of reedbed-dependent birds than dry reedbeds.

Actions:

- Increase the area of wet reedbed in BMZ 2 (GW #8b) and maintain as wet reedbeds with a diversity of water depths, including to control red imported fire ants.
- Enlarge area of reedbed in BMZ 6 (pond #23b) by lowering or removing the internal bunds, and levelling internal channels to allow spreading of reedbed.

1.5 Strategy: Maintain five traditionally-operated brackish water *gei wai* and restore total *gei wai* area in BMZ 3 as winter feeding habitats for black-faced spoonbill, egrets and herons.

Actions:

- Conduct winter drain-down in the seaward side of the traditionally-operated brackish *gei wai* (GW #12, #13, #14, #18b, #19b), GW #10, GW #23a to provide feeding habitat.
- Maintain breeding habitat for egrets and herons in the seaward side of GW #14, and maintain the island in the northwest corner of GW #8a as a potential egrettry.
- Use water buffaloes to create open, shallow feeding habitat in rain-fed ponds (pond #17b, #24a-g).
- Drain down water level of GW #3, #4, #6, #7, #8b, #11, #16/17, #21 in summer to provide feeding habitat for waterbirds. Restore open water area of BMZ 3.

Target 6. By 2024, the roosting population of collared crows in MPNR maintained as more than 200 individuals.

1.6 Strategy: Protect the pre-roosting sites, and intertidal roosting mangrove patches.

Actions:

- Identify and map the daytime foraging areas in south and southeast of MPNR. Manage and conserve the pre-roosting trees, bunds, and islands as suitable habitats, especially along GW #16/17, #21, #22, #23, and FCA road.
- Conduct roosting counts.

Target 7. By 2024, distribution of the Eurasian otter population mapped and estimated with a conservation management plan for MPNR in place.

1.7 Strategy: Research and conservation focus on breeding and raise awareness and education for otter conservation.

Actions:

- Conduct a camera trap survey to map distribution of otters in the reserve and conduct population estimates.
- Develop a conservation management plan by 2022, and begin implementation.
- Identify and monitor holts and suitable sites for artificial holts.

Target 8. By 2024, the major populations of Hong Kong Bent-wing Firefly and their habitat conserved and secured.

1.8 Strategy: Collaborate with AFCD and other stakeholders to protect and conserve the priority habitats and firefly populations in and around MPNR.

Actions:

- Conduct field surveys to map out and estimate population hotspots.
- Develop distribution model of fireflies using Maxent, based on survey information.
- Develop conservation and protection plan for firefly hotspots in collaboration with stakeholders.

Target 9. By 2024, status of Reeves' turtle and Chinese soft-shelled turtle updated, and a recovery plan prepared.

1.9 Strategy: Implement species' recovery plans based on surveys to confirm presence and distributions in MPNR.

Actions:

- Conduct surveys for both species to confirm and map distribution in the reserve.
- If presence is confirmed, conduct study to determine habitat and thermoregulatory behaviour, and potential conflict and competition with the red-eared slider (*Trachemys scripta elegans*), an exotic species that is now prevalent across the reserve.
- Based on the survey data, develop and implement a species recovery plan for implementation in the MPNR.

Target 10. By 2024, the distribution of four-spot midget in the reserve is stable.

1.10 Strategy: Conserve the breeding habitat, including the water conditions necessary for eggs and nymphs to survive, with emergent vegetation necessary for metamorphosis to become complete.

Action:

- Establish a monitoring system for adults to track population status and distribution.

1B Threat targets

Target 11. By 2024, the spread of exotic species is under control and impacts on conservation target species and habitats are minimal.

1.11 Strategy: Constantly monitor the status of the exotic species and apply controls to manage the populations and prevent the spread of the relevant species.

Actions:

- Four exotic plants should be regularly checked and managed in the Reserve: *Mikania micrantha*, *Typha* sp., *Sonneratia* spp. and *Leucaena leucocephala*.

- Cut back the low part of stems of *Mikania* growing on top of mangroves, in particular at GW #12 and #13, before they bloom in November.
- Develop alternate control mechanisms, including physical removal and mulching during the early growth stages, rather than applying herbicides.
- Monitor the intertidal channels for *Sonneratia* seedlings and physically remove.
- Monitor and uproot *Leucaena leucocephala* seedlings and saplings along the perimeter and internal bunds.
- Manage the apple snails in Pond #16b by removing adult snails from March to October, and destroying eggs on emerging vegetation.
- Monitor and destroy red imported fire ant mounds as they appear.
- Collaborate with researchers to develop more efficient and effective ways to control all the above species.

Target 12. By 2024, a climate adaptation strategy and plan for MPNR in place.

1.12 Strategy: Prepare and propose to government stakeholders an adaptation plan to allow for ecosystem and habitat responses to climate change and consequent impacts to the MPNR.

Actions:

- Develop and run a climate impact model to project habitat and ecosystem responses.
- Based on model outputs explore potential to secure critical areas to maintain ecosystems, ecosystem process, and biodiversity under future climate change scenarios.
- Develop and establish a climate monitoring system using bio-indicators.

Target 13. Through the period up to 2024, the 45ha area of intertidal mudflat along the western boundary of the nature reserve kept clear of encroaching mangroves, grasses and sedges.

1.13 Strategy: Control mangrove seedlings and patches of grasses and sedges intruding into the mudflats in front of the floating bird hides.

Actions:

- Test feasibility of using manual methods of removing the grass patches, using improvised rototiller mounted on mud scooters, or other innovative technologies.
- Control invading grass patches and mangroves from the mudflat area.

Table 6. Actions identified for the different Biodiversity Management Zones (BMZ) in the Mai Po Nature Reserve, and their links to the conservation targets (highlighted as yellow cells). The annual and 5-year schedules of activities are provided in Annexes A-G.

BMZ	Black-faced Spoonbill	Shorebird assemblage	Duck assemblage	Breeding Black-winged Stilt	Reedbed-dependent bird assemblage	Ardeids	Eurasian Otter
1	<ul style="list-style-type: none"> Shallow, open water roosting habitat (GW #3, #4, #6, #7) primarily for wintering population of black-faced spoonbill and ducks 						
2	<ul style="list-style-type: none"> Maintain the wet reedbeds in GW #9, #10 and #11b, and increase area of wet reedbeds in GW #8b, GW #23b Provide feeding habitat in reedbed dominated ponds for egrets, herons, and bitterns 						
3	<ul style="list-style-type: none"> Maintain and restore as winter feeding areas for black-faced spoonbill and ardeids in GW #12, #13, #14, #18, #19 Provide breeding habitat for egrets on seaward side of GW #14 						
4	<ul style="list-style-type: none"> Monitor and manage vegetation for black-winged stilt nesting on islands and regulate water level to avoid submerging nests in ponds #15a-b Provide feeding habitat for egrets and herons during drain down Manage habitat for ducks Monitor otters and encourage occupation in ponds Maintain biodiversity and habitat for education programmes 						
5	<ul style="list-style-type: none"> Maintain shallow water high tide roosting areas with shallow islands for black-faced spoonbills ducks and shorebird assemblage in GW #16/17 Maintain islands with no/short vegetation cover as night roosts for ducks in GW #16/17 Monitor and manage vegetation for black-winged stilt nesting on islands and regulate water level to avoid submerging nests in GW #16/17 						
6	<ul style="list-style-type: none"> Re-profile and restore open deep-water foraging areas for ducks in ponds #20 Re-profile Pond #24f/g to provide shallow water marshland for waterbirds. Lower or remove internal bunds and enlarge reedbed areas reedbed dependent birds in pond #23b. 						
7	<ul style="list-style-type: none"> Maintain shallow water high tide roosting areas (with shallow islands in GW #8a, #21 and #23a; and without islands in GW #11a and #22a-b) for black-faced spoonbills, ducks, and shorebird assemblage Monitor and manage vegetation for black-winged stilt nesting on islands and regulate water height to avoid submerging nests in GW #8a, #21 and #23a 						

7.2 Education and Awareness Objective and Key Activities

Objective 2. To raise public awareness and education of the importance of wetlands and their conservation, including the provision of universal access.

2.1 Strategy: Use the natural environment and facilities at the MPNR as a key platform to raise awareness for wetland conservation, as part of thematic outdoor learning experiences for students and teacher training through the centre-based education activities under the One Planet School programme that will complement the regular school curricula.

Expected Outcomes:

- Students should be able to understand how their day-to-day activities interacting with natural systems, including wetlands, and be encouraged to take action for conservation.
- Teachers and students will be committed to take corresponding conservation actions after the programme.

Key Activities:

- Regular review of approach and content of activities to complement latest developments in the sector (e.g. e-STEM, fieldwork-based questions in geography DSE examination, life-wide learning, use of appropriate technology/device to support survey-based activities, etc.).
- Provide students with quality learning experiences supported by teachers and motivate students to take corresponding conservation action.
- Upgrade the MPNR Infrastructure (project expected to be completed in 2022 including the MPEC, AFCD path and tower hide to support the continuous development of student education activities.
- Increase in the number of centre-based education activities from 415 in 2018-19 to 530 by 2022-23.
- Use MPNR as one of the training hubs for teacher professional development programmes (4-5 events planned per year across all WWF centres).

2.2 Strategy: Use the facilities at the MPNR to collaborate with youth groups and tertiary student communities to engage and motivate young people for conservation and as sustainability advocates through action-based learning activities under the One Planet Youth programme.

Expected Outcomes:

- Partnership formed with youth groups that undergo programmes related to conservation and sustainability who will become citizen scientists.

Key Activities:

- Implement programmes for youth that complement and contribute to the research and monitoring programmes in Mai Po, targeting an increase of 90 programmes by 2023, from the 30 programmes in 2019.

2.3 Strategy: Organize education and awareness programmes for local communities, targeting families and children under the Local Communities programme.

Expected Outcomes:

- Increased awareness among the local community about the importance of the MPNR and its role in nature conservation and climate change resilience building.
- Greater support for the MPNR among the local community and stakeholders.

Key Activities:

- In collaboration with WWF-Hong Kong's visitor experience team, communications and digital services team, and external parties, develop fun-filled education activities in different formats to engage the general public and specific segments of the community.
- Organize regular and season specific Connect2Nature Academy including summer activities and centre-based events targeting children and families to spread conservation and sustainability messages. Target an increase in the number of people engaged from 400 in FY19 to 520 in FY23.
- Continue to use the MPNR as one of the key WWF platforms to support the organization of the annual City Nature Challenge to echo global biodiversity conservation objectives.

7.3 Regional Training and Outreach Objective and Key Activities

Objective 3. To share experience and knowledge with other Ramsar sites wetlands in the EAAF for coordinated conservation and persistence of the EAAF avian landscape.

3.1 Strategy: Use the Mai Po Nature Reserve and the Mai Po Inner Deep Bay Ramsar Site as a 'living laboratory' to demonstrate the practical application of wetland reserve management.

Expected Outcomes

- Improved knowledge and skills of regional wetland managers allow successful management of the wetland network that contributes to the persistence of the flyway and migrations.
- Greater regional awareness about the importance of wetlands among all stakeholders that support conservation.

Key Activities:

- Conduct 10 training courses and study tours for wetland managers and officials annually, for over 150 participants in total.
- On-site wetland training and advisory work at four to six important wetland sites along the EAAF for continued engagement, outreach, networking, and regional capacity building.
- Develop an online network of wetland managers for communication.

3.2 Strategy: Work with the Mai Po education and training team to support a regional awareness programme on the importance of the MPNR and its contribution and role in the Ramsar Convention and EAAF Partnership.

Expected Outcomes:

- Greater awareness across the EAAF countries on the importance of wetland conservation to support and sustain the EAAF for bird migrations.
- Greater awareness of ecological processes and natural history related to waterbird migrations, appreciation of conservation benefits, including the role of wetlands in climate change adaptation and resilience building.

Key Activities

- Work with the Education Team to integrate Education on Sustainable Development in the wetland management training courses into the following regional wetland conservation projects:
 - Yellow Sea wetland conservation project: capacity building and consultancy for government officials on ESD
 - Advisory support and consultancy services given to wetland CEPA co-workers in the region
 - Staff-exchange/interflow actions co-organized between WWF-Hong Kong and other co-workers in the region
 - Wetland Link International – Asia: acting as a steering committee member to promote wetland CEPA in the region.

7.4 Research and Monitoring Objective and Key Activities

Objective 4. To develop Mai Po as a regional centre of excellence for wetland research and monitoring.

4.1 Strategy: Establish a long-term monitoring programme for conservation targets, threats, and selected indicators of ecosystem change in MPNR and Deep Bay

Activities

- Conduct morning bird counts to record all birds in the MPNR twice a month throughout the year
- Monitor the number of roosting black-faced spoonbills, roosting ducks, shorebirds and terns, feeding ardeids, and develop diversity indices for assemblages.
- Monitor the numbers and diversity of roosting birds in reedbed-dominated areas in the MPNR
- Monitor the number of roosting collared crows in the MPNR and the adjacent mangroves in summer and winter
- Monitor the odonate populations in rain-fed ponds in the MPNR in spring and summer, and the distribution of four-spot midge populations in the inter-tidal mangrove along boardwalks
- Monitor the number of Hong Kong bent-winged firefly in and around MPNR
- Record the amount and sizes of shrimp harvested during summer harvesting
- Monitor the number of feral dogs in the MPNR and the surrounding fishponds
- Monitor the water quality in the MPNR throughout the year and water depths in *gei wai*.
- Conduct fixed-point photography at selected locations to monitor the habitat changes in the MPNR
- Map the distribution of each habitat type in MPNR for area estimates of habitats
- Implement a camera trap programme to monitor and map the distributions of mammals in MPNR.

- Monitor the health and spreading of reedbeds in the MPNR.

4.2 Strategy: Use new tools or technologies (created by WWF-Hong Kong or through collaboration with academics or technology companies) for better data collection and management.

Activities

- Explore and test the feasibility of unmanned aerial vehicle (UAV) in management and monitoring, especially for wildlife detection and surveying, habitat mapping, and detecting illegal fishermen and nets. UAVs can be used to assist bird counts and generate orthomosaic photos of the mudflat, *gei wai*, and ponds. A guideline for the use of UAV for research in the reserve will be produced to share knowledge with regional wetland managers. The use of UAVs will take into consideration the disturbance to birds, and utmost caution will be exercised when testing the UAVs.
- Bathymetry mapping of *gei wai* and ponds. Maintenance of suitable water depth for waterbirds and other aquatic fauna is one of the key management strategies for *gei wai* and ponds in the Reserve. At present, knowledge on the bathymetry of the *gei wai* and pond is based on observation and experience. Bathymetric mapping would provide more precise measurements of the depths. Over years, the data collected could also be used to estimate sedimentation rate of each *gei wai*.
- Explore possibilities in the application of machine learning (e.g. artificial intelligence) in image-based species identification. Automated data collection using camera traps and acoustic recorders enables continuous monitoring of wildlife occurrence and often leads to large amount of data collected in a short period of time. In the MPNR, camera traps have been set to monitor mammals throughout the day and acoustic recorders could be installed to monitor bats at night. To meet the identification demand, modern techniques of automated species recognition will be explored. This project is expected to serve as the beginning of the use of artificial intelligent system in assisting image-based species identification of the data collected in the MPNR.

4.3 Strategy: Conduct research that will help to improve habitat management and species conservation and recovery in MPNR and Deep Bay

Activities

- Use a structured camera trap array to investigate the distribution and space use of Eurasian otter (*Lutra lutra*) MPNR.
- Map the distribution of *Mikania micrantha* in MPNR and evaluate the effectiveness of various control methods. In the MPNR, *M. micrantha* is found in dry areas, in particular the landward side of *gei wai*.
- Use GPS trackers to track the movements of the captive water buffalos in the ponds (GW #17b) to assess the efficacy of the buffalos in maintaining habitat diversity in the ponds. The water buffaloes have been used as a management tool on vegetation control in MPNR since 2006.

Tracking the movements and time spent in different habitats that will be correlated to the habitats (water, grasslands, wallows, etc.) will provide evidence of the effectiveness of using buffalos to maintain the desired habitats.

- Compare vegetation composition and structure in ponds with and without buffalo.
- Evaluate the habitat use of high tide roosting sites by waterbirds, especially in BMZ 5 and BMZ 7 to understand the habitat choice of different species. The physical characteristics of the ponds will be correlated to actual bird locations.
- Determine suitable water level management practices for waterbirds in the intertidal GW #22, which is controlled by sluice boards. As the *gei wai* water level rises and falls daily, it attracts foraging waterbirds and provides temporary roosting habitat. Considering that the spring migration period is from March to May, extending the intertidal operation of GW #22 to cover more of the migration period is potentially beneficial to the spring migrants.
- Investigate the environmental correlates that influence the productivity in *gei wai*. A reduction in shrimps in *gei wai* has been observed in recent years, during summer harvesting and this raises concerns on the food availability to the conservation targets in the MPNR.
- Investigate the seasonal occurrence of *Ruppia maritima* in *gei wai*. The plant is important for waterfowl, and introducing it to other ponds may be an option for future management. However, this has to be balanced with the impact on shrimp harvesting. Given these potential conflicts between survival of *R. maritima* and *gei wai* management, this study is expected to review the impacts of drain down to the growth of the *R. maritima* and its impact on shrimp harvest.
- Mapping spider distributions in MPNR and along boardwalks. Spiders are one of the lesser known taxa in MPNR and in Hong Kong. But three Hong Kong endemic species are known to exist in MPNR and potentially new species in the genus *Olios* have been found in the mangrove along boardwalk. While these species are potentially of conservation concern, their distributions in the Reserve are largely unknown.

4.4. Strategy: Encourage local and cross-border scientific activities in MPNR and Deep Bay to improve wetland conservation in the region.

Activities:

- Organize conferences and workshops for scientific knowledge exchange and capacity building in research.
- Produce research and monitoring reports and peer-reviewed publications.
- Provide advisory and on-site support to external researchers.
- Work with WWF-Hong Kong's education team to develop citizen science projects conducted in MPNR.

8 INFRASTRUCTURE MANAGEMENT

The infrastructure managed by WWF-Hong Kong (Figure 15) that is used for education, public awareness, and research purposes includes:

- Over 4 km of concrete footpaths.
- Seventeen bird hides, comprised of one 3-storey tower hide, six single-storey hides, four floating hides, two observation screens and four *gei wai* huts converted for use as bird hides.
- One 1.3 km wooden boardwalk with floating and fixed sections along the Frontier Closed Area leading to the four floating hides overlooking Deep Bay.
- Five fixed boardwalks through reedbed, mangrove and rain-fed habitats with seven bridges for access to hides and three wooden footpaths along bunds.
- A Nature Trail with trail-side information boards.
- Three large and three small rain shelters.
- Two wooden pond platforms for education purposes.
- A Field Studies Centre, Wildlife Education Centre, green hut and a *gei wai* museum for public education.

The Education Centre will undergo internal renovation due to open first phase in December 2020.

Other infrastructure used for habitat management and research include the following:

- Fifteen sluice gates to manage water levels in the *gei wai*
- Six *gei wai* huts and three tool sheds as field staff workspaces and equipment storage
- A 435 m boardwalk and a ringing hut for bird ringing research in the reedbed
- Eleven sections of short temporary boardwalks for management and research work access
- A 1 km dirt track between *gei wai* #14 and #16/17 for vehicle access to the Education Centre
- Fences and shelters for water buffalo in pond #17b and #24.

The annual recurrent maintenance schedule for the infrastructure, including maintaining visitor facilities and ponds and *gei wai*, is provided in Annexes H and I. The Assistant Manager, Wetland Habitat (Figure 16) will be responsible for implementing the maintenance schedule, and will oversee 11 staff responsible for infrastructure maintenance.

To ensure the public safety of using the infrastructure in reserve, the team will carry out site inspections every two months and report to the Assistant Manager, Wetland Habitat to arrange repair work if required.

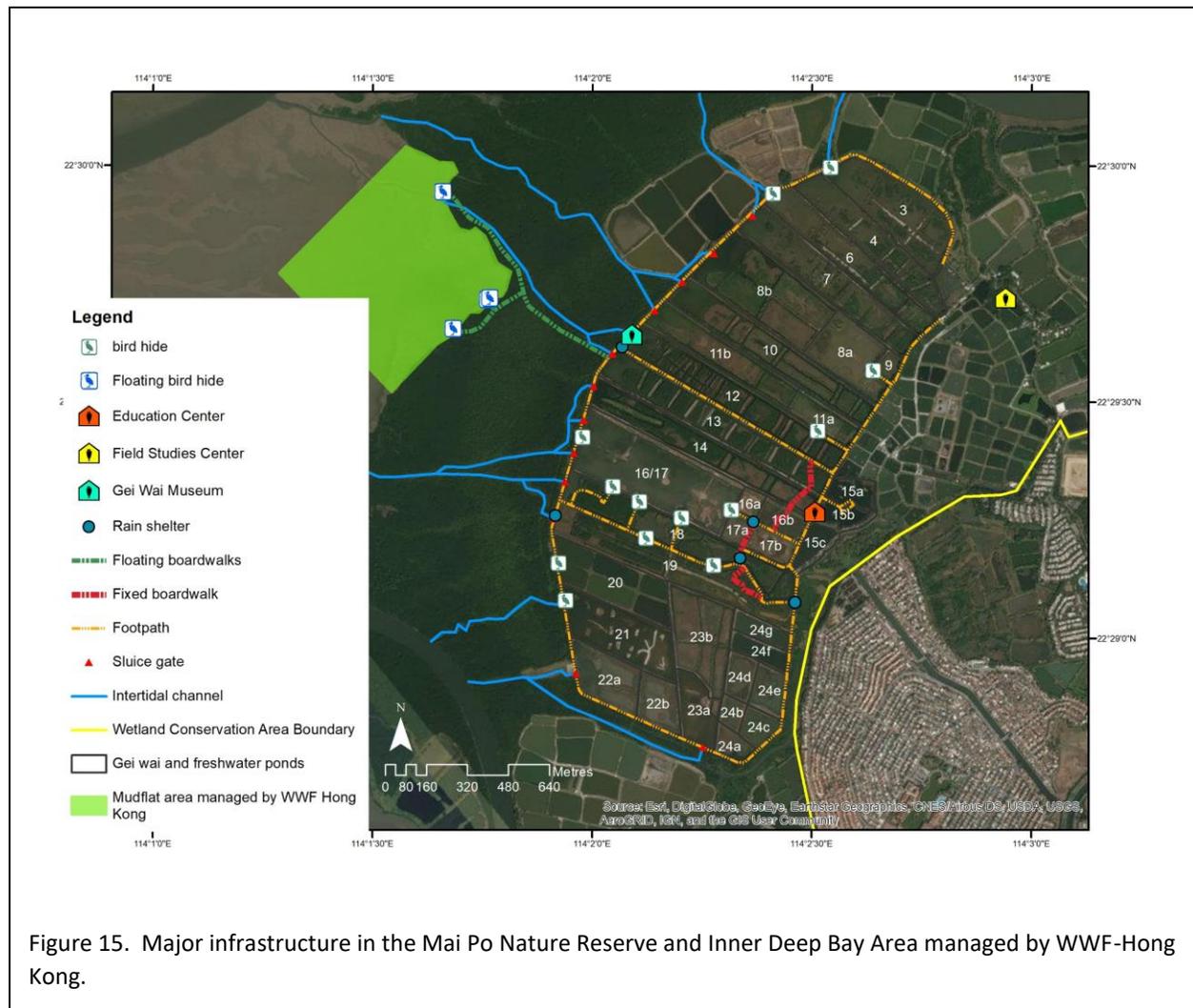


Figure 15. Major infrastructure in the Mai Po Nature Reserve and Inner Deep Bay Area managed by WWF-Hong Kong.

8.1 Proposed Major Repair Work of Infrastructure in Reserve

Several buildings and structures in the MPNR requires repair and renovation (Table 7)

Gei Wai #14 Hut: The hut near the sluice gate of GW #14 was severely damaged by Typhoon Mangkhut in September 2018. It needs to be repaired for storing field equipment and tools such as grass-cutters and sprayers. The floor of the hut will be raised up to 0.5 meter higher than the FCA road to reduce the risk that the equipment/tools are flooded by possible extraordinary high surge caused by typhoon in the future.

Sluice gate at Gei Wai #8b: This sluice gate has over 60 years of history in the reserve. The concrete structure is now cracked resulting in water leakage. Rebuilding of sluice gate is necessary to maintain the normal function of *gei wai*. While the traditional sluice gate with wood sluice boards that are pulled up and pushed down manually will be kept during the rebuilding, a gate with a metal board operated by an electric motor will be designed and installed and trialed. If the trial is successful, similar motorized metal gates can be added to most sluice gates in reserve in the future. Together with an automatic water level

detector and programme, the possibility for automatically controlling water level of *gei wai* can be further explored in the long term.

Rotary floating bird hide: This bird hide was built in 1998. Although the main structure of the hide remains in good condition, a large number of wooden planks on the floor and wall are broken or damaged. Therefore, for the safety of visitors, these boards have to be repaired.

Bird hides 5 and 6: These two bird hides are popular for watching birds in GW #16/17, which is the major high-tide roosting site for shorebirds during spring, autumn and winter. Numerous wooden floor planks have become loose and require replacement to ensure public safety.

Gei Wai Museum: The museum plays an important role to demonstrate the 'wise use of wetlands' model and cultural heritage in the reserve to visitors, since Mai Po's *gei wai* are the last remaining in Hong Kong. The roof and exterior wall of the building is damaged and requires replacement.

Table 7. Summary of the proposed major repair work of infrastructure.

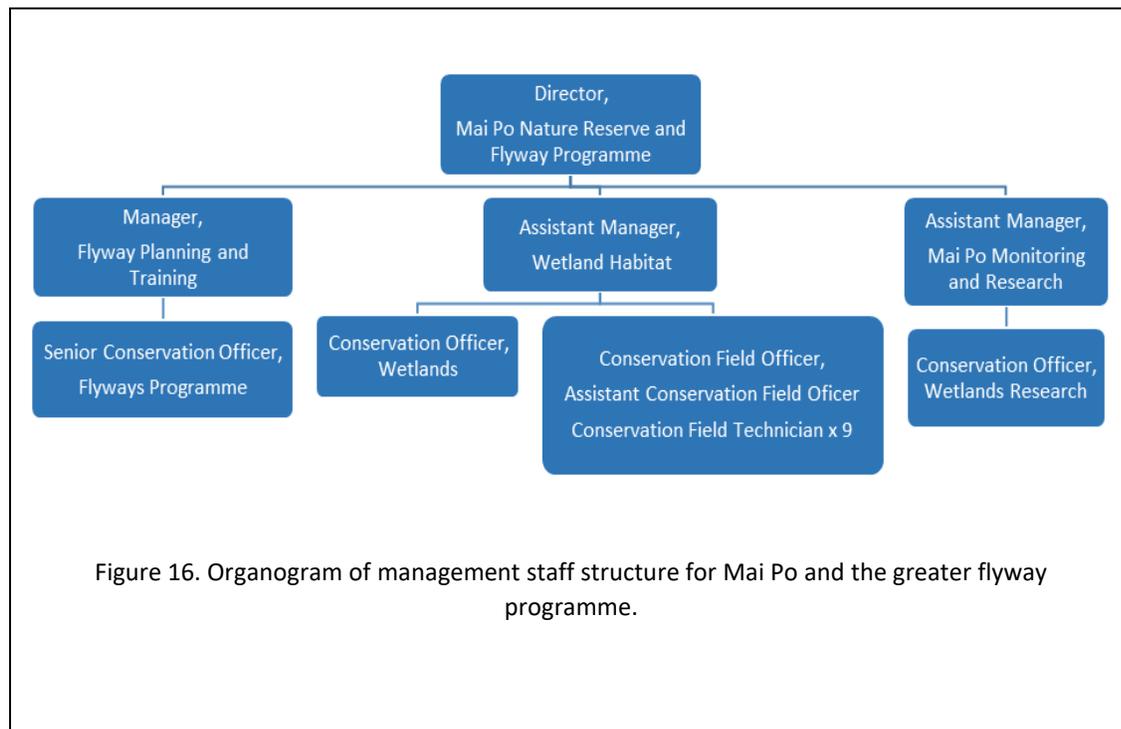
Proposed item	Urgency	Duration	Manpower
<i>Gei Wai</i> #14 Hut	High	3 months	In-house
Sluice gate GW #8b	High	4 months	In-house
Rotary Floating Bird hide	High	4 months	In-house
Bird hides #5 and #6	Medium	2 months	In-house
<i>Gei Wai</i> Museum	Medium	2 months	In-house

9 IMPLEMENTATION MECHANISMS: RESOURCES, PERSONNEL, RESPONSIBLE INSTITUTIONS

MPNR has been managed by WWF-Hong Kong since 1983, with support from the AFCD, which oversees the overall conservation management of the Mai Po Inner Deep Bay Ramsar Site. A conservation strategy and management plans for the Ramsar Site is prepared and implemented by AFCD, and sets out the context of the management of the Reserve.

WWF-Hong Kong develops five-year management plans for MPNR under advice of the Mai Po Management Committee, which is comprised of representatives from the AFCD, local academics, wetland managers, researchers, and local environmental NGOs. Committee membership is renewed every five years following the lifespan of the management plan.

The total cadre for MPNR is 19 staff, with the Director, Mai Po Nature Reserve and Flyway Programme in charge of the reserve and links to the flyway (Figure 17). The larger flyway outreach and knowledge exchange will be coordinated and overseen by the Manager, Flyway Programme. Two Assistant Managers will look after habitat management and infrastructure, and research and monitoring, respectively. The Assistant Manager, Habitat Management and Infrastructure will be supported by two Conservation Officers and 11 field staff, including the Conservation Field Manager. The Assistant Manager, Research and Monitoring will be supported by one Conservation Officer, and will be responsible for coordinating with relevant institutions (especially the Hong Kong Bird Watching Society and universities) to develop a research and monitoring programme, and implement collaborative projects. The research programme will comprise of projects that support and inform Mai Po management.



10 MONITORING PLAN (LOG FRAME)

Logical framework for activities with verifiable indicators. Activities are prioritized for importance; Red = High priority, Orange = Medium priority, and Yellow = Lower priority.

GOAL: To, a) manage the Mai Po Nature Reserve as climate resilient and adapted staging and wintering ground for migratory birds along the EAAF and for threatened indigenous biodiversity, b) sustain the practice of *gei wai* as an example of traditional wise use of wetlands, and c) be a regional centre for knowledge and awareness on wetland conservation.

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Objective 1. To maintain or increase populations of priority species by managing the required habitat diversity that integrates climate adaptation strategies.								
1A Species targets								
<p>Target 1. By 2024, no decline in the population of Black-faced Spoonbills from current population trends .</p> <p>Target 2. By 2024, the numbers and relative species composition (diversity) of the shorebird and duck assemblages remains stable, relative to past 5-year trend.</p> <p>Target 3. By 2024, Black-winged Stilt continue to nest in MPNR</p> <p>Target 4. By 2024, the reedbed dependent bird assemblage maintains numbers and assemblage diversity.</p> <p>Target 5. By 2024, numbers and composition of Ardeid community remains stable.</p>								
1.1 Strategy: Manage the habitat in selected BMZs as primary high tide roosting and feeding habitats for Black-faced Spoonbills, ducks and shorebirds								
Maintain and increase the open water area in the three brackish <i>gei wai</i> in BMZ 1 (GW #3, #6, #7) primarily as roosting habitat for Black-faced Spoonbill and ducks.	Extent of open water area available	Field surveys and mapping	Year 2, 4 and 5		H		H	H

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Maintain five traditionally-operated brackish water <i>gei wai</i> as winter feeding areas for Black-faced Spoonbills and Ardeids.	Five operational <i>gei wai</i> .	Field surveys	Annual	H	H	H	H	H
Desilt water channels of GW #6, #7, #8b, #12, #18, #19 to maintain deep water area for shrimps and fishes, which are the food for waterbirds	Desiltation work of selected <i>gei wai</i> completed	Field verification	Year 2-5		H	H	H	H
Re-profile islands and pond floor of GW #8a and connect #8a with #7 to restore the roosting habitats for shorebirds, ducks and Ardeids	Re-profiling work completed	Field verification	Year 4				H	
Reconnect landward and seaward parts of GW #18, #19 to increase the brackish water area for <i>gei wai</i> shrimp.	Reconnection work completed	Field verification	Year 4 and 5				H	H
Remove predatory fish to increase food quantity available for waterbirds	Remove predatory fish	Field verification	Annual	H	H	H	H	H
Provide feeding habitat during drain-down in the seaward side of the traditionally-operated brackish <i>gei wai</i> (GW #12, #13, #14, #18b, #19b), and open brackish water <i>gei wai</i> (GW #3, #4, #6, #7).	Flocks of Black-faced Spoonbill and Ardeids foraging in BMZs during drain down	Field verification	During scheduled drain down periods	H	H	H	H	H
Provide open, shallow water habitat in Pond #17b and #24a-g by using water buffalo.	Presence of Ardeids using habitats opened by buffalo wallows	Field observations	Bi-monthly	H	H	H	H	H

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Maintain shallow water high-tide roosting areas with no/short grass-topped islands in BMZ 5 (GW #16/17) and BMZ 7 (GW #8a, #21, #23a) for Black-faced Spoonbill, shorebird and duck assemblages.	Keep water levels at BMZ 5 and 7 favourable to Black-faced Spoonbill, shorebird and duck assemblages. Re-profile islands to remove vegetation, adjust height and create gentle slope in GW #8a	Water depth observations Field surveys for use by Black-faced Spoonbill, shorebird and duck assemblages	Annual (winter and spring) Re-profile islands in Year 2	H	H	H	H	H
Manage all bunds inside the Reserve as Black-faced Spoonbill and ducks roost.	Bunds have low or little vegetation in winter Black-faced Spoonbill and ducks using bunds as roosting areas	Field observations	Annual (winter and spring)	H	H	H	H	H
Re-profile BMZ 6 (Pond #24f and #24g) to provide shallow water rain-fed marshland for waterbirds.	Pond #24f and #24g have shallow water marshland	Field verification	Year 1	H				
Adjust water level of all <i>gei wai</i> and ponds according to annual water level management plan (see Annex D) to provide favourable water depth for waterbirds.	Water depth measures	Field verification	monthly	H	H	H	H	H
Restore overall open landscape of the Reserve for Black-faced Spoonbill, shorebird assemblage, duck assemblage and feeding Ardeids	Tree mapping and survey Tree management	Field verification	Year 1 - 5	H	H	H	H	H
1.2 Strategy: Maintain roosting areas and increase the open, deep-water foraging habitats in selected BMZs for the duck assemblage								

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Maintain islands with no/short grass-topped in BMZ 5 (GW #16/17), BMZ4 (Pond #15a-b) and BMZ 7 (GW #8a, #21, #23a) as roosting areas for ducks.	<p>Presence of islands with no or low vegetative cover.</p> <p>Ducks using islands as roosting sites</p>	Field surveys (winter and spring months)	Annual (winter and spring months)	H	H	H	H	H
Remove encroaching vegetation around edges of Pond #20 and merge the 6 sub-ponds to create deep water open areas for foraging.	<p>Vegetation cut</p> <p>6 ponds merged to form large open areas</p>	Field verification	<p>Annual (Oct)</p> <p>Year 4 (merge 6 sub-ponds and re-profile pond floor)</p>	H	H	H	H	H
1.3 Strategy: Manage the habitat in selected BMZs as nesting sites for Black-winged Stilt								
Monitor and management vegetation on islands in BMZ 5 and 7 for nesting Black-winged Stilt, and maintain stable water levels in the relevant ponds until young birds fledge.	<p>Presence of nests and chicks</p> <p>Stable water levels, if nests are observed.</p>	Field observations from April to July	Annual (April to July)	H	H	H	H	H
Explore possible methods to attract Black-winged Stilt to breed, including artificial floating islands	Presence of nests and chicks	Field observations from April to July	Year 2-5 (April to July)		H	H	M	M
1.4 Strategy: Increase the spatial extent of wet reedbeds that have been shown to support higher numbers and diversity of reedbed dependent birds than dry reedbed.								
Increase the area of reedbed in BMZ 2 (GW #8b) and maintain as wet reedbeds with a diversity of water depths, including controlling Red Imported Fire Ants.	Increase in extent of wet reedbeds in GW #8b	Field verifications	<p>Year 1</p> <p>Annual monitoring of reedbeds for new growth.</p>	H				

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Enlarge area of reedbed in BMZ 6 (GW #23b) by lowering or removing the internal bunds, and levelling internal channels to allow spreading of reedbed.	Internal bunds removed in BMZ 6. Evidence of reedbed extending	Field verification	Year 1 Annual monitoring of reedbeds for new growth.	H	M	M	M	M
1.5 Strategy: Maintain five traditionally-operated brackish water <i>gei wai</i> and restore total <i>gei wai</i> area in BMZ 3 as winter feeding habitats for Black-faced Spoonbill, egrets and herons.								
Conduct winter drain-down of the traditionally-operated brackish <i>gei wai</i> (GW #12, #13, #14, #18b, #19b), to provide feeding habitat.	Drain down activities conducted	Field verification and records	Annual (winter)	H	H	H	H	H
Maintain breeding habitat for egrets and herons in the seaward side of GW #14, and maintain the island in the northwest corner of GW #8a as a potential egretery.	Numbers of egrets using the seaward side of the GW for breeding and as egretery.	Field verification	Annual	M	M	M	M	M
Use water buffaloes to create open, shallow feeding habitat in rain-fed ponds (Pond #17b, #24a-g).	Habitat status and composition in ponds with and without buffalo	Field surveys (including by drone)	Annual	M	M	M	M	M
Drain down water level of GW #3, #4, #6, #7, #8b, #11, #16/17, #21 in summer to provide feeding habitat for water birds.	Drain down activities conducted	Field verification and records	Annual (Summer)	H	H	H	H	H
Restore open water area of BMZ 3	Extent of open water following restoration	Field verification	Annual after restoration		H	H	H	H
Target 6: By 2024, the roosting population of Collared Crows in Mai Po maintained as more than 200 individuals.								
1.6 Strategy: Protect the pre-roosting sites, and intertidal roosting mangrove patches.								

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Identify and map the daytime foraging areas in the areas to the south and southeast of the MPNR.	Foraging habitats surveyed and mapped. Meetings and discussions with AFCD and TPB	Survey and research reports and findings Meeting minutes and outcomes with TPB/AFCD	Once (Year 2) As necessary (after surveys are completed)		L	L	L	L
Manage and conserve the pre-roosting trees, bunds, and islands as suitable habitats, especially along GW #16/17, #21, #22, #23, and FCA road.	Trees along respective bunds used by roosting crows mapped	Field observations and reports	Annual	H	H	H	H	H
Conduct roosting counts	Survey estimates/numbers	Reports	Annual (summer and winter)	H	H	H	H	H
Target 7. By 2024, distribution of the Eurasian Otter population mapped, population estimated, and a conservation management plan for MPNR in place.								
1.7 Strategy: Research and conservation focus on breeding and raise awareness and education for otter conservation.								
Conduct a camera trap survey to map distribution of otters in the Reserve and conduct population estimates.	Cameras deployed Population estimate available	Field verification Report and scientific papers	Year 1-5	H	H	H	H	H
Develop a conservation management plan by 2022, and begin implementation.	Conservation plan available, and projects implemented	Plan and project reports	Plan preparation (Year 3-4) Project reports (annual thereafter)			M	M	M
Identify and monitor holts and suitable sites for artificial holts.	Map and database of holts and suitable breeding areas Monitoring plan implemented	Maps/spatial database Monitoring reports	Year 4-5 Bimonthly				M	M

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Target 8. By 2024, the major populations of Hong Kong Bent-winged Firefly and their habitat conserved and secured.								
1.8 Strategy: Collaborate with AFCD and other stakeholders to protect and conserve the priority habitats and firefly populations in and around MPNR.								
Conduct field surveys to map out and estimate population hotspots in the Nature Reserve.	Distributions mapped, and spatial database of distributions created. Populations estimated	Maps and survey reports available	Annually	H	H	H	H	H
Develop distribution model of fireflies using Maxent, based on survey information	Maxent analysis conducted	Report	Year 3/4			L	L	
Develop conservation and protection plan for 'firefly hotspots' in collaboration with stakeholders.	Conservation plan and strategy prepared	Plan/report	Year 5					H
Target 9. By 2024, status of Reeves' and Chinese Soft-shelled Turtles updated, and a recovery plan for the MPNR prepared.								
1.9 Strategy: Implement species recovery plans based on surveys to confirm presence and distributions in the MPNR.								
Conduct surveys for both species to confirm distribution in the Reserve	Surveys conducted	Survey reports and maps	Year 2		H			
If presence is confirmed, conduct study to determine habitat and thermoregulatory behaviour, and potential conflict and competition with the Red-eared Slider (<i>Trachemys scripta elegans</i>), an exotic species that is now prevalent across the Reserve.	Study completed	Reports and publications	Year 3/4			L	L	
Based on the survey data, develop a species recovery plan	Recovery plan prepared	Plan	Year 4/5				M	M

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Target 10. By 2024 the distribution of Four-spot Midget in the Reserve is stable.								
1.10 Strategy: Conserve the breeding habitat, including the water conditions necessary for eggs and nymphs to survive, with emergent vegetation necessary for metamorphosis to become complete.								
Survey the aquatic habitats for nymphs and map distribution	Survey conducted and distribution mapped	Survey reports and spatial database	Year 4/5				M	M
Establish a monitoring system for both adults and nymphs to track population status and distribution.	Monitoring system in place	Survey reports	Annual (Year 2-5)		H	H	H	H
1B Threat targets								
Target 11. By 2024, the spread of exotic species are under control and impacts on conservation target species and habitats are minimal.								
1.11 Strategy: Constantly monitor the status of the exotic species and apply controls to manage the populations and prevent the spread of the relevant species.								
Regularly check and manage four exotic plants in the Reserve: <i>Mikania micrantha</i> , <i>Typha</i> spp., <i>Sonneratia</i> spp. and <i>Leucaena leucocephala</i> .	Management and control methods in place and operational	Management reports Field verification	Semi-annual	H	H	H	H	H
Cut back the low part of stems of <i>Mikania</i> growing on top of mangroves, in particular at GW #12 and #13, before they bloom in November	Removal programme in place.	Management report Field verification	Annual (Sep-Oct)	H	H	H	H	H
Develop alternate control mechanisms, including physical removal and mulching during the early growth stages, rather than applying herbicides.	Use of various physical removal methods piloted and up-scaled	Reports Field verification	Year 1-3 for pilot testing Year 4 onwards for implementation monitoring	M	M	M	M	

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Monitor the intertidal channels for <i>Sonneratia</i> seedlings and physically remove.	No seedling growth in intertidal channels	Field verification	Quarterly	H	H	H	H	H
Monitor and uproot <i>Leucaena leucocephala</i> seedlings and saplings along the perimeter and internal bunds	No seedling growth along bunds	Field verification	Quarterly	H	H	H	H	H
Manage the Apple Snails in Pond #16b by removing adult snails from March to October, and destroying eggs on emerging vegetation.	Numbers of snails removed, and locations.	Reports and Field verification	Monthly from March-Oct	H	H	H	H	H
Monitor and destroy Red Imported Fire Ant mounds as they appear.	Number and locations of nests removed	Reports	Monthly	H	H	H	H	H
Collaborate with researchers to develop more efficient and effective ways to control all the above species.	Numbers of collaborative initiatives	Reports Field verification	Annual	M	M	M	M	M
Target 12. By 2024, a climate adaptation strategy and plan for Mai Po in place.								
1.12 Strategy: Prepare and propose to government stakeholders an adaptation plan to allow for ecosystem and habitat responses to climate change and consequent impacts to the MPNR.								
Develop and run a climate impact model to project habitat and ecosystem responses.	Climate impact analysis conducted	Report	Year 1/2	H	H			
Based on model outputs explore potential to secure critical areas to maintain ecosystems, ecosystem process, and biodiversity under future climate change scenarios.	Potential climate refugia identified and secured as conservation areas and included in RAMSAR management plan.	AFCD agreement to include and zone climate refugia as core conservation areas.	Year 2/3		H	H		
Develop and establish a climate monitoring system using bio-indicators.	Monitoring programme in place	M and E reports and assessments			H	H	H	H

	Objectively verifiable indicators	Means of verification	Frequency	Timeline				
				Y1	Y2	Y3	Y4	Y5
Target 13. Through the period up to 2024, a 45 ha area of intertidal mudflat along the western boundary of the Nature Reserve kept clear of encroaching mangroves and grasses.								
1.13 Strategy: Control mangrove seedlings and patches of grasses and sedges intruding into the mudflats in front of the floating bird hides.								
Test feasibility of using manual methods of removing the grass patches, using improvised rototiller mounted on mud scooters.	Rototiller tested and success assessed.	Report	Year 2/3		H	H		
Control invading grass patches and mangroves from the mudflat area.	45 ha area free of grasses and mangroves throughout autumn, winter and spring	Field verification	Annual	H	H	H	H	H

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Management of captive water buffalos. ©Caleb Choi/WWF-Hong Kong

12 APPENDICES

Appendix 1. List of flora recorded from Mai Po Nature Reserve. This list represents cumulative species records from the reserve over the past 35 years.

FERNS			
Leather Fern	<i>Acrostichum aureum</i>	Flexuose Climbing Fern	<i>Lygodium flexuosum</i>
Oriental Blechnum	<i>Blechnum orientale</i>	Climbing Fern	<i>Lygodium japonicum</i>
Water Fern	<i>Ceratopteris thalictroides</i>	Scansorial Climbing Fern	<i>Lygodium scandens</i>
Hairy Wood-fern	<i>Cyclosorus acuminatus</i>	-	<i>Nephrolepis</i> sp.
Interrupted Tri-vein Fern	<i>Cyclosorus interruptus</i>	Nodding Clubmoss	<i>Palhinhaea cernua</i>
Wood-fern	<i>Cyclosorus parasiticus</i>	Silver Fern	<i>Pityrogramma calomelanos</i>
Linear Forked Fern	<i>Dicranopteris linearis</i>		
GRASSES AND SEDGES			
Glutene-rice Grass	<i>Apluda mutica</i>	India Duck-beak	<i>Ischaemum ciliare</i>
Bamboo	<i>Bambusa</i> sp.	Common Rush	<i>Juncus effusus</i>
Australian Bluestem	<i>Bothriochloa bladhii</i>	Short-leaved Kyllinga	<i>Kyllinga brevifolia</i>
Couch Grass	<i>Cynodon dactylon</i>	Uni-spike Kyllinga	<i>Kyllinga nemoralis</i>
Laxspiculate Galingale	<i>Cyperus distans</i>	Rice Grass	<i>Leersia hexandra</i>
Tall-culm Galingale	<i>Cyperus exaltatus</i>	Chinese Sprangletop	<i>Leptochloa chinensis</i>
Imbricate Galingale	<i>Cyperus imbricatus</i>	Common Lophantherum	<i>Lophantherum gracile</i>
Rice Galingale	<i>Cyperus iria</i>	Sawgrass	<i>Mariscus cyperoides</i>
Malacca Galingale	<i>Cyperus malaccensis</i>	Fearthery Spike Sawgrass	<i>Mariscus javanicus</i>
Pilose Galingale	<i>Cyperus pilosus</i>	Burma-reed	<i>Neyraudia reynaudiana</i>
Nut-grass Galingale	<i>Cyperus rotundus</i>	Aquatic Panic Grass	<i>Panicum dichotomiflorum</i>
-	<i>Cyrtococcum patens</i>	Panic Grass	<i>Panicum repens</i>
Crow-foot Grass	<i>Dactyloctenium aegyptium</i>	Knot Grass	<i>Paspalum distichum</i>
Two-flowered Golden-beard	<i>Dichanthium annulatum</i>	India Paspalum	<i>Paspalum scrobiculatum</i>
Ciliate Crabgrass	<i>Digitaria ciliaris</i>	Ditch Millet	<i>Paspalum scrobiculatum</i> var. <i>orbiculare</i>
Common Crabgrass	<i>Digitaria sanguinalis</i>	Beach Paspalum	<i>Paspalum vaginatum</i>
Hispid Crabgrass	<i>Digitaria setigera</i>	Common Reedgrass	<i>Phragmites australis</i>
Barn-yard Grass	<i>Echinochloa crusgalli</i>	Reed	<i>Phragmites vallatorius</i>
Needle Spikesedge	<i>Eleocharis acicularis</i>	Golden-hair Grass	<i>Pogonatherum crinitum</i>
Goose Grass	<i>Eleusine indica</i>	Branch Pycurus	<i>Pycurus polystachyos</i>
Thalia Lovegrass	<i>Eragrostis atrovirens</i>	Reed-like Sugarcane	<i>Saccharum arundinaceum</i>
Ceylon Centipede-grass	<i>Eragrostis zeylanica</i>	Indina Cupscale	<i>Sacciolepis indica</i>
Cup Grass	<i>Eriochloa procera</i>	Coastal Bulrush	<i>Schoenoplectus subulatus</i>
Dichotomous Fimbristylis	<i>Fimbristylis dichotoma</i>	Australian Smut-grass	<i>Sporobolus fertilis</i>
Ferruginous-scale Fimbristylis	<i>Fimbristylis sieboldii</i>	Seashore Dropgrass	<i>Sporobolus virginicus</i>
Lalang Grass	<i>Imperata cylindrica</i> var. <i>major</i>	Chinese Lawn Grass	<i>Zoysia sinica</i>
Duck-beak Grass	<i>Ischaemum aristatum</i> var. <i>glaucum</i>		

Introduced grasses and sedges			
Carpet Grass	<i>Axonopus compressus</i>	Napier Grass	<i>Pennisetum purpureum</i>
Blunt Signal-grass	<i>Brachiaria mutica</i>	-	<i>Cyperus odoratus</i>
Redtop	<i>Melinis repens</i>	Water Chestnut	<i>Eleocharis dulcis</i>
Guinea Grass	<i>Panicum maximum</i>	Aromatic Kyllinga	<i>Kyllinga polyphylla</i>
Hilo Grass	<i>Paspalum conjugatum</i>	Cattail-leaved Lepironia	<i>Lepironia articulata</i>
Mission Grass	<i>Pennisetum polystachion</i>	Narrow-leaved Cat-tail	<i>Typha angustifolia</i>
CLIMBERS			
Sea Sword Bean	<i>Canavalia maritima</i>	Two-flowered Aniseia	<i>Ipomoea biflora</i>
Balloon Vine	<i>Cardiospermum halicacabum</i>	Ivy-like Merremia	<i>Merremia hederacea</i>
Cassytha	<i>Cassytha filiformis</i>	Common Indian-mulberry	<i>Morinda umbellata</i>
Snail Seed	<i>Cocculus orbiculatus</i>	Chinese Feverine	<i>Paederia scandens</i>
Chinese Dodder	<i>Cuscuta chinensis</i>	Goat Horns	<i>Strophanthus divaricatus</i>
White-flowered Derris	<i>Derris alborubra</i>	Sandpaper Vine	<i>Tetracera asiatica</i>
Derris	<i>Derris trifoliata</i>	Wight's Toxocarpus	<i>Toxocarpus wightianus</i>
Creeping Fig	<i>Ficus pumila</i>	Indian Zehneria	<i>Zehneria japonica</i>
Oblong Gymnanthera	<i>Gymnanthera oblonga</i>		
Introduced climbers			
Malabar-Nightshade	<i>Basella alba</i>	Cairo Morning Glory	<i>Ipomoea cairica</i>
White Gourd	<i>Benincasa hispida</i>	Mile-a-minuted Weed	<i>Mikania micrantha</i>
Hairy Gourd	<i>Benincasa hispida var. chieh qua</i>	Passion Flower	<i>Passiflora foetida</i>
Brazil Bougainvillea	<i>Bougainvillea spectabilis</i>	Triangular Passion Flower	<i>Passiflora suberosa</i>
Chinese Trumpet-creeper	<i>Campsis grandiflora</i>		
HERBS			
Common Achyranthes	<i>Achyranthes aspera</i>	Water-dragon	<i>Ludwigia adscendens</i>
Giant Alocasia	<i>Alocasia macrorrhizos</i>	Jute-leaved Melochia	<i>Melochia corchorifolia</i>
Sessile Alternanthera	<i>Alternanthera sessilis</i>	Naked Flower Murdannia	<i>Murdannia nudiflora</i>
Alyce Clover	<i>Alysicarpus vaginalis</i>	Sorrel	<i>Oxalis corniculata</i>
Green Amaranth	<i>Amaranthus viridis</i>	Chinese Knotweed	<i>Persicaria chinensis</i>
Water hyssop	<i>Bacopa monnieri</i>	Glabrous Knotweed	<i>Persicaria glabra</i>
Malay Blumea	<i>Blumea lacera</i>	White Smartweed	<i>Persicaria lapathifolia</i>
Moneywort	<i>Centella asiatica</i>	Plantain	<i>Plantago major</i>
Lamb's Quarters	<i>Chenopodium album</i>	Spiny Knotweed	<i>Polygonum perfoliatum</i>
Taro	<i>Colocasia esculenta</i>	Purslane	<i>Portulaca oleracea</i>
Diffuse Day-flower	<i>Commelina diffusa</i>	Toothed-fruited Dock	<i>Rumex dentatus</i>
Mock Jute	<i>Corchorus aestuans</i>	Trisetiferous Dock	<i>Rumex trisetifer</i>
-	<i>Crinum spp.</i>	Wigeon Grass	<i>Ruppia maritima</i>
Rattlebox	<i>Crotalaria retusa</i>	-	<i>Senecio scandens</i>
Dianella	<i>Dianella ensifolia</i>	Acute Sida	<i>Sida acuta</i>
Eclipta	<i>Eclipta prostrata</i>	Sida Hemp	<i>Sida rhombifolia</i>
Tassel-Flower	<i>Emilia sonchifolia</i>	Black Nightshade	<i>Solanum nigrum</i>

Wild Globe Amaranth	<i>Gomphrena celosioides</i>	Gold Button	<i>Spilanthes paniculata</i>
-	<i>Gynura divaricata</i>	South Sea-Blite	<i>Suaeda australis</i>
Beach Morning-glory	<i>Ipomoea pes-caprae</i>	Rose Mallow	<i>Urena lobate</i>
Lesser Duck-weed	<i>Lemna minor</i>	Procumbent Indian Mallow	<i>Urena procumbens</i>
Brittle False Pimpernel	<i>Lindernia crustacea</i>	Iron Weed	<i>Vernonia cinerea</i>
Lily Turf	<i>Liriope spicata</i>	Common Zeuxine	<i>Zeuxine strateumatica</i>
Introduced herbs			
Billygoat-weed	<i>Ageratum conyzoides</i>	Sweet Potato	<i>Ipomoea batatas</i>
Variegated Shell Ginger	<i>Alpinia zerumbet</i>	-	<i>Ipomoea triloba</i>
-	<i>Alternanthera paronychioides</i>	-	<i>Ludwigia erecta</i>
Alligator-weed	<i>Alternanthera philoxeroides</i>	One-leaved Clover	<i>Macroptilium lathyroides</i>
-	<i>Aster subulatus</i>	Sensitive Plant	<i>Mimosa pudica</i>
-	<i>Asystasia micrantha</i>	Common Banana	<i>Musa x paradisiaca</i>
-	<i>Bidens alba</i>	-	<i>Nymphaea</i> spp.
Hairy Bur-marigold	<i>Bidens pilosa</i>	Lavender Sorrel	<i>Oxalis debilis</i> subsp. <i>Corymbosa</i>
Indian Canna	<i>Canna indica</i>	-	<i>Philodendron</i> spp.
Canna Lily	<i>Canna x generalis</i>	Ground Cherry	<i>Physalis angulate</i>
-	<i>Conyza bonariensis</i>	India Poberry	<i>Phytolacca acinosa</i>
-	<i>Conyza sumatrensis</i>	-	<i>Ruellia coerulea</i>
-	<i>Crassocephalum crepidioides</i>	Sickle Senna	<i>Senna tora</i>
Smooth Crotalaria	<i>Crotalaria pallida</i>	Java Sesbania	<i>Sesbania javanica</i>
Ivy-arum	<i>Epipremnum aureum</i>	Shining-fruit Nightshade	<i>Solanum americanum</i>
-	<i>Eupatorium odoratum</i>	Tetrongan	<i>Solanum torvum</i>
Red-involucre Euphorbia	<i>Euphorbia cyathophora</i>	Sow-Thistle	<i>Sonchus oleraceus</i>
Garden spurge	<i>Euphorbia hirta</i>	African Evergreen	<i>Syngonium podophyllum</i>
-	<i>Gynura bicolor</i>	-	<i>Wedelia triloba</i>
American Hymenocallis	<i>Hymenocallis littoralis</i>	Yellow Rain Lily	<i>Zephyranthes citrina</i>
Water Spinach	<i>Ipomoea aquatica</i>		
SHRUBS			
Spiny Bears Breech	<i>Acanthus ilicifolius</i>	-	<i>Kandelia obovata</i>
Chinese Antirhea	<i>Antirhea chinensis</i>	Chinese Privet	<i>Ligustrum sinense</i>
Common Aporosa	<i>Aporosa dioica</i>	Round-leaved Litsea	<i>Litsea rotundifolia</i>
Hilo Holly	<i>Ardisia crenata</i>	Oblong-leaved Litsea	<i>Litsea rotundifolia</i> var. <i>oblongifolia</i>
Spotted Ardisia	<i>Ardisia lindleyana</i>	-	<i>Ludwigia hyssopifolia</i>
Wild Asparagus	<i>Asparagus cochinchinensis</i>	-	<i>Maesa perlaris</i>
Box-leaved Atalantia	<i>Atalantia buxifolia</i>	Common Melastoma	<i>Melastoma malabathricum</i>
Chinese Aucuba	<i>Aucuba chinensis</i>	Blood-red Melastoma	<i>Melastoma sanguineum</i>
Black Mangrove	<i>Avicennia marina</i>	Thorny Wingnut	<i>Paliurus ramosissimus</i>
Waxy Leaf	<i>Breynia fruticosa</i>	Hong Kong Pavetta	<i>Pavetta hongkongensis</i>
Many-petaled Mangrove	<i>Bruguiera gymnorhiza</i>	Necklace Plant	<i>Phyllanthus niruri</i>
-	<i>Cansjera rheedii</i>	Night-closing Leaf	<i>Phyllanthus urinaria</i>

Batavia Cinnamon	<i>Cinnamomum burmannii</i>	Marsh Fleabane	<i>Pluchea indica</i>
-	<i>Clerodendrum inerme</i>	Wild Coffee	<i>Psychotria asiatica</i>
Thick-leaved Croton	<i>Croton crassifolius</i>	Hong Kong Hawthorn	<i>Rhaphiolepis indica</i>
Three-flowered Beggarweed	<i>Desmodium triflorum</i>	Red Azalea	<i>Rhododendron simsii</i>
Desmos	<i>Desmos chinensis</i>	Rose Myrtle	<i>Rhodomyrtus tomentosa</i>
Air Potato	<i>Dioscorea bulbifera</i>	Sumac	<i>Rhus chinensis</i>
Small Persimmon	<i>Diospyros vaccinioides</i>	Hedge Sageretia	<i>Sageretia thea</i>
Chinese Eurya	<i>Eurya chinensis</i>	Sarcandra	<i>Sarcandra glabra</i>
Pear-fruit Fig	<i>Ficus pyriformis</i>	Chinese Scolopia	<i>Scolopia chinensis</i>
Japanese Superb Fig	<i>Ficus subpisocarpa</i>	-	<i>Tadehagi triquetrum</i>
Cape Jasmine	<i>Gardenia jasminoides</i>	India-charcoal Trema	<i>Trema tomentosa</i>
Auricular Hedyotis	<i>Hedyotis auricularia</i>	Triumfetta	<i>Triumfetta rhomboidea</i>
Corymbose Hedyotis	<i>Hedyotis corymbosa</i>	-	<i>Wedelia biflora</i>
Rough-leaved Holly	<i>Ilex asprella</i>	Indian Wikstroemia	<i>Wikstroemia indica</i>
Chinese Ixora	<i>Ixora chinensis</i>	Hawk's Beard	<i>Youngia japonica</i>
Introduced shrubs			
Mock Lime	<i>Aglaia odorata</i>	Lantana	<i>Lantana camara</i>
Allamanda	<i>Allamanda cathartica</i>	White Popinac	<i>Leucaena leucocephala</i>
-	<i>Ardisia elliptica</i>	Matrimony Vine	<i>Lycium chinense</i>
Blood-flower	<i>Asclepias curassavica</i>	Turk's Cap	<i>Malvaviscus arboreus var. penduliflorus</i>
Philippine Violet	<i>Barleria cristata</i>	Orange-jessamine	<i>Murraya paniculata</i>
Pink Power Puff	<i>Calliandra haematocephala</i>	Pomegranate	<i>Punica granatum</i>
Garden Croton	<i>Codiaeum variegatum</i>	Double-fruited Cassia	<i>Senna bicapsularis</i>
Blue Eranthemum	<i>Eranthemum pulchellum</i>	Yellow Oleander	<i>Thevetia peruviana</i>
Oval Kumquat	<i>Fortunella margarita</i>	Bush Thunbergia	<i>Thunbergia erecta</i>
Chinese Hibiscus	<i>Hibiscus rosa-sinensis</i>	Shrubby Woodfordia	<i>Woodfordia fruticosa</i>
TREES			
-	<i>Aegiceras corniculatum</i>	Sweet Gum	<i>Liquidambar formosana</i>
Autumn Maple	<i>Bischofia javanica</i>	Pond Spice	<i>Litsea glutinosa</i>
Pop-gun Seed	<i>Bridelia tomentosa</i>	Elephant's Ear	<i>Macaranga tanarius var. tomentosa</i>
Chinese Hackberry	<i>Celtis sinensis</i>	Turn-in-the-wind	<i>Mallotus paniculatus</i>
Cerbera	<i>Cerbera manghas</i>	Microcos	<i>Microcos nervosa</i>
Camphor Tree	<i>Cinnamomum camphora</i>	White Mulberry	<i>Morus alba</i>
Lidded Cleistocalyx	<i>Cleistocalyx nervosum</i>	Wax Tree	<i>Rhus succedanea</i>
Milky Mangrove	<i>Excoecaria agallocha</i>	Mountain Tallow Tree	<i>Sapium discolor</i>
Chinese Banyan	<i>Ficus microcarpa</i>	Chinese Tallow Tree	<i>Sapium sebiferum</i>
Big-leaved Fig	<i>Ficus virens</i>	Ivy Tree	<i>Schefflera heptaphylla</i>
Water Pine	<i>Glyptostrobus pensilis</i>	Lance-leaved Sterculia	<i>Sterculia lanceolata</i>
Coastal Heritiera	<i>Heritiera littoralis</i>	Box-leaved Syzygium	<i>Syzygium buxifolium</i>
Cuban Bast	<i>Hibiscus tiliaceus</i>		

Introduced trees			
Ear-leaved Acacia	<i>Acacia auriculiformis</i>	Ivory Coral Tree	<i>Erythrina speciosa</i>
Taiwan Acacia	<i>Acacia confusa</i>	Swamp Mahogany	<i>Eucalyptus robusta</i>
Big-leaved Acacia	<i>Acacia mangium</i>	Peepul Tree, Bodh Tree	<i>Ficus religiosa</i>
Lebbeck Tree	<i>Albizia lebbeck</i>	Fortune's Cape Jasmi	<i>Gardenia jasminoides var. fortuniana</i>
Formosan Alder	<i>Alnus japonica</i>	Silk Oak	<i>Grevillea robusta</i>
Sugar-apple	<i>Annona squamosa</i>	Chinese Holly	<i>Ilex rotunda</i>
Jackfruit	<i>Artocarpus heterophyllus</i>	Chinese Fan-palm	<i>Livistona chinensis</i>
Purple Camel's Foot	<i>Bauhinia purpurea</i>	Tapioca Plant, Cassava	<i>Manihot esculenta</i>
Tree Cotton	<i>Bombax ceiba</i>	China-berry	<i>Melia azedarach</i>
Fishtail Palm	<i>Caryota maxima</i>	Frangipani	<i>Plumeria rubra</i>
Horsetail Tree	<i>Casuarina equisetifolia</i>	Guava	<i>Psidium guajava</i>
Citrus	<i>Citrus sp.</i>	Weeping Willow	<i>Salix babylonica</i>
Obtuse-leaved Crateva	<i>Crateva trifoliata</i>	Dhaincha	<i>Sesbania cannabina</i>
Spider Tree	<i>Crateva unilocularis</i>	-	<i>Sonneratia apetala</i>
Flame Tree	<i>Delonix regia</i>	-	<i>Sonneratia caseolaris</i>
Longan	<i>Dimocarpus longan</i>	Rose Apple	<i>Syzygium jambos</i>

Appendix 2. Cumulative list of birds recorded from Mai Po Nature Reserve.

Section A: Species which have been recorded in an apparently wild state (Category I and II in HK List)

Lesser Whistling Duck	<i>Dendrocygna javanica</i>	Black Stork	<i>Ciconia nigra</i>
Greylag Goose	<i>Anser anser</i>	Oriental Stork	<i>Ciconia boyciana</i>
Taiga Bean Goose	<i>Anser fabalis</i>	Black-headed Ibis	<i>Threskiornis melanocephalus</i>
Tundra Bean Goose	<i>Anser serrirostris</i>	Glossy Ibis	<i>Plegadis falcinellus</i>
Greater White-fronted Goose	<i>Anser albifrons</i>	Eurasian Spoonbill	<i>Platalea leucorodia</i>
Lesser White-fronted Goose	<i>Anser erythropus</i>	Black-faced Spoonbill	<i>Platalea minor</i>
Whooper Swan	<i>Cygnus cygnus</i>	Eurasian Bittern	<i>Botaurus stellaris</i>
Common Shelduck	<i>Tadorna tadorna</i>	Yellow Bittern	<i>Ixobrychus sinensis</i>
Ruddy Shelduck	<i>Tadorna ferruginea</i>	Von Schrenck's Bittern	<i>Ixobrychus eurhythmus</i>
Mandarin Duck	<i>Aix galericulata</i>	Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>
Cotton Pygmy Goose	<i>Nettapus coromandelianus</i>	Black Bittern	<i>Dupetor flavicollis</i>
Baikal Teal	<i>Sibirionetta formosa</i>	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>
Garganey	<i>Spatula querquedula</i>	Striated Heron	<i>Butorides striata</i>
Northern Shoveler	<i>Spatula clypeata</i>	Chinese Pond Heron	<i>Ardeola bacchus</i>
Gadwall	<i>Mareca strepera</i>	Eastern Cattle Egret	<i>Bubulcus coromandus</i>
Falcated Duck	<i>Mareca falcata</i>	Grey Heron	<i>Ardea cinerea</i>
Eurasian Wigeon	<i>Mareca penelope</i>	Purple Heron	<i>Ardea purpurea</i>
American Wigeon	<i>Mareca americana</i>	Great Egret	<i>Ardea alba</i>
Philippine Duck	<i>Anas luzonica</i>	Intermediate Egret	<i>Ardea intermedia</i>
Indian Spot-billed Duck	<i>Anas poecilorhyncha</i>	Little Egret	<i>Egretta garzetta</i>
Chinese Spot-billed Duck	<i>Anas zonorhyncha</i>	Pacific Reef Heron	<i>Egretta sacra</i>
Mallard	<i>Anas platyrhynchos</i>	Chinese Egret	<i>Egretta eulophotes</i>
Northern Pintail	<i>Anas acuta</i>	Dalmatian Pelican	<i>Pelecanus crispus</i>
Eurasian Teal	<i>Anas crecca</i>	Christmas Island Frigatebird	<i>Fregata andrewsi</i>
Green-winged Teal	<i>Anas carolinensis</i>	Lesser Frigatebird	<i>Fregata ariel</i>
Red-crested Pochard	<i>Netta rufina</i>	Great Cormorant	<i>Phalacrocorax carbo</i>

Common Pochard	<i>Aythya ferina</i>	Western Osprey	<i>Pandion haliaetus</i>
Baer's Pochard	<i>Aythya baeri</i>	Black-winged Kite	<i>Elanus caeruleus</i>
Ferruginous Duck	<i>Aythya nyroca</i>	Crested Honey Buzzard	<i>Pernis ptilorhynchus</i>
Tufted Duck	<i>Aythya fuligula</i>	Black Baza	<i>Aviceda leuphotes</i>
Greater Scaup	<i>Aythya marila</i>	Eurasian Black Vulture	<i>Aegypius monachus</i>
White-winged Scoter	<i>Melanitta deglandi</i>	Crested Serpent Eagle	<i>Spilornis cheela</i>
Black Scoter	<i>Melanitta americana</i>	Greater Spotted Eagle	<i>Clanga clanga</i>
Common Goldeneye	<i>Bucephala clangula</i>	Steppe Eagle	<i>Aquila nipalensis</i>
Smew	<i>Mergellus albellus</i>	Eastern Imperial Eagle	<i>Aquila heliaca</i>
Red-breasted Merganser	<i>Mergus serrator</i>	Bonelli's Eagle	<i>Aquila fasciata</i>
Chinese Francolin	<i>Francolinus pintadeanus</i>	Crested Goshawk	<i>Accipiter trivirgatus</i>
Japanese Quail	<i>Coturnix japonica</i>	Chinese Sparrowhawk	<i>Accipiter soloensis</i>
Streaked Shearwater	<i>Calonectris leucomelas</i>	Japanese Sparrowhawk	<i>Accipiter gularis</i>
Little Grebe	<i>Tachybaptus ruficollis</i>	Besra	<i>Accipiter virgatus</i>
Great Crested Grebe	<i>Podiceps cristatus</i>	Eurasian Sparrowhawk	<i>Accipiter nisus</i>
Horned Grebe	<i>Podiceps auritus</i>	Northern Goshawk	<i>Accipiter gentilis</i>
Black-necked Grebe	<i>Podiceps nigricollis</i>	Eastern Marsh Harrier	<i>Circus spilonotus</i>
Pied Harrier	<i>Circus melanoleucos</i>	Red Knot	<i>Calidris canutus</i>
Black Kite	<i>Milvus migrans</i>	Ruff	<i>Calidris pugnax</i>
Brahminy Kite	<i>Haliastur indus</i>	Broad-billed Sandpiper	<i>Calidris falcinellus</i>
White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	Sharp-tailed Sandpiper	<i>Calidris acuminata</i>
Grey-faced Buzzard	<i>Butastur indicus</i>	Curlew Sandpiper	<i>Calidris ferruginea</i>
Eastern Buzzard	<i>Buteo japonicus</i>	Temminck's Stint	<i>Calidris temminckii</i>
Slaty-breasted Rail	<i>Gallirallus striatus</i>	Long-toed Stint	<i>Calidris subminuta</i>
Western Water Rail	<i>Rallus aquaticus</i>	Spoon-billed Sandpiper	<i>Calidris pygmeus</i>
Eastern Water Rail	<i>Rallus indicus</i>	Red-necked Stint	<i>Calidris ruficollis</i>
White-breasted Waterhen	<i>Amauornis phoenicurus</i>	Sanderling	<i>Calidris alba</i>
Baillon's Crake	<i>Porzana pusilla</i>	Dunlin	<i>Calidris alpina</i>
Ruddy-breasted Crake	<i>Porzana fusca</i>	Little Stint	<i>Calidris minuta</i>
White-browed Crake	<i>Porzana cinerea</i>	Buff-breasted Sandpiper	<i>Calidris subruficollis</i>
Watercock	<i>Gallixrex cinerea</i>	Pectoral Sandpiper	<i>Calidris melanotos</i>
Grey-headed Swampphen	<i>Porphyrio poliocephalus</i>	Asian Dowitcher	<i>Limnodromus semipalmatus</i>
Common Moorhen	<i>Gallinula chloropus</i>	Long-billed Dowitcher	<i>Limnodromus scolopaceus</i>
Eurasian Coot	<i>Fulica atra</i>	Eurasian Woodcock	<i>Scolopax rusticola</i>
Siberian Crane	<i>Grus leucogeranus</i>	Pintail Snipe	<i>Gallinago stenura</i>
Common Crane	<i>Grus grus</i>	Swinhoe's Snipe	<i>Gallinago megala</i>
Yellow-legged Buttonquail	<i>Turnix tanki</i>	Common Snipe	<i>Gallinago gallinago</i>
Barred Buttonquail	<i>Turnix suscitator</i>	Terek Sandpiper	<i>Xenus cinereus</i>
Great Stone-Curlew	<i>Esacus recurvirostris</i>	Red-necked Phalarope	<i>Phalaropus lobatus</i>
Eurasian Oystercatcher	<i>Haematopus ostralegus</i>	Red Phalarope	<i>Phalaropus fulicarius</i>
Black-winged Stilt	<i>Himantopus himantopus</i>	Common Sandpiper	<i>Actitis hypoleucos</i>
Pied Avocet	<i>Recurvirostra avosetta</i>	Green Sandpiper	<i>Tringa ochropus</i>
Northern Lapwing	<i>Vanellus vanellus</i>	Grey-tailed Tattler	<i>Tringa brevipes</i>
Grey-headed Lapwing	<i>Vanellus cinereus</i>	Lesser Yellowlegs	<i>Tringa flavipes</i>
European Golden Plover	<i>Pluvialis apricaria</i>	Common Redshank	<i>Tringa totanus</i>
Pacific Golden Plover	<i>Pluvialis fulva</i>	Marsh Sandpiper	<i>Tringa stagnatilis</i>
Grey Plover	<i>Pluvialis squatarola</i>	Wood Sandpiper	<i>Tringa glareola</i>
Common Ringed Plover	<i>Charadrius hiaticula</i>	Spotted Redshank	<i>Tringa erythropus</i>
Long-billed Plover	<i>Charadrius placidus</i>	Common Greenshank	<i>Tringa nebularia</i>
Little Ringed Plover	<i>Charadrius dubius</i>	Nordmann's Greenshank	<i>Tringa guttifer</i>
Kentish Plover	<i>Charadrius alexandrinus</i>	Oriental Pratincole	<i>Glareola maldivarum</i>
Lesser Sand Plover	<i>Charadrius mongolus</i>	Black-legged Kittiwake	<i>Rissa tridactyla</i>

Greater Sand Plover	<i>Charadrius leschenaultii</i>	Slender-billed Gull	<i>Chroicocephalus genei</i>
Oriental Plover	<i>Charadrius veredus</i>	Brown-headed Gull	<i>Chroicocephalus brunnicephalus</i>
Greater Painted-snipe	<i>Rostratula benghalensis</i>	Black-headed Gull	<i>Chroicocephalus ridibundus</i>
Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	Saunders's Gull	<i>Chroicocephalus saundersi</i>
Whimbrel	<i>Numenius phaeopus</i>	Little Gull	<i>Hydrocoloeus minutus</i>
Little Curlew	<i>Numenius minutus</i>	Franklin's Gull	<i>Leucophaeus pipixcan</i>
Far Eastern Curlew	<i>Numenius madagascariensis</i>	Relict Gull	<i>Ichthyaetus relictus</i>
Eurasian Curlew	<i>Numenius arquata</i>	Pallas's Gull	<i>Ichthyaetus ichthyaetus</i>
Bar-tailed Godwit	<i>Limosa lapponica</i>	Black-tailed Gull	<i>Larus crassirostris</i>
Black-tailed Godwit	<i>Limosa limosa</i>	Mew Gull	<i>Larus canus</i>
Ruddy Turnstone	<i>Arenaria interpres</i>	Glaucous-winged Gull	<i>Larus glaucescens</i>
Great Knot	<i>Calidris tenuirostris</i>	Glaucous Gull	<i>Larus hyperboreus</i>
Vega Gull	<i>Larus vegae</i>	Black-capped Kingfisher	<i>Halcyon pileata</i>
Slaty-backed Gull	<i>Larus schistisagus</i>	Collared Kingfisher	<i>Todiramphus chloris</i>
Heuglin's Gull	<i>Larus fuscus</i>	Common Kingfisher	<i>Alcedo atthis</i>
Gull-billed Tern	<i>Gelochelidon nilotica</i>	Pied Kingfisher	<i>Ceryle rudis</i>
Caspian Tern	<i>Hydroprogne caspia</i>	Blue-tailed Bee-eater	<i>Merops philippinus</i>
Greater Crested Tern	<i>Thalasseus bergii</i>	Blue-throated Bee-eater	<i>Merops viridis</i>
Little Tern	<i>Sternula albifrons</i>	Eurasian Hoopoe	<i>Upupa epops</i>
Bridled Tern	<i>Onychoprion anaethetus</i>	Eurasian Wryneck	<i>Jynx torquilla</i>
Common Tern	<i>Sterna hirundo</i>	Bay Woodpecker	<i>Blythipicus pyrrhotis</i>
Whiskered Tern	<i>Chlidonias hybrida</i>	Common Kestrel	<i>Falco tinnunculus</i>
White-winged Tern	<i>Chlidonias leucopterus</i>	Amur Falcon	<i>Falco amurensis</i>
Long-tailed Jaeger	<i>Stercorarius longicaudus</i>	Eurasian Hobby	<i>Falco subbuteo</i>
Ancient Murrelet	<i>Synthliboramphus antiquus</i>	Peregrine Falcon	<i>Falco peregrinus</i>
Domestic Pigeon	<i>Columba livia</i>	Yellow-crested Cockatoo	<i>Cacatua sulphurea</i>
Oriental Turtle Dove	<i>Streptopelia orientalis</i>	Alexandrine Parakeet	<i>Psittacula eupatria</i>
Eurasian Collared Dove	<i>Streptopelia decaocto</i>	Rose-ringed Parakeet	<i>Psittacula krameri</i>
Red Turtle Dove	<i>Streptopelia tranquebarica</i>	Fairy Pitta	<i>Pitta nympha</i>
Spotted Dove	<i>Spilopelia chinensis</i>	Black-winged Cuckooshrike	<i>Coracina melaschistos</i>
Common Emerald Dove	<i>Chalcophaps indica</i>	Swinhoe's Minivet	<i>Pericrocotus cantonensis</i>
White-bellied Green Pigeon	<i>Treron sieboldii</i>	Ashy Minivet	<i>Pericrocotus divaricatus</i>
Greater Coucal	<i>Centropus sinensis</i>	Scarlet Minivet	<i>Pericrocotus speciosus</i>
Lesser Coucal	<i>Centropus bengalensis</i>	Tiger Shrike	<i>Lanius tigrinus</i>
Chestnut-winged Cuckoo	<i>Clamator coromandus</i>	Bull-headed Shrike	<i>Lanius bucephalus</i>
Asian Koel	<i>Eudynamys scolopaceus</i>	Brown Shrike	<i>Lanius cristatus</i>
Plaintive Cuckoo	<i>Cacomantis merulinus</i>	Red-backed Shrike	<i>Lanius collurio</i>
Square-tailed Drongo- Cuckoo	<i>Surniculus lugubris</i>	Long-tailed Shrike	<i>Lanius schach</i>
Large Hawk Cuckoo	<i>Hierococcyx sparverioides</i>	Black-naped Oriole	<i>Oriolus chinensis</i>
Lesser Cuckoo	<i>Cuculus poliocephalus</i>	Black Drongo	<i>Dicrurus macrocercus</i>
Indian Cuckoo	<i>Cuculus micropterus</i>	Ashy Drongo	<i>Dicrurus leucophaeus</i>
Oriental Cuckoo	<i>Cuculus optatus</i>	Hair-crested Drongo	<i>Dicrurus hottentottus</i>
Eastern Grass Owl	<i>Tyto longimembris</i>	Black-naped Monarch	<i>Hypothymis azurea</i>
Collared Scops Owl	<i>Otus lettia</i>	Amur Paradise Flycatcher	<i>Terpsiphone incei</i>
Oriental Scops Owl	<i>Otus sunia</i>	Japanese Paradise Flycatcher	<i>Terpsiphone atrocaudata</i>
Eurasian Eagle Owl	<i>Bubo bubo</i>	Eurasian Jay	<i>Garrulus glandarius</i>
Asian Barred Owlet	<i>Glaucidium cuculoides</i>	Azure-winged Magpie	<i>Cyanopica cyanus</i>
Northern Boobook	<i>Ninox japonica</i>	Red-billed Blue Magpie	<i>Urocissa erythroryncha</i>
Short-eared Owl	<i>Asio flammeus</i>	Grey Treepie	<i>Dendrocitta formosae</i>
Grey Nightjar	<i>Caprimulgus jotaka</i>	Eurasian Magpie	<i>Pica pica</i>
Savanna Nightjar	<i>Caprimulgus affinis</i>	Daurian Jackdaw	<i>Coloeus dauuricus</i>
Himalayan Swiftlet	<i>Aerodramus brevirostris</i>	House Crow	<i>Corvus splendens</i>
White-throated Needletail	<i>Hirundapus caudacutus</i>	Rook	<i>Corvus frugilegus</i>
Silver-backed Needletail	<i>Hirundapus cochinchinensis</i>	Carrion Crow	<i>Corvus corone</i>
Common Swift	<i>Apus apus</i>	Collared Crow	<i>Corvus torquatus</i>

Pacific Swift	<i>Apus pacificus</i>	Large-billed Crow	<i>Corvus macrorhynchos</i>
House Swift	<i>Apus nipalensis</i>	Grey-headed Canary-flycatcher	<i>Culicicapa ceylonensis</i>
Oriental Dollarbird	<i>Eurystomus orientalis</i>	Yellow-bellied Tit	<i>Pardaliparus venustulus</i>
White-throated Kingfisher	<i>Halcyon smyrnensis</i>	Cinereous Tit	<i>Parus cinereus</i>
Chinese Penduline Tit	<i>Remiz consobrinus</i>	Lanceolated Warbler	<i>Locustella lanceolata</i>
Oriental Skylark	<i>Alauda gulgula</i>	Middendorff's Grasshopper Warbler	<i>Locustella ochotensis</i>
Eurasian Skylark	<i>Alauda arvensis</i>	Styan's Grasshopper Warbler	<i>Helopsaltes pleskei</i>
Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	Pallas's Grasshopper Warbler	<i>Helopsaltes pleskei</i>
Chinese Bulbul	<i>Pycnonotus sinensis</i>	Japanese Swamp Warbler	<i>Locustella pryeri</i>
Sooty-headed Bulbul	<i>Pycnonotus aurigaster</i>	Zitting Cisticola	<i>Cisticola juncidis</i>
Mountain Bulbul	<i>Ixos mccllellandii</i>	Golden-headed Cisticola	<i>Cisticola exilis</i>
Chestnut Bulbul	<i>Hemixos castanonotus</i>	Yellow-bellied Prinia	<i>Prinia flaviventris</i>
Black Bulbul	<i>Hypsipetes leucocephalus</i>	Plain Prinia	<i>Prinia inornata</i>
Grey-throated Martin	<i>Riparia chinensis</i>	Common Tailorbird	<i>Orthotomus sutorius</i>
Sand Martin	<i>Riparia riparia</i>	Chinese Hwamei	<i>Garrulax canorus</i>
Barn Swallow	<i>Hirundo rustica</i>	Masked Laughingthrush	<i>Garrulax perspicillatus</i>
Common House Martin	<i>Delichon urbicum</i>	Greater Necklaced Laughingthrush	<i>Garrulax pectoralis</i>
Asian House Martin	<i>Delichon dasypus</i>	Black-throated Laughingthrush	<i>Garrulax chinensis</i>
Red-rumped Swallow	<i>Cecropis daurica</i>	Lesser Whitethroat	<i>Sylvia curruca</i>
Mountain Tailorbird	<i>Phyllergates cucullatus</i>	Vinous-throated Parrotbill	<i>Sinosuthora webbiana</i>
Manchurian Bush Warbler	<i>Horornis canturians</i>	Chestnut-collared Yuhina	<i>Yuhina torqueola</i>
Brown-flanked Bush Warbler	<i>Horornis fortipes</i>	Chestnut-flanked White-eye	<i>Zosterops erythropleurus</i>
Asian Stubtail	<i>Urosphena squameiceps</i>	Japanese White-eye	<i>Zosterops japonicas</i>
Pale-footed Bush Warbler	<i>Urosphena pallidipes</i>	Crested Myna	<i>Acridotheres cristatellus</i>
Common Chiffchaff	<i>Phylloscopus collybita</i>	Common Myna	<i>Acridotheres tristis</i>
Dusky Warbler	<i>Phylloscopus fuscatus</i>	Red-billed Starling	<i>Spodiopsar sericeus</i>
Yellow-streaked Warbler	<i>Phylloscopus armandii</i>	White-cheeked Starling	<i>Spodiopsar cineraceus</i>
Radde's Warbler	<i>Phylloscopus schwarzi</i>	Black-collared Starling	<i>Gracupica nigricollis</i>
Pallas's Leaf Warbler	<i>Phylloscopus proregulus</i>	Daurian Starling	<i>Agropsar sturninus</i>
Yellow-browed Warbler	<i>Phylloscopus inornatus</i>	Chestnut-cheeked Starling	<i>Agropsar philippensis</i>
Hume's Leaf Warbler	<i>Phylloscopus humei</i>	White-shouldered Starling	<i>Sturnia sinensis</i>
Arctic Warbler	<i>Phylloscopus borealis</i>	Chestnut-tailed Starling	<i>Sturnia malabarica</i>
Japanese Leaf Warbler	<i>Phylloscopus xanthodryas</i>	Rosy Starling	<i>Pastor roseus</i>
Two-barred Warbler	<i>Phylloscopus plumbeitarsus</i>	Common Starling	<i>Sturnus vulgaris</i>
Pale-legged Leaf Warbler	<i>Phylloscopus tenellipes</i>	Orange-headed Thrush	<i>Geokichla citrina</i>
Sakhalin Leaf Warbler	<i>Phylloscopus borealoides</i>	White's Thrush	<i>Zoothera aurea</i>
Eastern Crowned Warbler	<i>Phylloscopus coronatus</i>	Grey-backed Thrush	<i>Turdus hortulorum</i>
Goodson's Leaf Warbler	<i>Phylloscopus goodsoni</i>	Japanese Thrush	<i>Turdus cardis</i>
Alstrom's Warbler	<i>Seicercus soror</i>	Chinese Blackbird	<i>Turdus mandarinus</i>
Oriental Reed Warbler	<i>Acrocephalus orientalis</i>	Eyebrowed Thrush	<i>Turdus obscurus</i>
Black-browed Reed Warbler	<i>Acrocephalus bistrigiceps</i>	Pale Thrush	<i>Turdus pallidus</i>
Blunt-winged Warbler	<i>Acrocephalus concinens</i>	Naumann's Thrush	<i>Turdus naumanni</i>
Manchurian Reed Warbler	<i>Acrocephalus tangorum</i>	Dusky Thrush	<i>Turdus eunomus</i>
Paddyfield Warbler	<i>Acrocephalus agricola</i>	Oriental Magpie Robin	<i>Copsychus saularis</i>
Blyth's Reed Warbler	<i>Acrocephalus dumetorum</i>	Grey-streaked Flycatcher	<i>Muscicapa griseisticta</i>
Thick-billed Warbler	<i>Arundinax aedon</i>	Dark-sided Flycatcher	<i>Muscicapa sibirica</i>
Booted Warbler	<i>Iduna caligata</i>	Asian Brown Flycatcher	<i>Muscicapa latirostris</i>
Sykes's Warbler	<i>Iduna rama</i>	Ferruginous Flycatcher	<i>Muscicapa ferruginea</i>
Russet Bush Warbler	<i>Locustella mandelli</i>	Hainan Blue Flycatcher	<i>Cyornis hainanus</i>
Baikal Bush Warbler	<i>Locustella davidi</i>	Brown-chested Jungle Flycatcher	<i>Cyornis brunneatus</i>
Brown Bush Warbler	<i>Locustella luteoventris</i>	Blue-and-white Flycatcher	<i>Cyanoptila cyanomelana</i>
Verditer Flycatcher	<i>Eumyias thalassinus</i>	Grey Wagtail	<i>Motacilla cinerea</i>
Siberian Blue Robin	<i>Larvivera cyane</i>	White Wagtail	<i>Motacilla alba</i>

Rufous-tailed Robin	<i>Larvivora sibilans</i>	Richard's Pipit	<i>Anthus richardi</i>
Bluethroat	<i>Luscinia svecica</i>	Olive-backed Pipit	<i>Anthus hodgsoni</i>
Siberian Rubythroat	<i>Calliope calliope</i>	Pechora Pipit	<i>Anthus gustavi</i>
Red-flanked Bluetail	<i>Tarsiger cyanurus</i>	Red-throated Pipit	<i>Anthus cervinus</i>
Blue Whistling Thrush	<i>Myophonus caeruleus</i>	Buff-bellied Pipit	<i>Anthus rubescens</i>
Yellow-rumped Flycatcher	<i>Ficedula zanthopygia</i>	Water Pipit	<i>Anthus spinoletta</i>
Narcissus Flycatcher	<i>Ficedula narcissina</i>	Brambling	<i>Fringilla montifringilla</i>
Mugimaki Flycatcher	<i>Ficedula mugimaki</i>	Chinese Grosbeak	<i>Eophona migratoria</i>
Red-breasted Flycatcher	<i>Ficedula parva</i>	Japanese Grosbeak	<i>Eophona personata</i>
Red-throated Flycatcher	<i>Ficedula albicilla</i>	Common Rosefinch	<i>Carpodacus erythrinus</i>
Daurian Redstart	<i>Phoenicurus aureoreus</i>	Grey-capped Greenfinch	<i>Chloris sinica</i>
Plumbeous Water Redstart	<i>Phoenicurus fuliginosus</i>	Eurasian Siskin	<i>Spinus spinus</i>
Blue Rock Thrush	<i>Monticola solitarius</i>	Crested Bunting	<i>Emberiza lathamii</i>
White-throated Rock Thrush	<i>Monticola gularis</i>	Tristram's Bunting	<i>Emberiza tristrami</i>
Stejneger's Stonechat	<i>Saxicola stejnegeri</i>	Chestnut-eared Bunting	<i>Emberiza fucata</i>
Grey Bush Chat	<i>Saxicola ferreus</i>	Little Bunting	<i>Emberiza pusilla</i>
Scarlet-backed Flowerpecker	<i>Dicaeum cruentatum</i>	Yellow-browed Bunting	<i>Emberiza chrysophrys</i>
Fork-tailed Sunbird	<i>Aethopyga christinae</i>	Rustic Bunting	<i>Emberiza rustica</i>
House Sparrow	<i>Passer domesticus</i>	Yellow-breasted Bunting	<i>Emberiza aureola</i>
Russet Sparrow	<i>Passer cinnamomeus</i>	Chestnut Bunting	<i>Emberiza rutila</i>
Eurasian Tree Sparrow	<i>Passer montanus</i>	Black-headed Bunting	<i>Emberiza melanocephala</i>
Baya Weaver	<i>Ploceus philippinus</i>	Red-headed Bunting	<i>Emberiza bruniceps</i>
White-rumped Munia	<i>Lonchura striata</i>	Japanese Yellow Bunting	<i>Emberiza sulphurata</i>
Scaly-breasted Munia	<i>Lonchura punctulata</i>	Black-faced Bunting	<i>Emberiza spodocephala</i>
Chestnut Munia	<i>Lonchura atricapilla</i>	Pallas's Reed Bunting	<i>Emberiza pallasii</i>
Forest Wagtail	<i>Dendronanthus indicus</i>	Japanese Reed Bunting	<i>Emberiza yessoensis</i>
Eastern Yellow Wagtail	<i>Motacilla tschutschensis</i>	Common Reed Bunting	<i>Emberiza schoeniclus</i>
Citrine Wagtail	<i>Motacilla citreola</i>		

Section B: Cumulative list of species from Mai Po and Inner Deep Bay that are considered likely to be birds that have escaped or have been released from captivity (Category III in HK List)

Common Pheasant	<i>Phasianus colchicus</i>	Brown-breasted Bulbul	<i>Pycnonotus xanthorrhous</i>
Swan Goose	<i>Anser cygnoides</i>	Pale-bellied Myna	<i>Acridotheres cinereus</i>
Wood Duck	<i>Aix sponsa</i>	Pied Bush Chat	<i>Saxicola caprata</i>
Great White Pelican	<i>Pelecanus onocrotalus</i>	Yellow-crowned Bishop	<i>Euplectes afer</i>
Cockatiel	<i>Nymphicus hollandicus</i>	Southern Red Bishop	<i>Euplectes orix</i>
Red Lory	<i>Eos bornea</i>	White-headed Munia	<i>Lonchura maja</i>
Budgerigar	<i>Melopsittacus undulatus</i>	Java Sparrow	<i>Lonchura oryzivora</i>
Rosy-faced Lovebird	<i>Agapornis roseicollis</i>	Red Avadavat	<i>Amandava amandava</i>
Fischer's Lovebird	<i>Agapornis fischeri</i>	Pin-tailed Whydah	<i>Vidua macroura</i>
Red-and-green Macaw	<i>Ara chloropterus</i>	Yellow-fronted Canary	<i>Crithagra mozambica</i>
Bohemian Waxwing	<i>Bombycilla garrulus</i>	European Goldfinch	<i>Carduelis carduelis</i>
Bearded Reedling	<i>Panurus biarmicus</i>	White-rumped Seedeater	<i>Serinus leucopygius</i>
Mongolian Lark	<i>Melanocorypha mongolica</i>	Grey-necked Bunting	<i>Emberiza buchanani</i>
White-winged Lark	<i>Melanocorypha leucoptera</i>		

Appendix 3. Cumulative list of mammals recorded from Mai Po Nature Reserve.

Musk Shrew	<i>Suncus murinus</i>	Lesser Bent-winged Bat	<i>Miniopterus pusillus</i>
Leschenault's Rousette	<i>Rousettus leschenaulti</i>	Greater Bandicoot Rat	<i>Bandicota indica</i>
Short-nosed Fruit Bat	<i>Cynopterus sphinx</i>	Chestnut Spiny Rat	<i>Niviventer fulvescens</i>
Intermediate Horseshoe Bat	<i>Rhinolophus affinis</i>	Indochinese Forest Rat	<i>Rattus andamanensis</i>
Least Horseshoe Bat	<i>Rhinolophus pusillus</i>	Lesser Rice-field Rat	<i>Rattus losea</i>
Horsfield's Myotis	<i>Myotis horsfieldii</i>	Ryukyu Mouse	<i>Mus caroli</i>
Chinese Noctule	<i>Nyctalus plancyi</i>	East Asian Porcupine	<i>Hystrix brachyura</i>
Japanese Pipistrelle	<i>Pipistrellus abramus</i>	Eurasian Otter	<i>Lutra lutra</i>
Least Pipistrelle	<i>Pipistrellus tenuis</i>	Small Indian Civet	<i>Viverricula indica</i>
Chinese Pipistrelle	<i>Hypsugo pulveratus</i>	Small Asian Mongoose	<i>Herpestes javanicus</i>
Lesser Bamboo Bat	<i>Tylonycteris pachypus</i>	Leopard Cat	<i>Prionailurus bengalensis</i>
Lesser Yellow Bat	<i>Scotophilus kuhlii</i>	Wild Boar	<i>Sus scrofa</i>
Greater Bent-winged Bat	<i>Miniopterus magnater</i>		
Introduced species:			
Rhesus Macaque	<i>Macaca mulatta</i>	House Mouse	<i>Mus musculus</i>
Brown Rat	<i>Rattus norvegicus</i>	Domestic Dog	<i>Canis lupus familiaris</i>
Roof Rat	<i>Rattus rattus</i>	Domestic Cat	<i>Felis catus</i>
Asian House Rat	<i>Rattus tanezumi</i>	Domestic Water Buffalo	<i>Bubalus bubalis</i>

Appendix 4. Cumulative list of reptiles and amphibians recorded from Mai Po Nature Reserve**REPTILES**

Reeves' Turtle	<i>Mauremys reevesii</i>	Copperhead Racer	<i>Coelognathus radiates</i>
Chinese Soft-shelled Turtle	<i>Pelodiscus sinensis</i>	Common Rat Snake	<i>Ptyas mucosus</i>
Four-clawed Gecko	<i>Gehyra mutilata</i>	Indo-chinese rat snake	<i>Ptyas korros</i>
Bowring's Gecko	<i>Hemidactylus bowringii</i>	Taiwan Kukri Snake	<i>Oligodon formosanus</i>
Reeve's Smooth skink	<i>Scincella reevesii</i>	Checkered Keelback	<i>Xenochrophis flavipunctatus</i>
Chinese Skink	<i>Plestiodon chinensis</i>	Mangrove Water Snake	<i>Enhydris bennettii</i>
Long-tailed Skink	<i>Eutropis longicaudata</i>	Chinese Water Snake	<i>Enhydris chinensis</i>
Grass Lizard	<i>Takydromus sexlineatus</i>	Many-banded Krait	<i>Bungarus multicinctus</i>
Common Blind Snake	<i>Ramphotyphlops braminus</i>	Chinese Cobra	<i>Naja atra</i>
Burmese Python	<i>Python bivittatus</i>	King Cobra / Hamadryad	<i>Ophiophagus Hannah</i>
Banded Krait	<i>Bungarus fasciatus</i>		
<u>Introduced species:</u>			
Red-eared Slider	<i>Trachemys scripta</i>	Malaysian Box Turtle	<i>Cuora amboinensis</i>

AMPHIBIANS

Asian Common Toad	<i>Duttaphrynus melanostictus</i>	Brown Tree Frog	<i>Polypedates megacephalus</i>
Asiatic Painted Frog	<i>Kaloula pulchra</i>	Paddy Frog	<i>Fejervarya limnocharis</i>
Ornate Pigmy Frog	<i>Microhyla fissipes</i>	Gunther's Frog	<i>Hylarana guentheri</i>
Spotted Narrow-mouthed Frog	<i>Kalophrynus interlineatus</i>	Chinese Bullfrog	<i>Hoplobatrachus rugulosus</i>

Appendix 5. Cumulative list of fish species recorded from Mai Po Nature Reserve

White Seabream	<i>Acanthopagrus berda</i>	Swampy Eel	<i>Monopterus albus</i>
Yellowfin Seabream	<i>Acanthopagrus latus</i>	Grey Mullet	<i>Mugil cephalus</i>
Black Bream	<i>Acanthopagrus schlegeli</i>	Green-backed Mullet	<i>Mugil dussumieri</i>
Bald Glassy	<i>Ambassis gymnocephalus</i>	Estuarine Goby	<i>Mugilogobius abei</i>
Climbing Perch	<i>Anabas testudineus</i>	Yellowstripe Goby	<i>Mugilogobius chulae</i>
Japanese Eel	<i>Anguilla japonica</i>	-	<i>Ochetobius elongatus</i>
Blue-spotted Mud Skipper	<i>Boleophthalmus pectinirostris</i>	-	<i>Ophichthus celebicus</i>
Chinese Black Sleeper	<i>Bostrychus sinensis</i>	Mozambique Tilapia	<i>Oreochromis mossambicus</i>
Crimson-tipped Flathead Gudgeon	<i>Butis melanostigma</i>	Nile Tilapia	<i>Oreochromis niloticus</i>
Goldfish	<i>Carassius auratus</i>	Common Mud Skipper	<i>Periophthalmus cantonensis</i>
Small Snakehead	<i>Channa asiatica</i>	-	<i>Periophthalmus magnuspinnatus</i>
Spotted Snakehead	<i>Channa maculata</i>	Snake Eel	<i>Pisodonophis sp.</i>
Mullet	<i>Chelon sp.</i>	Bartail Flathead	<i>Platycephalus indicus</i>
Mud Carp	<i>Cirrhinus molitorella</i>	-	<i>Pseudogobius javanicus</i>
Catfish	<i>Clarias fuscus</i>	-	<i>Pseudogobius taijiangensis</i>
North African Catfish	<i>Clarias gariepinus</i>	Topmouth Gudgeon	<i>Pseudorasbora parva</i>
Grass Carp	<i>Ctenopharyngodon idellus</i>	Speckled Goby	<i>Redigobius bikolanus</i>
Common Carp	<i>Cyprinus carpio</i>	Barcheek Goby	<i>Rhinogobius giurinus</i>
Black Sleeper	<i>Eleotris melanosoma</i>	Walking Goby	<i>Scartelaos viridis</i>
Sharphead Sleeper	<i>Eleotris oxycephala</i>	Spotted Silver Scat	<i>Scatophagus argus</i>
Ladyfish	<i>Elops saurus</i>	Red Drum	<i>Sciaenops ocellatus</i>
Mosquito Fish	<i>Gambusia affinis</i>	Seaweed Piperfish	<i>Syngnathus sp</i>
Spotty Band Goby	<i>Glossogobius olivaceus</i>	Bearded Eel Goby	<i>Taenioides cirratus</i>
Bigmouth Sleeper	<i>Gobiomorus dormitor</i>	Jarbua Terapon	<i>Terapon jarbua</i>
Common Sea Bass	<i>Lateolabrax japonicus</i>	Shimofuri Goby	<i>Tridentiger bifasciatus</i>
Mangrove Red Snapper	<i>Lutjanus argentimaculatus</i>	Chameleon Goby	<i>Tridentiger trigonocephalus</i>
Barramundi	<i>Lates calcarifer</i>	Spottail Needlefish	<i>Tylosurus strongylurus</i>

Appendix 6. Cumulative list of benthic invertebrate species recorded from Mai Po Nature Reserve

NERMETINEA			
Anopla			
-	<i>Dendrorhynchus sinensis</i>		
-	<i>Procephalothrix orientalis</i>		
ANNELIDA			
Oligochaeta			
-	<i>Limnodriloides biforis</i>	-	<i>Doliodrilus tener</i>
-	<i>Limnodriloides fraternus</i>	-	<i>Rhizodrilus russus</i>
-	<i>Tectidrilus achaetus</i>		
Hirudinea			
Unidentified leech	-		
Polychaeta			
-	<i>Dendronereis pinnaticirrus</i>	-	<i>Polydora</i> sp.
-	<i>Laonome</i> sp.	-	<i>Neanthes</i> sp.
-	<i>Ceratonereis</i> sp.	-	<i>Namalycastis aibiuma</i>
-	<i>Ceratonereies burmensis</i>	-	<i>Capitellis indet</i>
-	<i>Aglaophamus</i> sp.	-	<i>Notomastus</i> sp.
MOLLUSCA			
Gastropoda			
-	<i>Sermyla tornatella</i>	-	<i>Clenchiella</i> sp.
-	<i>Dostia violacea</i>	-	<i>Salinator fragilis</i>
-	<i>Haminoea yamagutii</i>	-	<i>Salinator</i> sp.
-	<i>Cerithideopsilla cingulata</i>	-	<i>Linopygrasp.</i>
-	<i>Cerithideopsilla djadjariensis</i>	-	<i>Pyramidellid</i> sp.
-	<i>Assiminea nitida</i>	-	<i>Ellobium politum</i>
-	<i>Assiminea sculpta</i>	-	<i>Ellobium</i> sp.
-	<i>Assiminea brevicula</i>	-	<i>Melanoides tuberculata</i>
-	<i>Assiminea</i> sp.	-	<i>Mainwaringia rhizophila</i>
-	<i>Iravadia ornata</i>	-	<i>Littorina melanostoma</i>
-	<i>Iravadia bombayana</i>	-	<i>Littoraria ardouiniana</i>
-	<i>Stenothyra glabra</i>	-	<i>Elysia leucolegnote</i>
-	<i>Stenothyra</i> sp.	-	<i>Tenellia adspersa</i>
Bivalvia			
-	<i>Pseudopythina maipoensis</i>	-	<i>Placuna placenta</i>
-	<i>Musculista senhausia</i>	-	<i>Crassostrea gigas</i>
-	<i>Glaucanome chinesis</i>	-	<i>Mytilopsis sallei</i>
ARTHROPODA			

Arachnida		
-	<i>Dometorina rostrata</i>	
-	<i>Amblysius</i> sp.	
Chelicerata		
Horseshoe Crab	<i>Carcinoscorpius rotundicaudata</i>	
Crustacea		
-	<i>Sesarmops sinensis</i>	- <i>Ilyoplax dentimerosa</i>
-	<i>Chiromantes dehaani</i>	- <i>Ilyoplax tansuiensis</i>
-	<i>Chiromantes tangi</i>	- <i>Ilyoplax pingi</i>
-	<i>Parasesarma affinis</i>	- <i>Ilyoplax serrata</i>
-	<i>Perisesarma bidens</i>	- <i>Ilyoplax ningpoensis</i>
-	<i>Perisesarma maipoensis</i>	Sentinel Crabs <i>Macrophthalmus tomentosus</i>
-	<i>Chasmagnathes convexus</i>	- <i>Macrophthalmus convexus</i>
-	<i>Holometopus serenei</i>	- <i>Macrophthalmus definitus</i>
-	<i>Helice tridens</i>	- <i>Macrophthalmus abbreviatus</i>
-	<i>Helice latimera</i>	- <i>Macrophthalmus latreillei</i>
-	<i>Helice</i> sp.	- <i>Macrophthalmus banzai</i>
-	<i>Metaplax longipes</i>	- <i>Scylla serrata</i>
-	<i>Metaplax elegans</i>	Sand prawn / Gei Wai Shrimp <i>Metapenaeus ensis</i>
-	<i>Metaplax takahasii</i>	- <i>Metapenaeus affinis</i>
Chinese Mitten Crab	<i>Eriocheir sinensis</i>	- <i>Penaeus monodon</i>
-	<i>Varuna yui</i>	- <i>Penaeus merguensis</i>
-	<i>Varuna litterata</i>	- <i>Penaeus penicillatus</i>
-	<i>Uca acuta</i>	- <i>Exopalaemon styliferus</i>
-	<i>Uca arcuata</i>	- <i>Coutierella tonkinensis</i>
-	<i>Uca paradussumieri</i>	- <i>Macrobrachium nipponense</i>
-	<i>Uca chlorophthalmus crassipes</i>	- <i>Palaemon orientis</i>
-	<i>Uca lactea</i>	- <i>Caridina nilotica gracilipes</i>
-	<i>Uca vocans vocans</i>	- <i>Alpheus euprosyne</i>
-	<i>Uca dusumieri</i>	- <i>Grandidierella</i> sp.
-	<i>Paracleistosoma depressum</i>	- <i>Kamaka</i> sp.
-	<i>Paracleistostoma crassipilum</i>	- <i>Melita</i> sp.
-	<i>Cleistostoma dilatatum</i>	- <i>Victoriopisa</i> sp.
-	<i>Cleistocoeloma sinensis</i>	- <i>Talorchestia</i> sp.
-	<i>Cleistocoeloma merguensis</i>	- <i>Discapseudes</i> sp.

Appendix 7. Cumulative list of spider species recorded from Mai Po Nature Reserve

-	<i>Argiope amoena</i>	-	<i>Uloborus guangxiensis</i>
-	<i>Argiope aemula</i>	-	<i>Uloborus plumipes</i>

-	<i>Argiope minuta</i>	Woodland Spider	<i>Nephila pilipes</i>
-	<i>Argiope macrochoera</i>	Silver Comb Footed Spider	<i>Argyrodes argentatus</i>
Black Tailed Spider	<i>Arachnura melanura</i>	Tiny Dew-drop Spider	<i>Argyrodes bonadea</i>
-	<i>Polys illepidus</i>	Silver Dewdrop Spider	<i>Argyrodes flavescens</i>
Tree Stump Spider	<i>Polys columnaris</i>	Split-faced Silver Spider	<i>Argyrodes fissifrons</i>
-	<i>Gea spinipes</i>	Dewdrop Spider	<i>Argyrodes miniaceus</i>
-	<i>Neoscona punctigera</i>	Tangle Web Spider	<i>Parasteatoda transipora</i>
-	<i>Neoscona scylla</i>	Cobweb Spider	<i>Anelosimus sp.</i>
-	<i>Neoscona nautica</i>	Tangle Web Spider	<i>Rhomphaea ceraosus</i>
-	<i>Neoscona semilunaris</i>	Tangle Web Spider	<i>Rhomphaea labiata</i>
-	<i>Araneus mitificus</i>	-	<i>Ariamnes cylindrogaster</i>
-	<i>Araneus ventricosus</i>	-	<i>Meotipa vesiculosa</i>
-	<i>Araneus inustus</i>	-	<i>Meotipa spiniventris</i>
-	<i>Parawixia dehanni</i>	Golden Comb-footed Spider	<i>Chrysso lingchuanensis</i>
Spiny-backed Orb-weaver	<i>Gasteracantha kuhlii</i>	-	<i>Nihonhimea japonica</i>
Lesser Bird-dropping Spider	<i>Cyrtarachne bufo</i>	Tangle-web Spider	<i>Phycosoma hana</i>
-	<i>Cyclosa confusa</i>	Tangle-web Spider	<i>Phycosoma sinica</i>
-	<i>Cyclosa ginnaga</i>	-	<i>Heterotheridion nigrovariegatum</i>
-	<i>Cyclosa omonaga</i>	Cupboard Spider	<i>Steatoda cingulata</i>
-	<i>Cyclosa vallate</i>	Cupboard Spider	<i>Steatoda nigrimaculata</i>
Tent Web Spider	<i>Cyrtophora guangxiensis</i>	-	<i>Parasteatoda songi</i>
-	<i>Eriovixia excelsa</i>	Jade Jumping Spider	<i>Siler cupreus</i>
-	<i>Larinia phthisica</i>	Jade Jumping Spider	<i>Siler semiglaucus</i>
-	<i>Larinia sp.</i>	-	<i>Bianor angulosus</i>
Grey House Spider	<i>Zosis geniculate</i>	-	<i>Rhene atrata</i>
Huntsman Spider	<i>Heteropoda venatoria</i>	-	<i>Rhene biembolusa</i>
-	<i>Heteropoda sp.</i>	Wasp Mimic Jumping Spider	<i>Rhene flavicomans</i>
-	<i>Pseudopoda sp.</i>	-	<i>Rhene flavigera</i>
-	<i>Olios sp.</i>	-	<i>Rhene sp.</i>
Long-spinnered Bark Spider	<i>Hersilia asiatica</i>	Banded Phintella	<i>Phintella versicolor</i>
Long-spinnered Bark Spider	<i>Hersilia striata</i>	-	<i>Cytaea sp.</i>
Grass Crab Spider	<i>Oxytate bhutanica</i>	Gray Wall Jumper	<i>Menemerus bivittatus</i>
Lynx Spider	<i>Oxyopes sertatus</i>	-	<i>Plexippus paykulli</i>
Long-bodied Cellar Spider	<i>Pholcus sp.</i>	-	<i>Telamonia festiva</i>
Short-bodied Cellar Spider	<i>Physocyclus globosus</i>	Ant Mimic Jumping Spider	<i>Myrmarachne angusta</i>
Lawn Wolf Spider	<i>Hippasa holmerae</i>	Ant Mimic Jumping Spider	<i>Myrmarachne formosana</i>
Spotted Wolf Spider	<i>Pardosa laura</i>	Ant Mimic Jumping Spider	<i>Myrmarachne gisti</i>
Spotted Wolf Spider	<i>Pardosa mionebulosa</i>	Ant Mimic Jumping Spider	<i>Myrmarachne schenkeli</i>
Spotted Wolf Spider	<i>Pardosa pseudoannulata</i>	-	<i>Epocilla calcarata</i>

Spotted Wolf Spider	<i>Pardosa pusiola</i>	-	<i>Hasarius adansoni</i>
Pirate Wolf Spider	<i>Pirata sp.</i>	-	<i>Portia fimbriata</i>
-	<i>Draposa burasantiensis</i>	-	<i>Portia labiata</i>
Crab Spider	<i>Thomisus labefactus</i>	-	<i>Phintelloides versicolor</i>
Crab Spider	<i>Thomisus guangxicus</i>	-	<i>Carrhotus sannio</i>
-	<i>Strigoplus sp.</i>	-	<i>Carrhotus xanthogramma</i>
Crab spider	<i>Ebrechtella tricuspoidatus</i>	-	<i>Afraflacilla philippinensis</i>
-	<i>Tmarus taiwanus</i>	-	<i>Afraflacilla sp.</i>
Grass Crab Spider	<i>Oxytate striatipes</i>	-	<i>Evarcha bicoronata</i>
Ladybird Crab Spider	<i>Camaricus maugei</i>	-	<i>Evarcha bulbosa</i>
Ant-mimic Crab Spider	<i>Amyciaea forticeps</i>	-	<i>Evarcha flavocincta</i>
Fishing Spider	<i>Dolomedes mizhoanus</i>	Fighting Spider	<i>Thiania inermis</i>
Fishing Spider	<i>Dolomedes raptor</i>	-	<i>Thyene imperialis</i>
Fishing Spider	<i>Nilus sp.</i>	-	<i>Phaeacius fimbriatus</i>
Sac Spider	<i>Clubiona deletrix</i>	-	<i>Phaeacius malayensis</i>
Sac Spider	<i>Clubiona filicata</i>	-	<i>Burmattus pococki</i>
Yellow Sac Spider	<i>Cheiracanthium insulanum</i>	-	<i>Holoplatys sp.</i>
Yellow Sac Spider	<i>Cheiracanthium zhejiangense</i>	-	<i>Harmochirus brachiatus</i>
Wandering Spider	<i>Anahita maolan</i>	Ant-like Corinnid Sac Spider	<i>Castianeira hongkong</i>
Philodromid Crab Spider	<i>Philodromus sp.</i>	-	<i>Corinnomma severum</i>
False Crab Spider	<i>Thanatus hongkong</i>	Long-jawed Spider	<i>Tetragnatha bituberculata</i>
Spitting Spider	<i>Scytodes sp.</i>	Long-jawed Spider	<i>Tetragnatha nitens</i>
-	<i>Zelotes sp.</i>	Long-jawed Spider	<i>Tetragnatha praedonia</i>
-	<i>Mimetes testaceus</i>	Long-jawed Spider	<i>Tetragnatha squamata</i>
-	<i>Hylyphantes sp.</i>	Long-jawed orb weaver spider	<i>Tylorida ventralis</i>
-	<i>Nerienne chunan</i>	-	<i>Zygiella sp.</i>
Dwarf Spider	<i>Erigone prominens</i>	-	<i>Orsinome sp.</i>
Lace-Webbed Spider	<i>Amaurobius sp</i>	Long-jawed Orb Weaver	<i>Leucauge blanda</i>
-	<i>Oecobius cellariorum</i>		

Appendix 8. Cumulative list of butterfly species recorded from Mai Po Nature Reserve

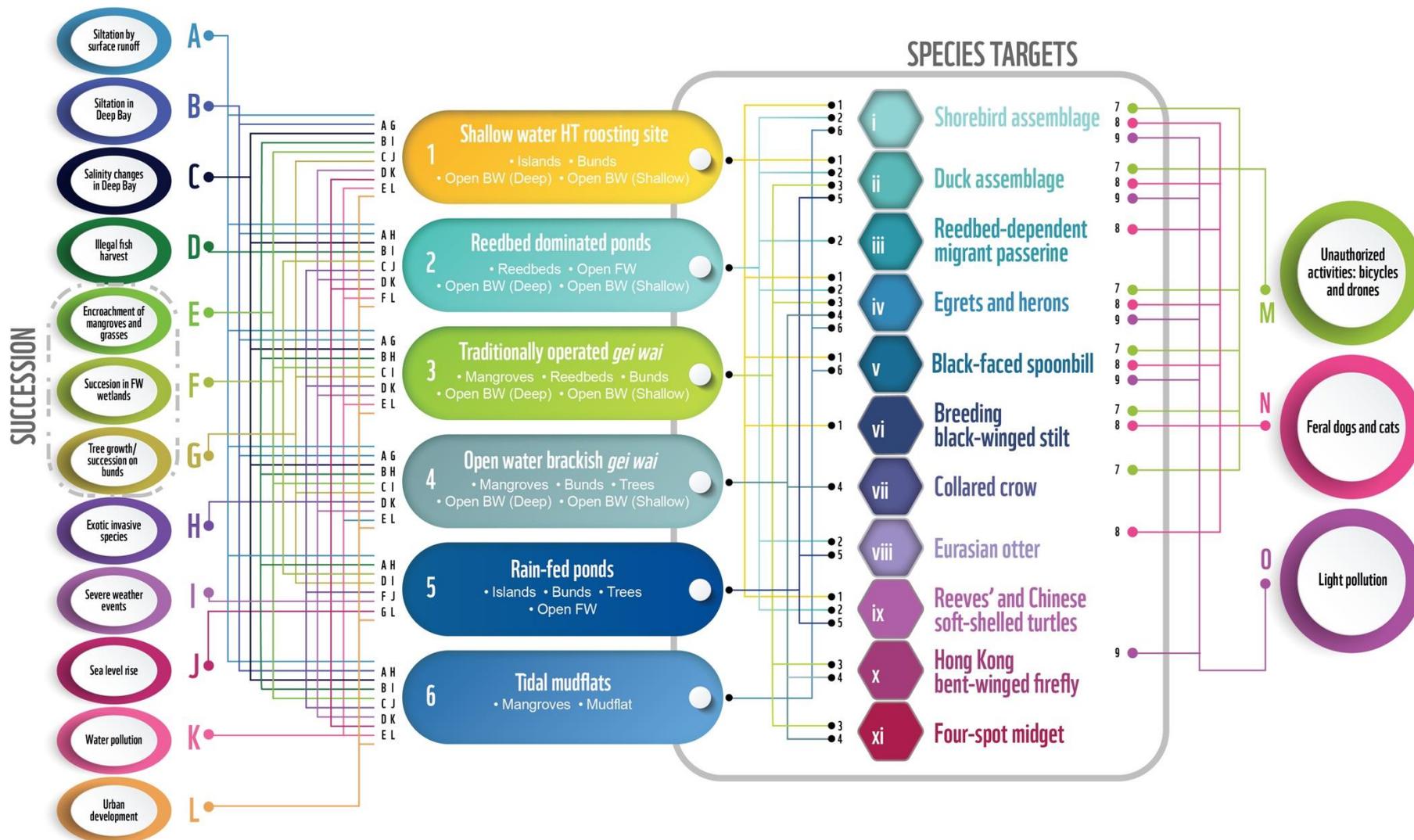
Common mime	<i>Chilasa clytia</i>	Pale Palm Dart	<i>Telicota colon stinga</i>
Tailed Jay	<i>Graphium agamemnon agamemnon</i>	Common Hedge Blue	<i>Acytolepis puspa gisca</i>
Common Jay	<i>Graphium doson axion</i>	Green Flash	<i>Artipe eryx eryx</i>
Common Bluebottle	<i>Graphium sarpedon sarpedon</i>	Powdered Oak Blue	<i>Arhopala bazalus turbata</i>
Lime Butterfly	<i>Papilio demoleus</i>	Burmese Bush Blue	<i>Arhopala birmana birmana</i>
Red Helen	<i>Papilio helenus helenus</i>	Forget-me-not ¹	<i>Catochrysops strabo strabo</i>
Great Mormon	<i>Papilio memnon agenor</i>	Lime Blue	<i>Chilades lajus leucofasciatus</i>
Paris Peacock	<i>Papilio paris paris</i>	Plains Cupid	<i>Chilades pandava pandava</i>
Common Mormon	<i>Papilio polytes polytes</i>	Cornelian	<i>Deudorix epijarbas menesicles</i>
Spangle	<i>Papilio protenor</i>	Gram Blue	<i>Euchrysops cnejus cnejus</i>
Swallowtail	<i>Papilio xuthus</i>	Tailed Cupid	<i>Everes lacturnus rileyi</i>
Five-bar Swordtail	<i>Pathysa antiphates antiphates</i>	Purple Sapphire	<i>Heliophorus epicles phoenicoparyphus</i>
Common Birdwing	<i>Troides helena spilotia</i>	Common Onyx	<i>Horaga onyx moltrechtii</i>
Chocolate Albatross	<i>Appias lycinda eleonora</i>	Silver Streak Blue	<i>Iraota timoleon timoleon</i>
Mottled Emigrant	<i>Catopsilia pyranthe pyranthe</i>	Dark Cerulean	<i>Jamides bochus bochus</i>
Lemon Emigrant	<i>Catopsilia pomona pomona</i>	Long-tailed Blue / Pea Blue	<i>Lampides boeticus</i>
Common Gull	<i>Cepora nerissa</i>	Transparent Six-line Blue	<i>Nacaduba kurava euplea</i>
Painted Jezebel	<i>Delias hyparete hierte</i>	White Royal	<i>Pratapa deva devula</i>
Red-base Jezebel	<i>Delias pasithoe pasithoe</i>	Pale Grass Blue	<i>Pseudozizeeria maha serica</i>
Three-spot Grass Yellow	<i>Eurema blanda hylama</i>	Slate Flash	<i>Rapala manea schistacea</i>
Common Grass Yellow	<i>Eurema hecabe hecabe</i>	Chocolate Royal	<i>Remelana jangala mudra</i>
Great Orange Tip	<i>Hebomoia glaucippe</i>	Long-banded Silverline	<i>Spindasis lohita formosana</i>
Indian Cabbage White	<i>Pieris canidia canidia</i>	Dark Grass Blue	<i>Zizeeria karsandra karsandra</i>
Small Cabbage White	<i>Pieris rapae</i>	Lesser Grass Blue	<i>Zizina otis otis</i>
Bush Hopper	<i>Ampittia dioscorides</i>	Toothed Sunbeam	<i>Curetis dentate denta</i>
Formosan Swift	<i>Borbo cinnara</i>	Quaker	<i>Neopithecops zalmora zalmora</i>
Colon Swift	<i>Caltoris bromus</i>	Plum Judy	<i>Abisara echerius echerius</i>
Banana Skipper	<i>Erionota torus</i>	Punchinello	<i>Zemeros flegyas flegyas</i>
Common Awl	<i>Hasora badra</i>	Angled Castor	<i>Ariadne ariadne alterna</i>
Banded Awl	<i>Hasora chromus</i>	Staff Sergeant	<i>Athyma selenophora leucophryne</i>
Common Redeye	<i>Matapa aria</i>	Red Lacewing	<i>Cethosia bibles phanaroia</i>
Chestnut Angle	<i>Odontoptilum angulatum</i>	Tawny Rajah	<i>Charaxes bernardus bernardus</i>
Common Straight Swift	<i>Parnara guttata</i>	Rustic	<i>Cupha erymanthis erymanthis</i>
Little Branded Swift	<i>Pelopidas agna agna</i>	Common Mapwing	<i>Cyrestis thyodamas chinensis</i>
Contiguous Swift	<i>Polytremis lubricans lubricans</i>	White-edged Blue Baron	<i>Euthalia phemius seitzi</i>
Chinese Dart	<i>Potanthus confucius confucius</i>	Red Ring Skirt	<i>Hestina assimilis assimilis</i>
Lesser Band Dart	<i>Potanthus trachala trachala</i>	Great Egg-fly	<i>Hypolimnas bolina kezia</i>
Indian Palm Bob	<i>Suastus gremius gremius</i>	Indian Fritillary	<i>Argyreus hyperbius hyperbius</i>

Danaid Egg-fly	<i>Hypolimnas misippus</i>	Common Tiger	<i>Danaus genutia genutia</i>
Peacock Pansy	<i>Junonia almana almana</i>	Common Indian Crow	<i>Euploea core amymone</i>
Grey Pansy	<i>Junonia atlites atlites</i>	Blue-spotted Crow	<i>Euploea midamus midamus</i>
Lemon Pansy	<i>Junonia lemonias lemonias</i>	Striped Blue Crow	<i>Euploea mulciber mulciber</i>
Blue Pansy	<i>Junonia orithya orithya</i>	Ceylon Blue Glassy Tiger	<i>Ideopsis similis similis</i>
Blue Admiral	<i>Kaniska canace canace</i>	Blue Tiger	<i>Tirumala limniace limniace</i>
Common Sailer	<i>Neptis hylas hylas</i>	Common Palmfly	<i>Elymnias hypermnestra hainana</i>
Five-dot Sergeant	<i>Parathyma sulphitia</i>	Banded Tree Brown	<i>Lethe confusa confusa</i>
Short-banded Sailor	<i>Phaedyma columella columella</i>	Bamboo Tree Brown	<i>Lethe europa beroe</i>
Common Nawab	<i>Polyura athamas athamas</i>	Common Evening Brown	<i>Melanitis leda leda</i>
Painted Lady	<i>Vanessa cardui</i>	Dark Evening Brown	<i>Melanitis phedima muskata</i>
Indian Red Admiral	<i>Vanessa indica indica</i>	Dark Brand Bush Brown	<i>Mycalesis mineus mineus</i>
Common Duffer	<i>Discophora sondaica tulliana</i>	South China Bush Brown	<i>Mycalesis zonata</i>
Large Faun	<i>Faunis eumeus eumeus</i>	Common Five-ring	<i>Ypthima baldus baldus</i>
Plain Tiger	<i>Danaus chrysippus chrysippus</i>		

Appendix 9. Cumulative list of dragonfly and damselfly species recorded from Mai Po Nature Reserve

Orange-tailed Midget	<i>Agriocnemis femina</i>	Black-tipped Percher	<i>Diplacodes nebulosa</i>
Wandering Midget	<i>Agriocnemis pygmaea</i>	Blue Percher	<i>Diplacodes trivalis</i>
Orange-tailed Sprite	<i>Ceriagrion aurantiacum ryukyuanum</i>	Amber-winged Glider	<i>Hydrobasileus croceus</i>
Asian Bluetail	<i>Ischnura asiatica</i>	Forest Chaser	<i>Lyriothemis elegantissima</i>
Common Bluetail	<i>Ischnura senegalensis</i>	Coastal Glider	<i>Macrodiplax cora</i>
Four-spot Midget	<i>Mortonagrion hirosei</i>	Elusive Adjutant	<i>Aethriamanta brevipennis brevipennis</i>
Marsh Dancer	<i>Onychargia atrocyana</i>	Russet Percher	<i>Neurothemis fulvia</i>
Eastern Lilysquatter	<i>Paracercion melanotum</i>	Pied Percher	<i>Neurothemis tullia</i>
Black Threadtail	<i>Prodasineura autumnalis</i>	Red-faced Skimmer	<i>Orthetrum chrysis</i>
Blue Sprite	<i>Pseudagrion microcephalum</i>	Common Blue Skimmer	<i>Orthetrum glaucum</i>
Orange-faced Sprite	<i>Pseudagrion rubriceps rubriceps</i>	Marsh Skimmer	<i>Orthetrum luzonicum</i>
Black-kneed Featherlegs	<i>Copera ciliata</i>	Greater Blue Skimmer	<i>Orthetrum melania</i>
Yellow Featherlegs	<i>Copera marginipes</i>	Mangrove Skimmer	<i>Orthetrum poecilops poecilops</i>
Common Evening Hawer	<i>Anaciaeschna jaspidea</i>	Common Red Skimmer	<i>Orthetrum pruinosum neglectum</i>
Pale-spotted Emperor	<i>Anax guttatus</i>	Green Skimmer	<i>Orthetrum sabina sabina</i>
Lesser Emperor	<i>Anax parthenope</i>	Asian Widow	<i>Palpopleura sexmaculata sexmaculata</i>
Little Dusk-hawker	<i>Gynacantha saltatrix</i>	Wandering Glider	<i>Pantala flavescens</i>
Blue-spotted Dusk-hawker	<i>Gynacantha japonica</i>	Blue Chaser	<i>Potamarcha congener</i>
Dingy Dusk-hawker	<i>Gynacantha subinterrupta</i>	Pied Skimmer	<i>Pseudothemis zonata</i>
Common Flangetail	<i>Ictinogomphus pertinax</i>	Variiegated Flutterer	<i>Rhyothemis variegata arria</i>
Golden Flangetail	<i>Sinictogomphus clavatus</i>	Evening Skimmer	<i>Tholymis tillarga</i>
Tawny Hooktail	<i>Paragomphus capricornis</i>	Saddlebag Glider	<i>Tramea virginia</i>
Regal Pond Cruiser	<i>Epopthalmia elegans</i>	Crimson Dropwing	<i>Trithemis aurora</i>
Asian Pintail	<i>Acisoma panorpoides</i>	Indigo Dropwing	<i>Trithemis festiva</i>
Blue Dasher	<i>Brachydiplax chalybea</i>	Scarlet Basker	<i>Urothemis signata signata</i>
Asian Amberwing	<i>Brachythemis contaminata</i>	Dingy Dusk-darter	<i>Zyxomma petiolatum</i>
Crimson Darter	<i>Crocothemis servilia</i>		

Appendix 10. Conceptual model of threats to conservation targets generated from MIRADI-based analysis.



Appendix 11. 2013-2018 five-year management plan review**11a.** 2013-2018 five-year recurrent work review

Code	Description	Priority	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Brackish <i>gei wai</i>							
BGW/R01	Bund vegetation, cutting	1	PY	PY	PY	PY	PY
BGW/R03	Emergent vegetation, control	1	PY	PY	PY	PY	PY
BGW/R09	Water levels, sluice gate operation	1	PY	PY	PY	PY	PY
BGW/R10	Water quality, water exchange	1	PY	PY	PY	PY	PY
BGW/R11	Sediment quality, sun-bake	1	PY	PY	PY	PY	PY
BGW/R12	Water levels, drawdown (dry season)	1	PY	PY	PY	PY	PY
BGW/R15a	Invasive climber, control (manual)	1	PY	PY	PY	PY	PY
BGW/R15b	Invasive climber, control (planting <i>C. manghas</i>)	3	XX	XX	XX	XX	XX
BGW/R20	Predatory fish, control	1	PY	PY	PY	PY	PY
Brackish waterbird roosts							
BWR/R01	Bund vegetation, cutting	1	PY	PY	PY	PY	PY
BWR/R02	Island vegetation, cutting	1	PY	PY	PY	PY	PY
BWR/R03	Emergent vegetation, control	1	PY	PY	PY	PY	PY
BWR/R09	Water levels, sluice gate operation	1	PY	PY	PY	PY	PY
BWR/R10	Water quality, water exchange	1	PY	PY	PY	PY	PY
BWR/R12a	Water levels, drawdown (wet season)	1	PY	PY	PY	PY	PY
BWR/R12b	Water levels, intertidal <i>gei wai</i>	1	PY	PY	PY	PY	PY
BWR/R13	Sediment quality, sun-bake	2	PY	PY	PY	PY	PY
BWR/R15	Invasive climber, control (manual)	2	PY	PY	PY	PY	PY
BWR/R18	Predatory fish, control	2	PY	PY	PY	PY	PY
Rain-fed habitats							
RFH/R01	Bund vegetation, cutting	1	PY	PY	PY	PY	PY
RFH/R02	Island vegetation cutting	1	PY	PY	PY	PY	PY
RFH/R03	Emergent vegetation, control	1	PY	PY	PY	PY	PY
RFH/R07	Vegetation, grazing	1	PY	PY	PY	PY	PY
RFH/R08	Emergent vegetation, planting	2					
RFH/R10	Water quality, water exchange	1	PY	PY	PY	PY	PY
RFH/R11	Water levels, L-pipe/pumping	1	PY	PY	PY	PY	PY
RFH/R14	Golden Apple Snail, control	1	PY	PY	PY	PY	PY
RFH/R20	Predatory fish, control	1	PY	PY	PY	PY	PY
RFH/R21	Supplementary feeding (ducks)	3	PY	PY	PY	PY	PY
RFH/R29	Seasonal rain-fed pond, trial (Pond #16a & #17a)	2	XX	XX	XX	XX	XX
Intertidal mudflat							
IMF/R03	Emergent vegetation, control	1	PY	PY	PY	PY	PY
Landscape							
GWL/R04	Trees, trim (landscape)	1	PY	PY	PY	PY	PY
GWL/R05a	Trees, trim (visitor paths)	1	PY	PY	PY	PY	PY
GWL/R05b	Trees, trim (overhanging mangrove trees)	1	XX	XX	PY	PY	PY
GWL/R16	Non-native trees/shrubs, remove	1	PY	PY	PY	PY	PY
GWL/A01	Tree management strategy, prepare	1			XX		
Additional management activities							
AA1/R06	Shrubs, trim (FCA inlet channels)	1	XX	XX	XX	PY	PY
AA1/R17	Red Imported Fire Ant, control	1	PY	PY	PY	PY	PY

Code	Description	Priority	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
AA1/R18	Invasive plants, control	1	PY	PY	PY	PY	PY
AA1/R19a	Feral dogs, control	1	PY	PY	PY	PY	PY
AA1/R19b	Feral dogs, liaise with AFCD AM Unit	1	PY	PY	PY	PY	PY
AA1/R23	GW #7 bird ringing island, maintain	3	PY	PY	PY	PY	PY
AA1/R24	Natural screens, planting	2	XX	XX	XX	XX	XX
AA1/R25	Butterfly garden, maintain	2	PY	PY	PY	PY	PY
AA1/R26	Education Centre pond, maintain	1	PY	PY	PY	PY	PY
AA1/R27	Visitor paths/facilities, maintain	1	PY	PY	PY	PY	PY
AA1/R28	Pond #8a egretry, maintain	1	PY	PY	PY	PY	PY
AA1/R29	Leaking bunds and sluice gates, repair	1	PY	PY	PY	PY	PY
AA1/R30	Liaise, helicopter operators	1	PY	PY	PY	PY	PY
Fulfill all legal and non-legal obligations							
AA2/R31	Comply with legal obligations	1	PY	PY	PY	PY	PY
AA2/R32	Liaise with relevant parties	1	PY	PY	PY	PY	PY
Total no. of project listed in Management Plan that year			49	49	50	49	49
Total no. of project listed in Annual Plan that yea			44	44	45	46	46
No. of completed project according to the Annual Plan			44	44	45	46	46
No. of project listed in Management Plan but not included in Annual Plan			5	5	5	3	3

Key:

P - Planned

X - Not planned

PY - Planned in annual plan and carried out

XX - Not planned in annual plan and not carried out

PX - Planned in annual plan but not carried out

11b. 2013-2018 five-year infrastructure and Centers management work review

Description	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Cleaning	PY	PY	PY	PY	PY
Center maintenance	PY	PY	PY	PY	PY
Infrastructure maintenance	PY	PY	PY	PY	PY
Vehicle and heavy machine maintenance	PY	PY	PY	PY	PY
Equipment maintenance and purchase	PY	PY	PY	PY	PY
Leading volunteer groups	PY	PY	PY	PY	PY

Key: PY - Planned in annual plan and carried out

11c. 2013-2018 five-year major habitat management work review

Code	Description	Year carried out	progress
Brackish <i>Gei Wai</i>			
BGW/C01a	Desilt channels, GW #10	2018	1950 m perimeter channels desilted
BGW/C01b	Desilt channels, GW #11b	2017	Increased scale to desilt all 2100 m perimeter and cross channels, plus restoration of 0.2 ha of open water area
BGW/C01c	Desilt channels, GW #13	2014	Only north perimeter channel and cross channels (2280 m)
BGW/C04a	Desilt reedbed, GW #8b	2016	All seaward-side 3.5 ha reedbed.
BGW/C04b	Desilt reedbed, GW #10	2018	0.7 ha wet reedbed restored
BGW/C04c	Desilt reedbed, GW #14 (east)	2016	1.8 ha, plus landward-side 695 m channel desilting
BGW/C05a	Cut reedbed, GW #8b	2014	5.5 ha
BGW/C05b	Cut reedbed, GW #10	2014	1.78 ha
Brackish waterbird roosts			
BWR/C01a	Desilt channels, GW #3	2018	1200 m north and south perimeter channel desilted
Additional	Desilt channels, GW #4	2018	750 m south perimeter channel, and 120 m channel along FCA road desilted, a gap created in bund between GW #3 and #4 at the seaward side to facilitate water exchange of GW #4
BWR/C01b	Desilt channels, GW #22	2016	All 1412 m channels, plus habitat restoration. Sluice gate repaired in 2017
BWR/C03	Desilt <i>gei wai</i> floor, GW #21	2014	Landward-side 2 ha area
BWR/C06	Construct earth bund, Pond #23	2014	Landward rain-fed reedbed separated from seaward brackish shallow water area
BWR/C09a	Build islands, GW #16/17	2016	All islands restored, plus open water area restored and desilting of all 1712 m perimeter channels
BWR/C09b	Build islands, GW #21	2014	3 islands created
Rain-fed habitats			
RFH/C01	Desilt channels, Pond #16b	2015&16	245 m + 264 m
RFH/C02	Desilt pond floor, Pond #20	2015	Pond #20a (1 ha)
RFH/C04a	Desilt reedbed, Pond #18a	2015	Landward-side 0.7 ha
RFH/C04b	Desilt reedbed, Pond #19a	2014	Landward-side 0.7 ha
RFH/C06a	Construct earth bund, Pond #18a	2015	Landward rain-fed area separated from seaward brackish water area
RFH/C06b	Construct earth bund, Pond #19a	2014	Landward rain-fed area separated from seaward brackish water area
RFH/C07	Remove earth bund, Pond #15a		Priority 3 (low), not carried out.
RFH/C08a MPNR	Modify earth bund, southern perimeter	2015	460 m perimeter bund raised >1 m in height
RFH/C08b	Modify earth bund, Pond #15b	2017	188 m bund repaired, plus island and open water restoration
RFH/C08c	Modify earth bund, Pond #24	2015	392 m bund lowered between Pond #24d/e/f
Additional	Desilt pond floor, Pond #16a	2016	0.6 ha

11d. 2013-2018 five-year monitoring projects review

Code	Description	Progress
	Monitoring Survey	
FM01	Morning Bird Count	done according to the plan
FM02	Black-faced Spoonbill	done according to the plan
FM03	Roosting Anatidae	done according to the plan
FM04	Roosting Shorebirds & Terns	did in the first two years (Mar- Oct, without survey in each Jun in both 2013 and 2014) by Mai Po staff, and then decided to use the data from AFCD-HKBWS shorebird surveys
FM05	Roosting Collared Crow	done according to the plan
FM06	Breeding Black-winged Stilt	done according to the plan
FM07	Ardeid and spoonbill use of <i>gei wai</i> during drawdown (dry season)	done according to the plan
FM07	Ardeid and spoonbill use of <i>gei wai</i> during drawdown (wet season)	done according to the plan
FM08	Waterbird use of mudflat	done in winters first two years (2013/2014 and 2014/2015 winters), and then decided to use the data from AFCD-HKBWS waterbird surveys
FM09	Amphibians	done in 2013, 2015 and 2016
FM10	Adult Odonata	done in 2015 and 2016
EM01	Water Quality	done according to the plan
EM02	Water Level	done in 2013, 2014 and 2015
EM03	Water Depth	GW#12, #19 and #23 not measured. All others done
EM04	Habitats	done according to the plan
EM05	Fixed Point Photography	done in 2013 and 2015, not done in 2017???
EM05b	Fixed Point Photography (mudflat)	done according to the plan

11e. 2013-2019 five-year research plan review

Research Project	Progress
Comparison of wet and dry reedbeds	done by WWF staff and Hong Kong Ringing Group and one paper published (Allcock et al, 2018. Permanently inundated Phragmites reedbed supports higher abundance of wetland-dependent bird species than drier reedbed during southward migration through Hong Kong. FORKTAIL 34: 9–13).
Management of <i>gei wai</i> mangroves and associated vegetation – Phase I	not done due to the lack of the manpower (staff were reallocated to conduct the Discovering Biodiversity Project)
Ecological value of freshwater habitats at MPNR	not done due to the lack of the manpower (staff were reallocated to conduct the Discovering Biodiversity Project)
Mai Po Climate Change Impact Study	not done due to the lack of funding and manpower
Bird Ringing (Banding)	done by different external ringing groups
Shorebird leg-flagging	done by Hong Kong Waterbirds ringing group

Appendix 12. Proposed research programme (HMT = Habitat Management Team, RMT=Research and Monitoring Team, H=High, M=Medium, L=Low)

	Urgency	Duration	Manpower	Level of study for external researcher	Benefit to MPNR	Benefit to other wetlands
Strategy: Use of new tools or technologies by WWF-Hong Kong or through collaboration with academics or technology companies to increase data accuracy or efficiency in data collection and data management in wetland monitoring						
Explore feasibility on the application of unmanned aerial vehicle (UAV) in management	M	1 year	HMT	-	H	M
Explore feasibility on the application of unmanned aerial vehicle (UAV) in monitoring	M	1 year	RMT	-	H	M
Bathymetry mapping of <i>gei wai</i> and ponds	H	5 years +	RMT & HMT	-	H	M
Explore possibilities in the application of machine learning in image-based species identification	L	1 year	RMT	Master	M	L
Strategy: Conduct research that improve habitat management and species conservation in the MPNR and Deep Bay						
Research that assist recovery of threatened species						
Investigating the space use of Eurasian Otter (<i>Lutra lutra</i>) in Deep Bay through a structured camera trap programme	H	3 years	RMT	MPhil/ PhD	H	M
Research on the ecology of invasive species in the MPNR and the surroundings and identify effective control methods						
Mapping of <i>Mikania micrantha</i> in the MPNR and evaluate the effectiveness of its control	M	2 years	External researcher preferred	MPhil	H	H
Research that evaluate current or new management practices in achieving its conservation goals						
Investigating the suitability of current habitat for water buffalo	M	6 months in 2 years	RMT	-	M	L
Evaluating the habitat use of high tide roosting sites by waterbirds	H	1-2 years	RMT	-	H	H
Determine suitable water level management practices for waterbirds in GW #22	M	1 month	RMT	-	M	L
Investigate the productivity in <i>gei wai</i>	H	5 years +	RMT & HMT	PhD	H	L
Research on species that may influence habitat management decisions or conservation targets						
Investigating seasonal variation of <i>Ruppia maritima</i> in <i>gei wai</i>	M	2-3 years	External researcher preferred	MPhil	H	L
Spider identification and mapping in the MPNR and along boardwalks	M	Summer in 2-3 years	HMT & external surveyor needed	-	M	L

Annex B. Five-year monitoring schedule.

Monitoring Action	Year 1	Year 2	Year 3	Year 4	Year 5
	2019-20	2020-21	2021-22	2022-23	2023-24
Roosting Black-faced Spoonbill Count					
Roosting Duck Count					
Shorebirds					
<i>Gei wai</i> Draining Waterbirds Count					
Morning Bird Count					
Dragonfly and Damselfly Count					
Habitat Mapping					
Fixed Point Photography					
Water Channel Depth Measurement					
Water Quality Survey					
Breeding Black-winged Stilt Count					
Reedbed Roosting Bird Count					
Shrimp harvesting record keeping					
Roosting Collared Crow Count					
Infra-red Camera Mammal Survey					
Four-spot Midget Count					
Hong Kong Bent-winged Firefly Count					
Feral Dog Count					
Obtain data from AFCD (Waterbirds, Shorebirds and Egret Count)					
Obtain data from HKRG (reedbed-dependent passerine, bitterns and herons)					

Annex C. Other important features which require monitoring

Other features which require monitoring	Attribute	Priority*	Annual reporting time	Monitoring Action
Breeding Black-winged Stilt	Location and number of nests and juveniles in BMZ 5, 6 & 7	H	Oct	Breeding Black-winged Stilt Count
Black-tailed Godwit	Percentage of Deep Bay population roosting at BMZ 5 & 7 during high tide in winter, spring and autumn	H	Oct	Obtain data from AFCD shorebird count
Eurasian Curlew		H		
Curlew Sandpiper		H		
Nordmann's Greenshank		H		
Spoon-billed Sandpiper		H		
Manchurian Reed Warbler	Number trapped in each ringing season at GW #8b reedbed	H	Oct	Obtain data from Hong Kong Ringing Group
Yellow-breasted Bunting		H		
Styan's Grasshopper Warbler		H		
Roosting Barn Swallow	Location and roosting populations in reedbed	L	May	Morning Bird Count / Reedbed roosting bird count/ data from Hong Kong Ringing Group
Roosting Yellow Wagtail		L		
Bitterns and Herons	Location, species and number breeding or night roosting.	H		
Egretry	Location, species and number of nests	H	Oct	Data from AFCD Egretry Count / Morning Bird Count
Aquatic Fauna (esp. <i>gei wai</i> shrimps)	Amount of shrimps harvested	H	Oct	Record keeping (Jun-Jul)
	Species, number of individuals, weight (GW #12, #18, #19)	H	Oct (2020-2024)	Aquatic Fauna Survey
Dragonfly and Damselfly	Adult population and diversity (Pond #16b, #20, #24)	H	Oct (2020, 2023)	Dragonfly and Damselfly Count
Monitor the number of feeding Black-faced Spoonbill, egrets and herons during draining once in each GW/Pond within the 5-year period (except those in BMZ 3 are monitored annually)	Number of individuals of each species	H	Oct	<i>Gei wai</i> draining waterbirds count / Morning Bird Count

Intertidal mudflat and waterbirds assemblages	Vegetation management effectiveness, bird usage after vegetation management	H	May	Fixed Point Photography, obtain data from AFCD Waterbirds Count.
Intertidal mangrove and channels	Extent	L	Oct	Habitat Mapping, obtain data from AFCD
Roosting Collared Crow	Roosting location and number of birds	H	Oct	Roosting Collared Crow Count
Greater Spotted Eagle	Location of tree used as roost (on map), number of birds	H	Oct	Morning Bird Count
Eastern Imperial Eagle		H		
Great Cormorant		M		
Eurasian Otter	Number of records	H	Oct	Infra-red camera mammal survey
Four-spot Midget	Number of adults at intertidal mangrove	M	Oct	Four-spot Midget Count
Hong Kong Bent-winged Firefly	Location and number of adults	M	Oct	Hong Kong Bent-winged Firefly Count
Widgeon Grass	Location and presence period	L	Oct	Anecdotal observations, record keeping

Annex D. Annual water level management regime for *gei wai*. Shaded cells indicate operational level state. Unshaded cells indicate high water level to control vegetation.

Gei wai	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
3, 4												
6												
7												
<ul style="list-style-type: none"> Operational level could be extended to mid-October to mid-April if bird number is high in the BMZ. When starting to adjust water level before winter, consider lowering water level of GW one by one starting from the 1st week of November to provide some feeding opportunities (GW #7> #6> #3 and #4). 												
8a												
11												
16/17												
21												
23a												
<ul style="list-style-type: none"> GW #11a and #16/17: if shorebird number fall low in spring and autumn, adjustment of water level should be considered as immediate adaptive management as informed by the Reserve Team. If Black-winged Stilt (or other waterbirds) are nesting, keep water level low until hatching (latest bird might hatch is July). Lower the water level before and after heavy rain. Evaluation of operational level requirements in each GW in mid-term of the 5-year period (2021). 												
22												
<ul style="list-style-type: none"> Intertidal. Trial to extend period of intertidal operation into April in 2020, monitor if it is beneficial to spring passage shorebirds 												
10												
12												
13												
14												
18b												
19b												
<ul style="list-style-type: none"> Kept within operational range throughout the year. GW #13 and #14: visitor boardwalk at landward side should not be flooded. 												

Annex E. Annual Water level management regime for rain-fed ponds.

Pond	Management Regime
8a, 9	<ul style="list-style-type: none"> Sep-Apr: operational level to expose islands (until connected to GW #7 in summer 2022)
15a-b	<ul style="list-style-type: none"> All year: operational level to expose islands If Black-winged Stilt (or other waterbirds) are nesting on islands, drop water level before and after heavy rain.
15c	<ul style="list-style-type: none"> All year: no management, keep high as rainwater storage
16a	<ul style="list-style-type: none"> All year: operational range If Black-winged Stilt (or other waterbirds) are nesting, drop water level before and after heavy rain.
16b	<ul style="list-style-type: none"> All year: operational range to expose boardwalk Top up with water from #15c if level drop below range
17a, 20, 23b	<ul style="list-style-type: none"> All year: operational range Top up with brackish water if level drop below range
18a, 19a	<ul style="list-style-type: none"> All year: operational range (until reconnected to GW #18 and GW #19 in 2023 and 2021).
17b, 24a-g	<ul style="list-style-type: none"> All year: operational range to expose grazing area

Annex F. *Gei wai* draining schedule for flushing and predatory fish management. Bolded figures indicate ponds that should be drained before starting capital habitat management work.

Year	Winter (Oct – Mar)		Summer (Apr – Sep)	Drain for capital work
2019	12 (Nov),	23a	3, 4, 8b , 21	23b, 24f/g
2020	13 (Jan),	10	6, 7 , 16/17, 11	8b
2021	14 (Dec),	23a	3, 4, 6 , 21	12
2022	18b, 19b,	10	7 , 16/17, 11	8a, 19, 20
2023	22 (Oct)	23a	3, 4 , 8b, 21	18
2024	Pond #16b	10	6, 7, 16/ 17, 11	21

Annex G. Habitat conditions which require monitoring

Habitat condition which require monitoring	Assessment Year	Monitoring Action	Management Action
Extent of vegetation encroachment in BMZ 5, 7	Dec-2021, Dec-2023	Habitat mapping	Adjustment of vegetation control frequency
Water depth in open water area in BMZ 5, 7		Field observation	Adjustment of operational water level
Effectiveness of intertidal operation at GW #22 for waterbirds	Apr-2020	GW #22 Waterbird count	Inform whether to extend the intertidal operation period to include April
Degree of non-reed vegetation invasion of each reedbed patch	Dec-2023	Habitat mapping	Inform management action for next management plan, e.g. channel desilting work, tree management work
Width of water channels		Habitat mapping	
Depth of water channels		Direct measurement	
Degree of open landscape and habitat changes	Dec-2019, 2021, 2023	Fixed point photography	
Water quality at each <i>gei wai</i> /pond	Every 2 months, annually	Water quality survey	Immediate action to be taken once poor water quality detected

Annex H. Five-year work timetable for capital works (H: high priority, M: medium Priority)

CAPITAL WORK ITEM	YEAR 1 2019	YEAR 2 2020	YEAR 3 2021	YEAR 4 2022	YEAR 5 2023
Creation of 2ha deep water reedbed in GW #8b	H				
Enhancement of reedbed at Pond #23b	H				
Reprofile of Pond #24 f/g	H				
Desilting of channels and open water restoration at GW #7		H			
Desilting of perimeter channel and control of vegetation encroaching perimeter channel at Pond #16b		M			
Desilting of channels and trial on electrically-motorized sluice gate at GW #8b		H			
Desilting of channels and open water restoration at GW #6			H		
Desilting of channels and trial on removing the internal bunds in GW #12			H & M		
GW #8a enhancement and connecting GW #8a with GW #7				H	
Merging of the 6 sub-ponds (#20a to #20f) and habitat enhancement at Pond #20				H	
Desilting of channels at GW #19 and reconnecting GW #19a and #19b				H	
Desilting of channels at GW #18 and reconnecting GW #18a and #18b					H
Modification of Pond #15a or #15b into aquatic plant demonstration site					L
Open water restoration at GW #3					M
Strategic tree management work:					
Tree survey and planning	H				
Phase I (GW #16, #17, #8, #11)		H			
Phase II (BMZ 1, GW #21, Pond #20)			H		
Phase III (GW #13, #14, #22, #23)				H	
Phase IV (GW #18, GW #19, all paths, Pond #15)					H

Annex I. Annual work schedule for recurrent works (H indicates peak month for the work item).

Recurrent work item	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Water exchange and water level management					H	H	H	H	H	H		
Draining and predatory fish management	H										H	H
Vegetation cutting on bunds – BMZ 1, Pond #20										H		
– BMZ 5, 7								H				
– BMZ 2, 3, 4 (every 2 years)									H			
Vegetation cutting on islands			H					H		H		
Control vegetation in open water area – BMZ 5, 7 other GW and ponds			H					H		H		
Removal of tree saplings along bunds	H											
Control of invasive species:		H	H									
• <i>Mikania micrantha</i>	H									H		H
• <i>Sonneratia spp.</i>												
• <i>Leucaena leucocephala</i>												
• <i>Typha</i>												
• Apple Snail	H					H	H					
• Red Imported Fire Ant			H					H		H		
Management of captive water buffalos and enclosures												
Management of feral dogs and cats												
Management of vegetation around visitor facilities				H	H	H	H	H	H			
Maintenance of infrastructures	H	H	H	H	H	H	H	H	H	H	H	H
Management of vegetation on intertidal mudflat						H	H	H	H	H		

Annex J Monitoring Manual

Annex J1 - Faunal Monitoring (FM)

FM01. Morning Bird Count

FEATURE	Avifauna
PARAMETERS	Abundance and distribution of bird species at MPNR.
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To systematically record bird species present along a fixed transect at MPNR for long-term tracking of bird populations. 2. To monitor the abundance and distribution of bird species at MPNR to evaluate effectiveness of habitat management and to inform future management decisions.
BACKGROUND	<p>Being relatively easy to observe and record and using a variety of habitats, birds are good indicator species for habitat quality. A number of species of conservation importance, either locally or at a regional or global scale, are present at MPNR. They are also the main attraction for many of the visitors to the Reserve. Regular monitoring of birds allows a greater understanding of the use of the Reserve by these species and can inform future management decisions, not only of the wetland habitats but also of the bunds and other terrestrial areas.</p> <p>Although the methodology of the Morning Bird Count does not provide information on the total abundance of each species on the Reserve as a whole, by following a fixed transect on a regular basis it permits the monitoring of any changes in the abundance of bird species which may indicate a change in habitat condition.</p>

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Bicycle 2. Binoculars (8x magnification or above) 3. Telescope and tripod 4. Voice recorder/ Pen and paper 5. Watch
Equipment (optional)	<ol style="list-style-type: none"> 1. Hand tally counter
Sampling site(s)	<ol style="list-style-type: none"> 1. A 6.2km transect running anti-clockwise encircling the perimeter of the MPNR: <ul style="list-style-type: none"> - Start and finish location at Gate 103 on the Frontier Closed Area (FCA) road 2. Side paths: <ul style="list-style-type: none"> - Path between Pond #8a and #9 - Path between Pond #16b and #17b

	<p>3. Mandatory scan points:</p> <ul style="list-style-type: none"> - Pond #8a: Tower Hide (top floor) - <i>Gei wai</i> #16/17: Hide #7; - Pond #16a and #17a: crossroads between Pond #16a, #16b, #17a and #17b; <p>4. Discretionary scan points:</p> <ul style="list-style-type: none"> - <i>Gei wai</i> #11: Hide #8 - <i>Gei wai</i> #16/17: Hides #1, #3, #5 - <i>Gei wai</i> #21: Hut #21 <p>See Figure FM01-1</p>
<p>Sampling technique</p>	<ol style="list-style-type: none"> 1. The entire transect route is cycled and all birds seen/heard are recorded. 2. The recorder should stop at several locations alongside each <i>gei wai</i>/pond (where possible) to provide uninterrupted views into the open areas of water and water channels. 3. Cycling speed should be slow enough to allow the recorder to stop quickly if needed, observe bird movements between waterbodies (to avoid double counting) and listen for bird calls. 4. The recorder should stop at all mandatory scan points (as listed above) to count birds. Discretionary scan points can be used if appropriate to provide a better view of the ponds for more accurate counts. 5. All birds recorded are divided into Category A or Category B. <ul style="list-style-type: none"> - Category A: all non-flying birds inside the MPNR <i>gei wai</i>/ponds; - Category B: All flying birds (including those within the MPNR perimeter) and other non-flying birds outside MPNR or not recorded under Category A; - Birds located on the MPNR perimeter trees belong to Category A, but those on the FCA fence belong to Category B. 6. Category A <ul style="list-style-type: none"> - The species and number of birds are recorded according to location. <i>Gei wai</i> are divided into East and West by an imaginary line across the middle of the site. Bunds are recorded according to the water bodies these divide. Birds on the perimeter road or path are assigned according to the adjacent water (Figure FM01-2). - More precise locations should be collected for waterbird / bird of prey species (as listed below) and mapped after completion of the count. 7. Mapping is required for the following observations: <ul style="list-style-type: none"> - The roosting location(s) of each individual/flock of Black-faced Spoonbill <i>Platalea minor</i>; - The roosting location(s) of each Great Cormorant <i>Phalacrocorax carbo</i> flock containing >5 individuals (October – March) on trees, bunds or islands; - The location of congregations of any waterbird group (i.e. 'Anatidae.', 'Ardeidae', 'Gulls and Terns', 'Rails and Coots, etc.' or 'Shorebirds') containing >50 individuals located in any sub-pond or <i>gei wai</i>; - The locations of each 'Bird of Prey'; - The location(s) of breeding evidence for any waterbird species; - At the discretion of the recorder, the location of any other bird(s) considered unusual or of interest for MPNR.

	<p>8. Category B - Only the species and number of birds are recorded.</p> <p>9. All factors likely to significantly influence the data (e.g. drained <i>gei wai</i>, recent vegetation cutting on islands, disturbances, etc.) should be noted.</p>
Sampling time of year	All months of the year.
Sampling time of day	Each count commences 15 minutes before sunrise and should last no more than 3 hours. (Note: Longer time (<60min) may be necessary in winter due to higher bird numbers.)
Sampling frequency	<p>Two samples should be collected each month.</p> <p>One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day.</p> <p>There should be at least a 7-day interval between any 2 counts.</p> <p>Both counts should be conducted on the best available high tides in Deep Bay (i.e. preferably tide height >2.1m or highest available tide if there is no morning high tide in the period) during the first 1.5 hour of the survey so there is a greater chance of encountering shorebirds on <i>Gei wai</i> #16/17. If this is not possible then a further consideration should be if the tide reaches >2.1m by the expected time of arrival at the eastern side of <i>Gei wai</i> #11 (approx. 2.5 hours after the survey starts).</p> <p>Where possible, one of the two monthly counts is preferably be conducted within a 7-day period on either side of the AFCD's Deep Bay Monthly Waterbird Count, to enable a better comparison between MPNR, the Ramsar Site and Deep Bay waterbird numbers;</p>
No. of samples	24 per year
Repeat interval	Annually
Weather conditions	<p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count.</p>

<p>When visibility is especially poor (e.g. morning mist or air pollution), such that the recorder can not see clearly into the central areas of the <i>gei wai</i>, the count should be rescheduled.</p>

<p>Under any unusual or exceptional circumstances that the count is interrupted for a prolonged period of time, the current count should be abandoned and rescheduled.</p>
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Figure FM01-1: Transect route of morning bird count

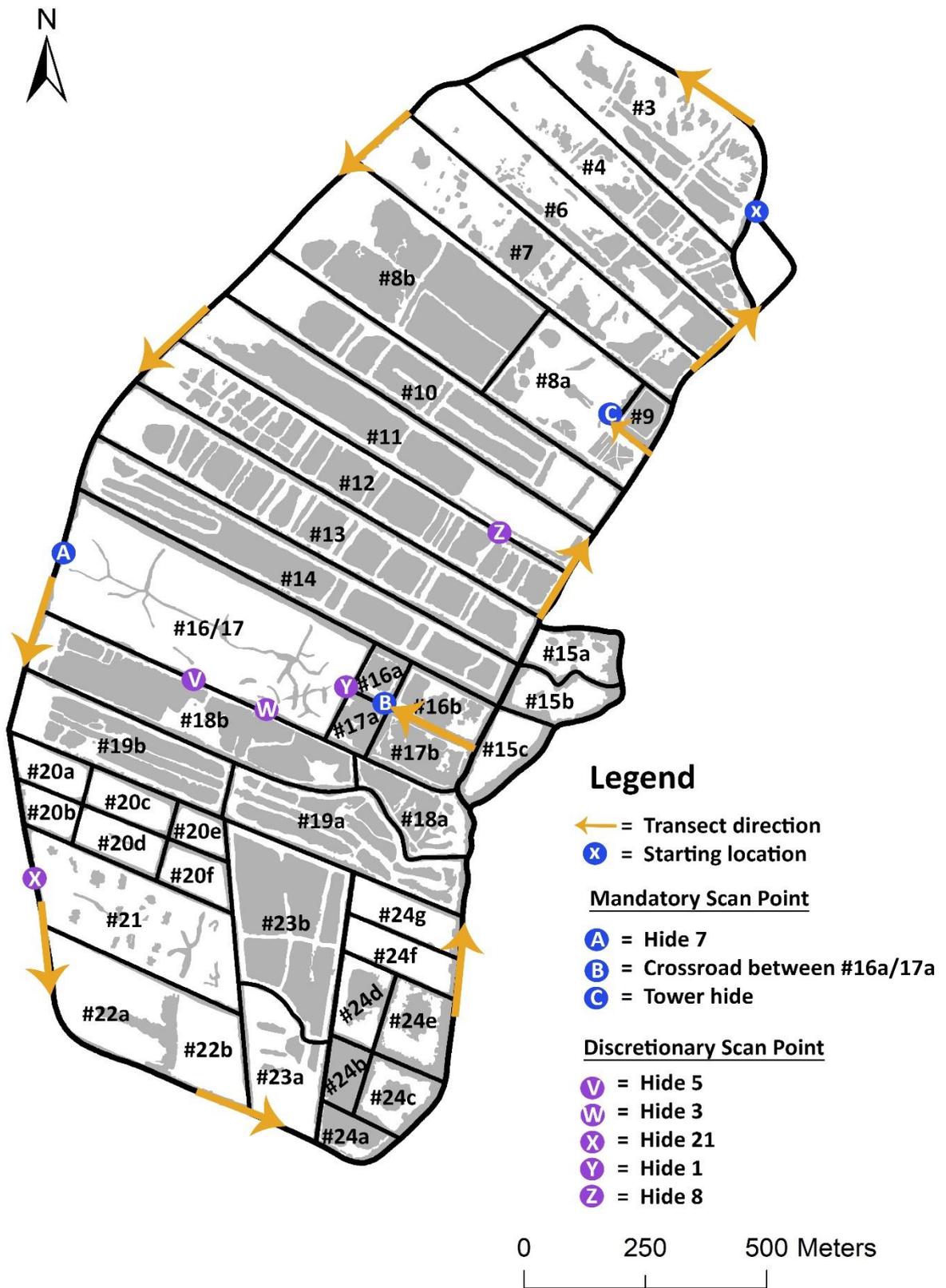
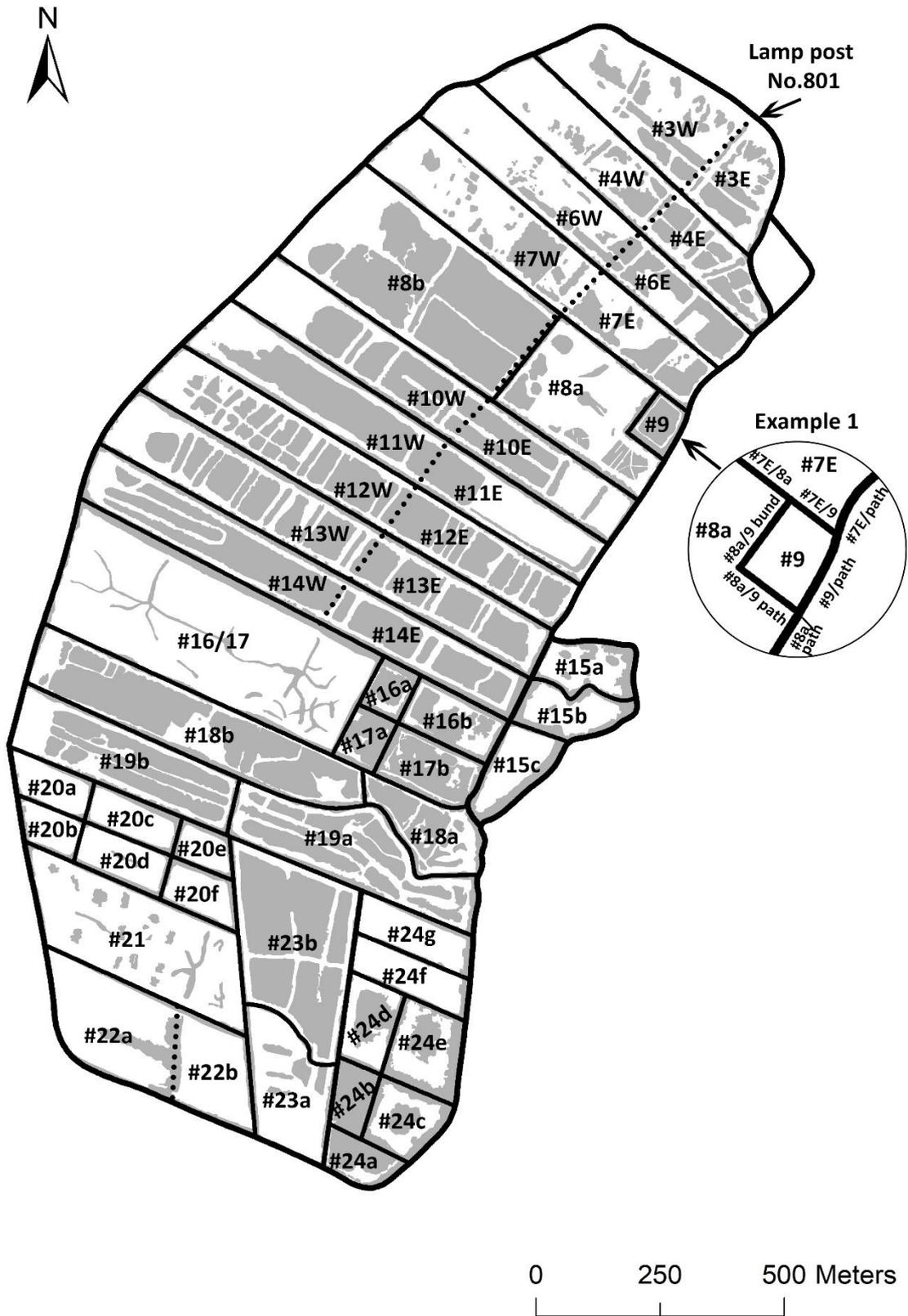


Figure FM01-2: Location codes



FM02. Black-faced Spoonbill Count

FEATURE	Black-faced Spoonbill
PARAMETERS	Abundance and distribution at MPNR
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To monitor the population of this globally-threatened species. 2. To inform habitat management decisions at MPNR to permit enhancement of habitat for the species.
BACKGROUND	<p>Provision of habitat for Black-faced Spoonbills is the management intention of BMZ 1 (corresponding to <i>Gei wai</i> #3, #4, #6 and #7) of the Mai Po Inner Deep Bay Ramsar Site Management Plan. Provision of habitat is also one of the management objectives of the Mai Po Management Plan.</p> <p>Previous observations of Black-faced Spoonbills, including a radio-tracking study in 2002, have found that birds are most active in the morning and evening, but typically return to roosting areas (including the <i>gei wai</i> at MPNR) during the middle of the day and at night. Counting of birds during the middle of the day therefore provides a better estimate for total numbers using MPNR than during early morning or late afternoon counts. Night-time counts are not considered suitable because birds often return after dark, and may be difficult to count, especially if distant from the path.</p>
MANAGEMENT PLAN TARGET	By 2024, no decline in the roosting Black-faced Spoonbill from current trend.

METHODOLOGY

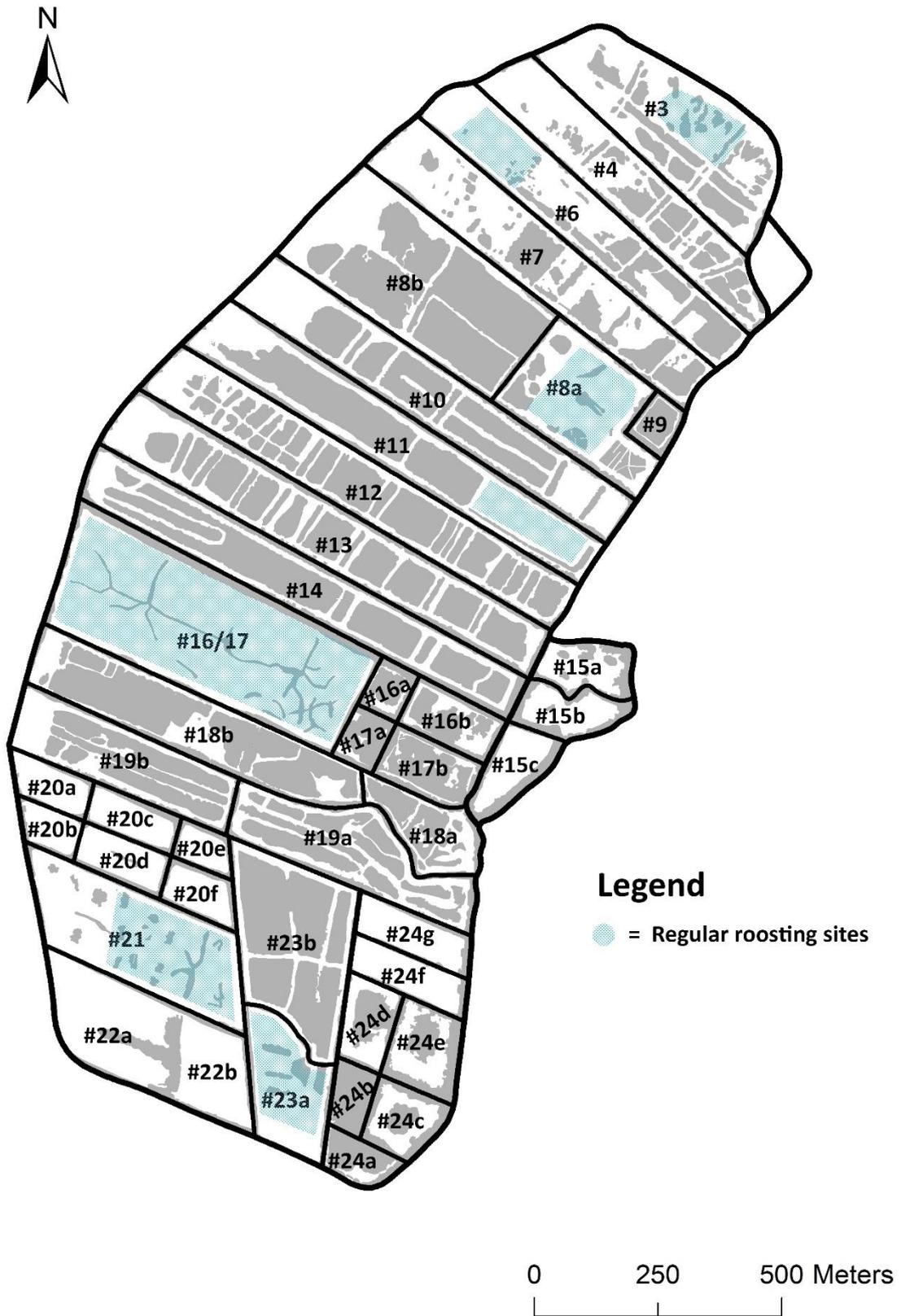
Equipment (essential)	<ol style="list-style-type: none"> 1. Binoculars (8x magnification or above). 2. Telescope and tripod 3. Voice recorder or paper with pen. 4. Bicycle.
Equipment (optional)	<ol style="list-style-type: none"> 1. Hand tally counter.
Sampling site(s)	<p>Main roosting areas for Black-faced Spoonbills are <i>Gei wai</i> #3, #4, #6, #7, #11, #16/17, #21, #22 and #23a, and Ponds #8a and #20. Surveys should be carried out throughout MPNR by following route around perimeter of reserve.</p> <p>See Figure FM02-1 for usual roosting locations.</p>

Sampling technique	<ol style="list-style-type: none"> 1. Surveyor should cycle around perimeter of reserve to cover all <i>gei wai</i> and ponds. Particular attention is required at waterbodies known to be used regularly by roosting spoonbills. 2. Number of spoonbills roosting at each <i>gei wai</i> / pond should be recorded. 3. Birds located on bunds should be assigned to a waterbody by using an imaginary line dissecting the bund equally between neighbouring <i>gei wai</i>/sub-ponds. 4. Birds flying over should not be counted, but birds seen arriving or leaving a waterbody should be recorded to that waterbody. Any movement of birds between waterbody should be noted to avoid double-counting. <p>All factors likely to significantly influence the data (e.g. drained <i>gei wai</i>, recent vegetation cutting on islands, disturbances, etc.) should be noted.</p>
Sampling time of year	1 st November – 31 st March
Sampling time of day	Surveys should start at 12.00 (noon) and should last for approximately 1 hour.
Sampling frequency	<p>Twice per month.</p> <p>One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day.</p> <p>There should be at least a 7-day interval between successive counts.</p> <p>Priority should be given to dates with higher tide in Deep Bay.</p>
No. of samples	Ten surveys per year.
Repeat interval	Annually
Weather condition	<p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count, the recorder should decide to either continue/abandon the count by assessing local weather condition and the remaining time duration of the count.</p>

<p>When visibility is especially poor (i.e. evening haze or air pollution), such that the recorder cannot see clearly into the central areas of the <i>gei wai</i>, the count should be rescheduled.</p>
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<p>Under any unusual or exceptional circumstances that the count is considerably interrupted, the current count should be abandoned and rescheduled.</p>
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Figure FM02-1: Regular roosting locations of Black-faced Spoonbill



FM03. Roosting Anatidae Count

FEATURE	Roosting Anatidae
PARAMETERS	Abundance and distribution of Anatidae roosting in evening at MPNR
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To provide data on the abundance and distribution of roosting Anatidae at MPNR to inform habitat management. 2. To track changes in abundance or distribution of Anatidae species.
BACKGROUND	<p>Anatidae (mostly ducks) are one of the most abundant waterbird groups wintering in Deep Bay area, and certain species are present in internationally important numbers in the Mai Po Inner Deep Bay Ramsar Site. Reliable data upon species, abundance and distribution within MPNR is essential to ensure habitats are managed successfully for their benefit.</p> <p>Numbers of Anatidae at MPNR increase overnight as birds roost in the safety of the reserve after spending the day foraging elsewhere (especially on the intertidal mudflats). Numbers are greatest during overnight high tides.</p>
MANAGEMENT PLAN TARGET	By 2024, the numbers and relative species composition (diversity) of duck assemblages remains stable, relative to past 5-year trend.

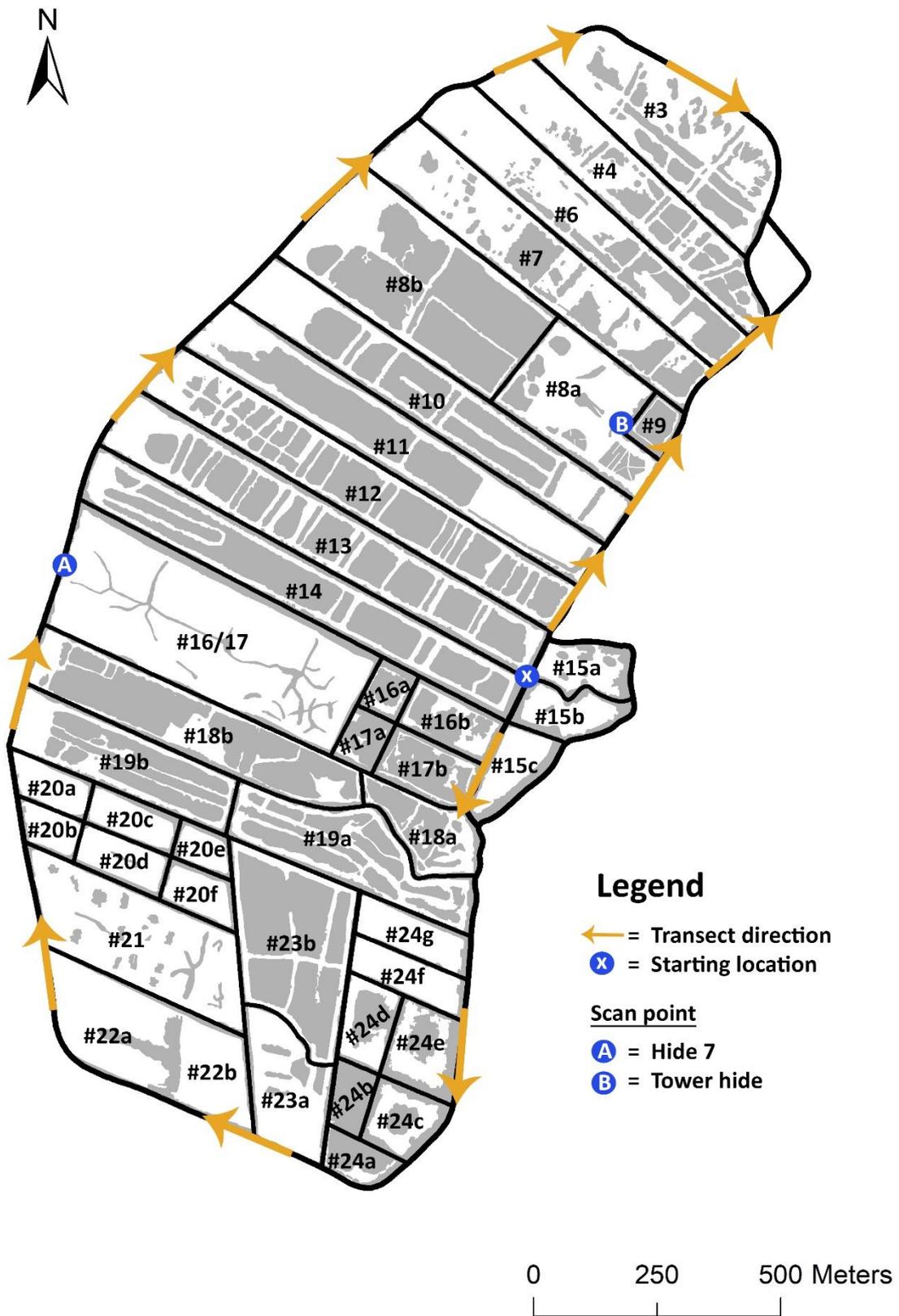
METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Binoculars (8x magnification or above). 2. Telescope and tripod. 3. Voice recorder or paper with pen. 4. Watch. 5. Bicycle (optional for recorder at fixed locations).
Equipment (optional)	<ol style="list-style-type: none"> 1. Hand tally counter.
Sampling site(s)	Transect count encircling perimeter of the MPNR. See Figure FM03-1.

Sampling technique	<ol style="list-style-type: none"> 1. The entire transect route is cycled and all non-flying Anatidae inside the MPNR are recorded. 2. The recorder should stop at several locations alongside each <i>gei wai</i>/pond (where possible) or at bird hides to provide uninterrupted views into the open areas of water and water channels. 3. The number and the associated <i>gei wai</i>/ sub-ponds of each Anatidae species should be recorded. 4. Birds located on internal bunds should be assigned to a waterbody by using an imaginary line dissecting the bund equally between neighbouring <i>gei wai</i>/sub-ponds. 5. Only non-flying birds are recorded and movements between waterbodies should be noted where possible to avoid double counting. 6. When large numbers of birds are expected at particular locations (especially those mentioned above), additional observers should be located at those sites at the start of the count and should record the number of birds present during this period. In this case, the <i>gei wai</i>/sub-ponds covered by additional observers need not be surveyed as part of the cycled transect. <p>All factors likely to significantly influence the data (e.g. drained <i>gei wai</i>, recent vegetation cutting on islands, disturbances, etc.) should be noted.</p>
Sampling time of year	From 15 th October to 15 th April.
Sampling time of day	Count commences 45 minutes before sunset and last for 1 hour.
Sampling frequency	<p>Sample should be collected every half month.</p> <p>There should be at least a 7-day interval between any 2 counts.</p> <p>One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day.</p> <p>Both counts should be conducted on the best available high tides in Deep Bay (i.e. preferably tide height >2.1m) during the survey so there is a greater chance of encountering more Anatidae coming in to MPNR from the Bay.</p> <p>Where possible, one of the two monthly counts should be conducted within a 7-day period either side of the AFCD's Deep Bay Monthly Waterbird Count to enable a direct comparison between MPNR, the Ramsar Site and Deep Bay waterbird numbers;</p>
No. of samples	12 per year

Repeat interval	Annually
Weather conditions	<p>The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the survey, the recorder should decide to either continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey.</p> <p>When visibility is especially poor (e.g. evening haze or air pollution), such that the recorder cannot see clearly into the central areas of the <i>gei wai</i>, the survey should be rescheduled.</p> <p>Under any unusual or exceptional circumstances that the survey is interrupted for a prolonged period of time, the current survey should be abandoned and rescheduled.</p>

Figure FM03-1: Counting locations and transect route for roosting anatidae count



FM04. Roosting Collared Crow Count

FEATURE	Collared Crow
PARAMETERS	<ol style="list-style-type: none"> 1. Roosting population 2. Roosting location
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To monitor the population of this globally near-threatened species. 2. To monitor habitat use or pre-roosting flock within MPNR to assess whether enhancement of habitat is feasible.
BACKGROUND	<p>Collared Crow is listed as a globally Vulnerable species under the IUCN Red List (BirdLife 2019). Deep Bay supports the largest known roosting population in Hong Kong, which is the second most important area for the species globally.</p> <p>Most birds in Deep Bay roost communally at night in the intertidal mangroves at the Frontier Closed Area (FCA) adjacent to MPNR. This roost location is outside the boundary of MPNR, but most birds do gather into pre-roost gatherings within MPNR before going to the final roosting location. Although no habitat enhancement is possible at the roost location, it is recognised that the population of this species should be monitored given the apparent global importance of the Deep Bay roosting population.</p> <p>Data shows MPNR and the surrounding habitats provide year-round roosting habitat for the species, but the number peaks in two periods of the year: July and August; and in mid-winter (late December to early February). Monitoring of the species at MPNR therefore concentrates in these two periods. A full year survey will also be conducted in 2019-2024 as a review on the survey periods.</p>
MANAGEMENT PLAN TARGET	By 2024, the roosting population of Collared Crow in Mai Po maintained as more than 200 individuals.

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Binoculars (8x magnification or above) 2. Voice recorder or paper with pen 3. Watch
Equipment (optional)	<ol style="list-style-type: none"> 1. Bicycle 2. Hand tally counter
Sampling site(s)	Count should be carried out at locations where pre-roosting flocks inside MPNR can be observed undisturbed (usually along the Frontier Closed Area road). Recorder might need to move between locations to observe birds' movement.

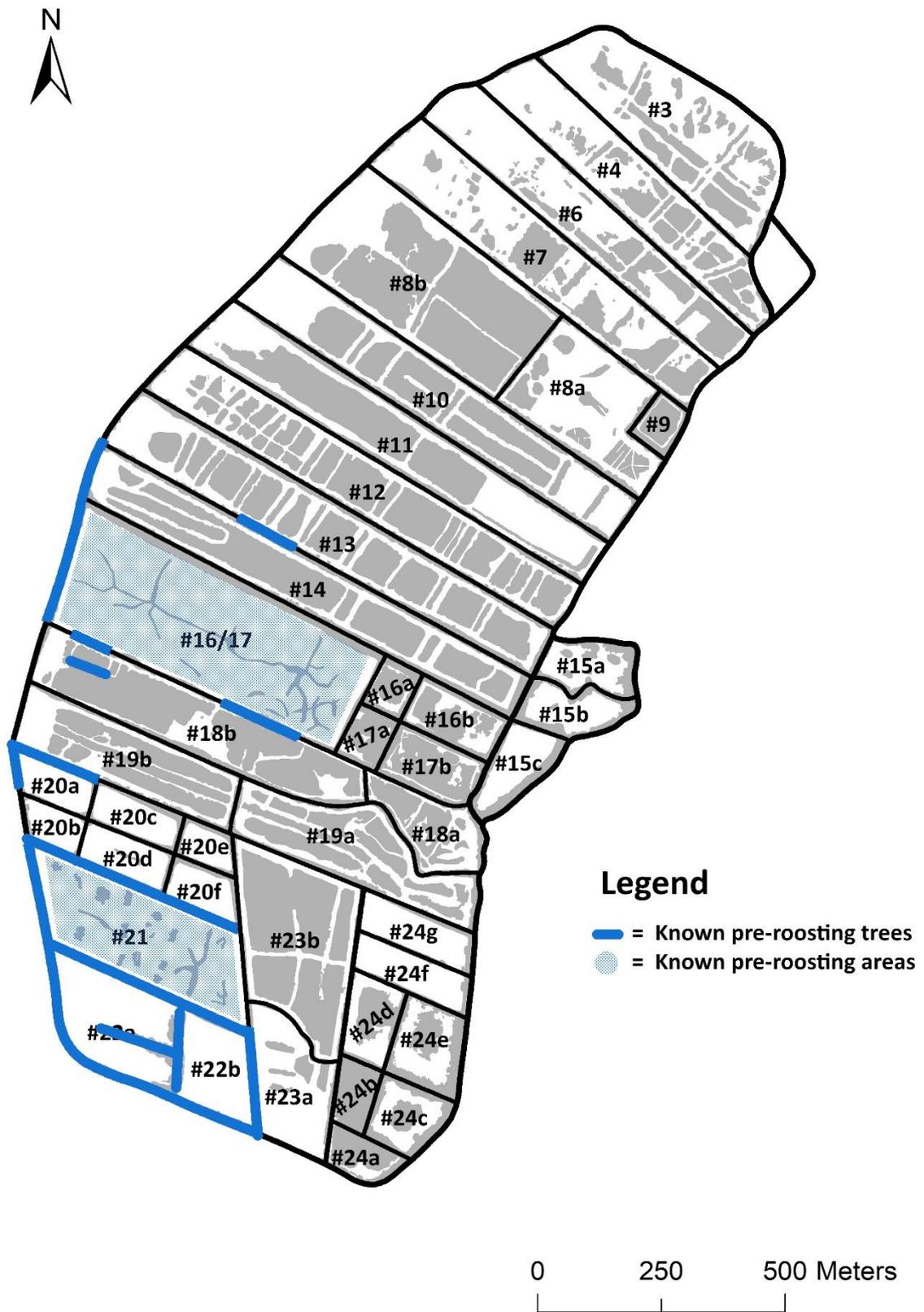
	See Figure FM04-1 for known locations.
Sampling technique	<ol style="list-style-type: none"> 1. The recorder should locate the pre-roosting flocks inside MPNR and be in position within the first 15 minutes of the survey. 2. Sampling time is split into 15-minute intervals. For each interval, the recorder should count the total number seen and record the net increase/decrease in the number of pre-roosting individuals within MPNR. 3. As birds enter their final roost, the recorder should count the total roosting population and record the location of the final roost. 4. Where possible, the recorder should take notes of the followings: <ul style="list-style-type: none"> - Location of the pre-roosting flocks; - Direction and time of arrival of birds joining the pre-roosting flock; - Movement of the pre-roosting flocks between locations; - Number and time that the pre-roosting flocks enter the final roost.
Sampling time of year	<ul style="list-style-type: none"> - Winter: mid-December to mid-February - Summer: July to August <p>One full year survey will be conducted in 2019-2024 (tentatively in 2022).</p>
Sampling time of day	Count commences 1 hour before sunset (survey ends when the last bird enters the final roost).
Sampling frequency	<p>Sample should be collected every half-month.</p> <p>One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day.</p> <p>There should be at least a 7-day interval between any 2 counts.</p>
No. of samples	<p>8 per year</p> <p>24 in 2022 as a full year survey</p>
Repeat interval	Annually
Weather condition	The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.

If any signal/warning is issued during the count, the recorder should decide to either continue/abandon the count by assessing local weather condition and the remaining time duration of the count.

When visibility is especially poor (i.e. evening haze or air pollution), such that the recorder cannot see clearly into the central areas of the *gei wai*, the count should be rescheduled.

Under any unusual or exceptional circumstances that the count is considerably interrupted, the current count should be abandoned and rescheduled.

Figure FM04-1: Known pre-roosting locations of collared crow



FM05. Reedbed Roosting Bird Count

FEATURE	Reedbed roosting birds
PARAMETERS	Abundance and distribution of birds using reedbed in MPNR for night-roosting.
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To provide abundance and distributional data on roosting birds in reedbed to inform habitat management. 2. To monitor abundance of roosting birds in reedbed to inform management decisions.
BACKGROUND	<p>The extensive reedbed stands within MPNR provide good quality roosting habitat for both waterbirds and non-waterbirds. Eurasian Bittern <i>Botaurus stellaris</i> and Purple Heron <i>Ardea purpurea</i> are particularly in favor of reedbed. Among non-waterbirds species, Barn Swallow <i>Hirundo rustica</i> and Eastern Yellow Wagtail <i>Motacilla tschutschensis</i> are known to roost in large numbers in the reedbed.</p> <p>Observation on Barn Swallow and Eastern Yellow Wagtail roosting in reedbed was done in 2007 and has confirmed that Barn Swallow utilizes MPNR as a pre-roost gathering site and roost regularly in the wet reedbed. Eastern Yellow Wagtail are found to be reliant on the reedbed in MPNR during passage and wintering periods.</p> <p>According to the current management plan, reedbed at GW#8b and Pond #23b will be enhanced in 2019. Monitoring the bird usage of the enhanced reedbed would be required to ensure the habitat changes made are appropriate and could deliver desirable results.</p>

METHODOLOGY

Equipment (essential)	<p>For each recorder:</p> <ol style="list-style-type: none"> 1. Binoculars (8x magnification or above). 2. Telescope and tripod. 3. Voice recorder or paper with pen. 4. Watch. 5. Bicycle.
Equipment (optional)	<ol style="list-style-type: none"> 1. Hand tally counter.
Sampling site(s)	<p>Count for swallows should be carried out at locations where pre-roosting flocks inside MPNR can be detected, which is usually along the Frontier Closed Area road.</p> <p>Fixed sampling sites:</p> <ul style="list-style-type: none"> - <i>Gei wai #8b</i>

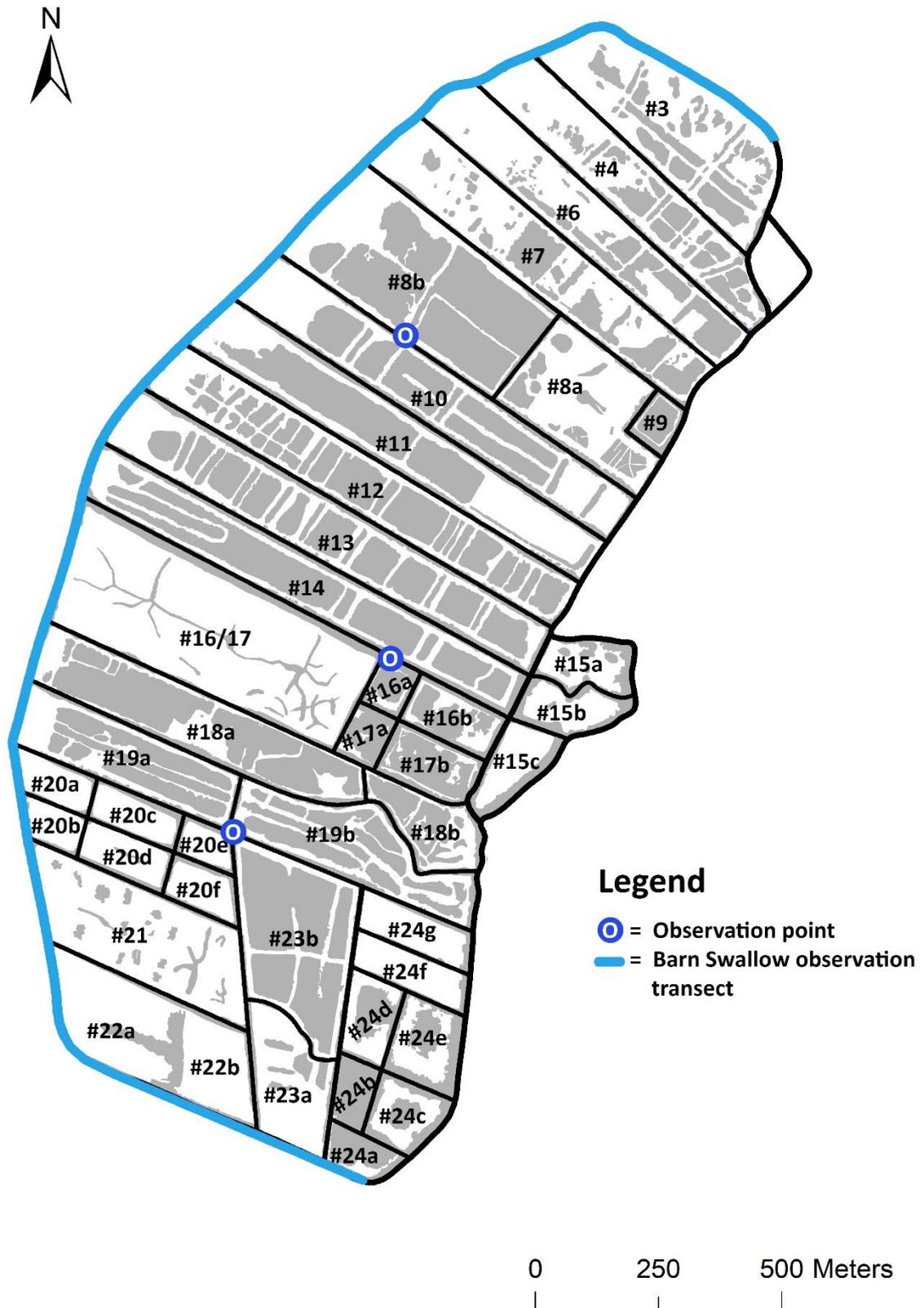
	<ul style="list-style-type: none"> - <i>Gei wai</i> #14 - <i>Gei wai</i> #23b <p>See Figure FM05-1.</p>
Sampling Technique	<ol style="list-style-type: none"> 1. Surveyor should check the reedbed along the FCA road and locate gathering of swallows. Once a flock is located, follow it and count the number of birds before they descend into reedbed stands. Final roosting population and location should be marked. Use of bicycle is required to travel rapidly between locations. 2. At fixed sampling sites, surveyor should record the number of Eastern Yellow Wagtails in the reedbed at 10-minute interval. To facilitate estimation of final number of roosting individuals, the number of birds entering or leaving the reedbed shall be recorded at each sampling interval. 3. If bitterns or heron are encountered in the fixed sampling sites or any reedbed within MPNR during the survey, the number, species and locations should be recorded. <p>All factors likely to significantly influence the data (e.g. drained <i>gei wai</i>, recent vegetation cutting on islands, disturbances, etc.) should be noted.</p>
Sampling time of year	<p>All months of the year for swallows, bitterns and herons.</p> <p>Only January-May, September-December for Eastern Yellow Wagtail.</p>
Sampling time of day	<p>Count commences 1 hour before sunset (survey ends when the last bird enters the final roost).</p>
Sampling frequency	<p>Surveys should be conducted every half month.</p> <p>One survey should be conducted in the first half of the month (before 15th) and one survey in the second half of the month (after 15th).</p> <p>There should be at least a 7-day interval between surveys.</p>
No. of samples	<p>24 per year</p>
Repeat interval	<p>Annually</p>
Weather conditions	<p>The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p>

If any signal/warning is issued during the survey, the recorder should decide to either continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey.

When visibility is especially poor (e.g. rainfall, haze or air pollution), such that the recorder cannot see clearly into the central areas of the *gei wai*, the survey should be rescheduled.

Under any unusual or exceptional circumstances that the survey is interrupted for a prolonged period of time, the current survey should be abandoned and rescheduled.

Figure FM05-1: Transect route and observation points of reedbed roosting bird count



FM06. Roosting Shorebirds and Terns Count

FEATURE	Shorebirds and Terns
PARAMETERS	Abundance and distribution of each shorebird and tern species using MPNR during high tide.
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To provide abundance and distributional data on roosting shorebirds and terns to inform habitat management. 2. To monitor abundance of shorebirds and terns to identify any change in long-term abundance so that action can be taken.
BACKGROUND	<p>Mai Po Inner Deep Bay Ramsar Site provides habitat for internationally important numbers of several shorebird species during winter and on migration between breeding and wintering sites. Provision of a safe high tide roost site is one of the Management Objectives of MPNR in BMZ5 & 7.</p> <p>Regular surveys of shorebirds at the high tide roosts provide data about the use of roosts and number of shorebirds, so that if any problems were to arise at the roost sites, appropriate action could be identified and implemented promptly. Moreover, as Futian Nature Reserve also provides high tide roosting sites for shorebirds, synchronized surveys with the Futian Nature Reserve is essential for monitoring the shorebird distribution in the Deep Bay during high tide period.</p> <p>Most species use MPNR primarily or exclusively during high tide period, so all surveys should be conducted at high tide. Because the time of high tide varies over the course of the year, the time of the surveys will also need to change over the year.</p>
MANAGEMENT PLAN TARGET	By 2024, the numbers and relative species composition (diversity) of the shorebird remain stable, relative to past 5-year trend.

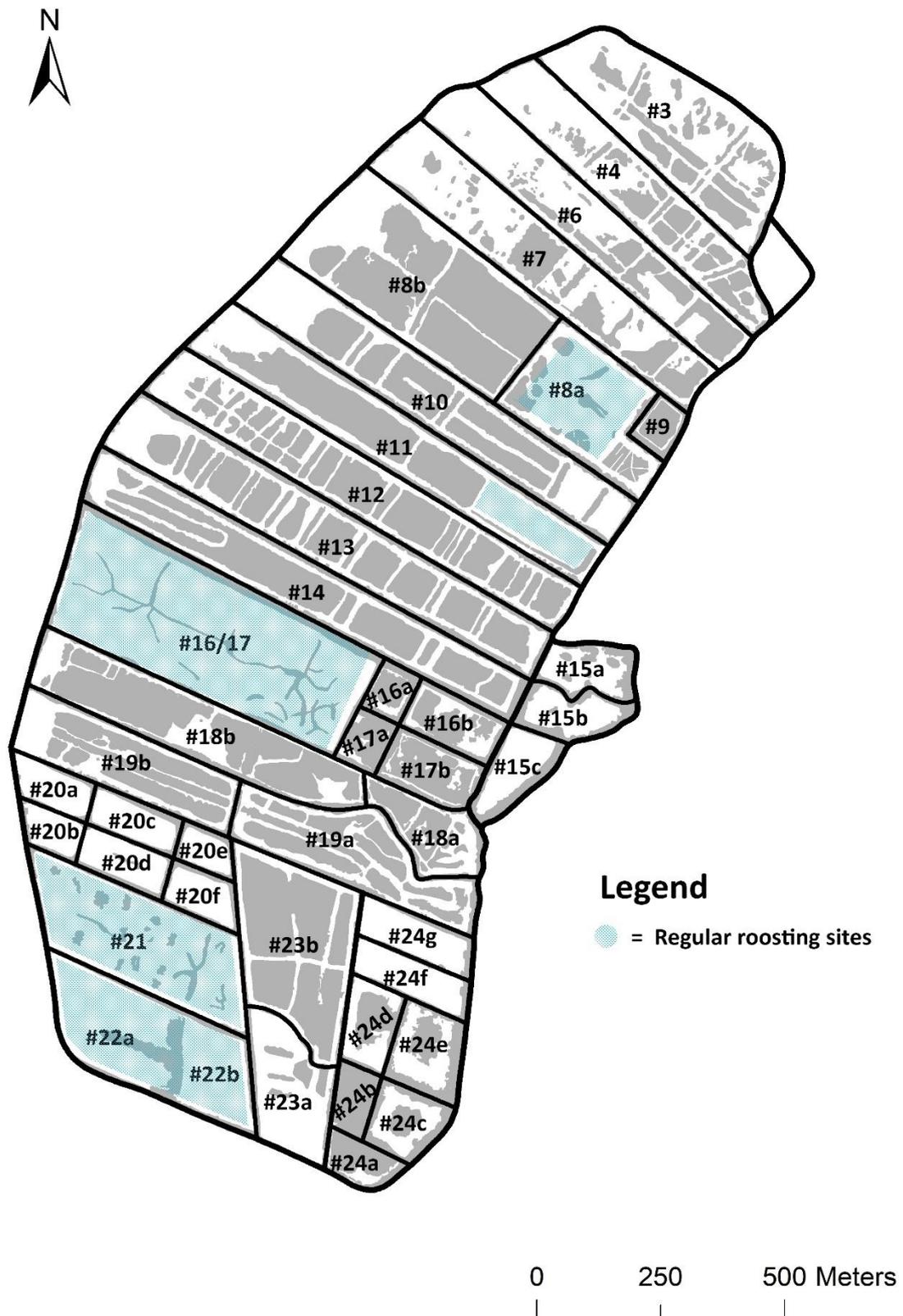
METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Binoculars (8x magnification or above). 2. Telescope and tripod. 3. Voice recorder or paper with pen. 4. Watch. 5. Bicycle.
Equipment (optional)	<ol style="list-style-type: none"> 1. Hand tally counter. 2. Bird field guide.
Sampling site(s)	<p>Fixed locations (to be surveyed during each survey):</p> <ul style="list-style-type: none"> - <i>Gei wai</i> #16/17 and Ponds #16a: Hide #1, #3, #5, #6 or #7; - <i>Gei wai</i> #11: Hide #8;

	<p>- <i>Gei wai</i> #21 and #22.</p> <p>Any other <i>gei wai</i> or rain-fed ponds in which the prevailing water level may be suitable for use by waterbirds (especially during drain-down or water exchange).</p> <p>See Figure FM06-1.</p>
<p>Survey Technique</p>	<ol style="list-style-type: none"> 1. Surveyor should visit all sites managed for roosting shorebirds as listed above. Use of bicycle is required to travel rapidly between survey locations. 2. Where conditions on another waterbody may provide conditions suitable for roosting shorebirds (particularly if water levels are low during periods of drain-down or water exchange), surveyor should also additionally visit these locations to check for the presence of shorebirds. 3. At each waterbody, surveyor should record the total number of individuals of each shorebird species (i.e. species of Recurvirostridae, Charadriidae, Rostratulidae, Jacanidae, Scolopacidae or Glareolidae) present. Numbers of Gull-billed Terns or Caspian Terns should also be recorded if these are present. 4. Birds located on internal bunds should be assigned to a waterbody by using an imaginary line dissecting the bund equally between neighbouring <i>gei wai</i>/sub-ponds. 5. Only non-flying birds are recorded and movements between waterbodies should be noted to avoid double counting. <p>Two or more surveyors may be required during times of peak abundance (particularly during peak spring migration period in April and May).</p> <p>Tide height (taken from the Real Time Tide value for Tsim Bei Tsui: http://www.hko.gov.hk/tide/marine/hko_tb.htm) should be recorded at start and end of survey, as well as the peak tide height during the survey. Predicted tide should also be recorded.</p> <p>All factors likely to significantly influence the data (e.g. drained <i>gei wai</i>, recent vegetation cutting on islands, disturbances, etc.) should be noted.</p>
<p>Sampling time of year</p>	<p>All months of the year.</p>
<p>Sampling time of day</p>	<p>Survey conducted to coincide with daytime high tide period (Between 06:00 and 18:00, tide > 2.2m at Tsim Bei Tsui in March-October and tide > 1.8m at Tsim Bei Tsui in November-February); time of day of high tide will change according to season and shall coincide with the sampling time and day in Futian Nature Reserve.</p>

Sampling frequency	<p>Surveys should be conducted every half month, on each cycle of peak high tides during migration period.</p> <p>Date of the surveys are set according to the following criteria:</p> <ol style="list-style-type: none"> 1. One survey should be conducted in the first half of the month (before 15th) and one survey in the second half of the month (after 15th); 2. Periods of spring tides reoccur on a cycle of approximately every two weeks and one survey should be conducted during each cycle, with at least a seven-day interval between surveys; 3. Where possible, surveys should coincide with the peak predicted tidal height of each spring tide cycle, to maximize the chance that birds have left the mudflats.
No. of samples	24 per year
Repeat interval	Annually
Weather conditions	<p>The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the survey, the recorder should decide to either continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey.</p> <p>When visibility is especially poor (e.g. rainfall, haze or air pollution), such that the recorder cannot see clearly into the central areas of the <i>gei wai</i>, the survey should be rescheduled.</p> <p>Under any unusual or exceptional circumstances that the survey is interrupted for a prolonged period of time, the current survey should be abandoned and rescheduled.</p>

Figure FM06-1: Regular roosting site of shorebirds and terns



FM07. Breeding Black-winged Stilt Count

FEATURE	Black-winged Stilt
PARAMETERS	Abundance, distribution and success of breeding attempts by Black-winged Stilts at MPNR
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To monitor breeding population size and breeding success of Black-winged Stilts at MPNR; 2. To record the distribution of nesting attempts so that favoured locations can be identified and appropriate management decisions can be made to benefit the species.
BACKGROUND	Black-winged Stilt mostly breeds on islands in shallow water <i>gei wai</i> or rain-fed ponds. Nest-building starts in most years from April and the first chicks hatch in early May. Surveys provide data not only on the number of nesting attempts but also on the number of juveniles produced, allowing calculation of nesting success/productivity in each year.
MANAGEMENT PLAN TARGET	By 2024, Black-winged Stilt continue to nest in MPNR.

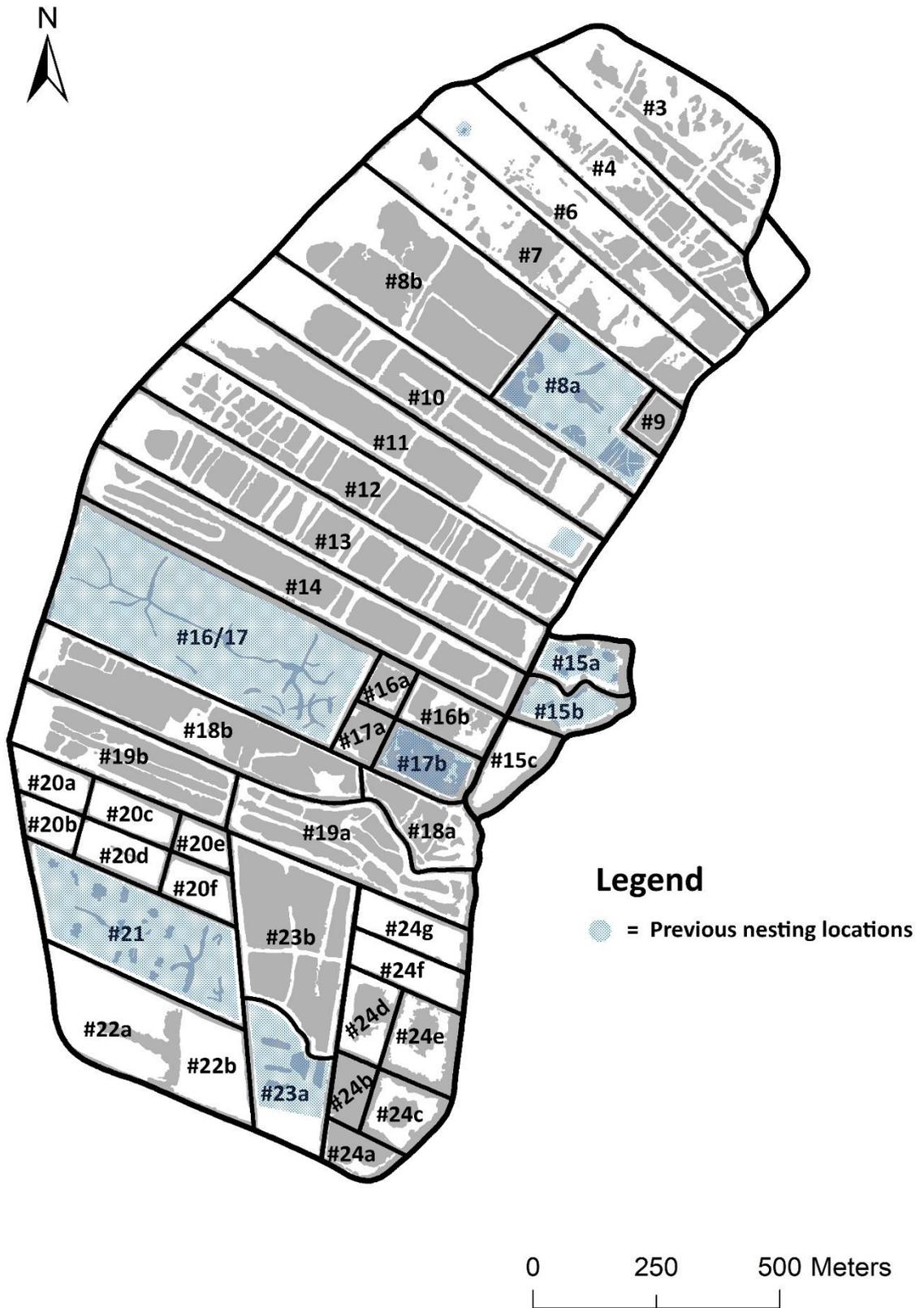
METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Bicycle 2. Binoculars (8x magnification or above) 3. Telescope and tripod 4. Pencil/pen 5. Recording map (Appendix I)
Equipment (optional)	<ol style="list-style-type: none"> 1. Camera
Sampling site(s)	<p>Survey should be carried out at all potential nesting sites within MPNR. Previous nesting locations include:</p> <ul style="list-style-type: none"> - Pond #8a - Pond #15a and b - <i>Gei wai</i> #16/17 - <i>Gei wai</i> #21 - <i>Gei wai</i> #23a <p>Juveniles leave the nest soon after hatching and can travel from the nesting location to other water bodies, so all <i>gei wai</i>/ponds should be checked to count juveniles.</p>

	See Figure FM07-1 for previous nesting locations.
Sampling technique	<ol style="list-style-type: none"> 1. The recorder should station at observation locations (bird hides or along road/foot path) overlooking each <i>gei wai</i>/pond. 2. Recorder should count the number of nests within each <i>gei wai</i>/pond and mark the location of each nest on the recording maps (Appendix I). 3. Enough observation time should be spent observing sitting adults to determine whether a nest is present. Presence of a nest is confirmed by observation of any of the following: <ul style="list-style-type: none"> - Presence of eggs; - Parent birds switching nest-sitting responsibility; - Nest building material elevated from ground. 4. The recorder should also take notes of any nest building pairs. 5. Recorder should determine the number of unfledged chicks or juveniles for all <i>gei wai</i>/ponds. The total number of unfledged chicks or juveniles at each waterbody should be recorded. 6. All factors likely to significantly influence the data (for example a drained <i>gei wai</i>, recent vegetation cutting on islands, disturbance, etc.) should be noted.
Sampling time of year	<p>May - June</p> <p>Nest-building may start in April and nesting attempts may continue into July so, at discretion of the recorder, extra surveys can be scheduled in these months if required.</p>
Sampling time of day	Any.
Sampling frequency	<p>Once every half-month.</p> <p>One of the counts should be conducted on or before the 15th and the other after the 15th of the month.</p> <p>There should be at least a 7-day interval between the two counts.</p>
No. of samples	<p>Minimum four per year.</p> <p>Extra surveys may be scheduled in April and/or July at the discretion of the recorder if breeding activity is observed in these months.</p>

Repeat interval	Annually.
Weather condition	<p>Heavy rain can make it difficult to assess the presence of eggs or small chicks if these are being sheltered by the adult, and may make observation at a distance difficult. Surveys should therefore avoid periods of heavy rainfall if possible.</p> <p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count or if weather deteriorates, the recorder should decide to either continue or reschedule the count by assessing local weather condition and the remaining time duration of the count.</p>

Figure FM07-1: Previous nesting locations of Black-winged Stilt



FM08. *Gei wai* Draining Waterbirds Count

FEATURE	Ardeids and spoonbills using draining <i>gei wai</i>
PARAMETERS	Abundance of ardeids and spoonbills on <i>gei wai</i> during drawdown (including birds foraging and/or roosting).
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To provide information on the abundance of ardeids and spoonbills attracted into each <i>gei wai</i> during drain-down periods. 2. To evaluate the effectiveness of drain-down in each <i>gei wai</i> so that management decisions can be made about each <i>gei wai</i> if necessary.
BACKGROUND	<p><i>Gei wai</i> at MPNR are drained to attract foraging waterbirds, especially ardeids (herons and egrets) and spoonbills. These species are attracted to feed as falling water levels allow wading and trap fish and shrimp in remaining water. Drain-down is conducted during winter and summer according to a schedule drawn up at the start of the season.</p> <p>Surveys of waterbirds foraging at <i>Gei wai</i> #12, #13 & #14 during winter drawdown have been conducted since 2006, and these will be continued to provide a long-term dataset for these <i>gei wai</i>. Other <i>gei wai</i> will also be surveyed whenever drawdown is conducted.</p> <p>Surveys have previously been conducted into waterbird usage of draining <i>gei wai</i>, which suggested peak numbers of ardeids and spoonbills occur approximately 30-60 minutes after sunrise, and that on a traditional draining schedule (draining over a period of seven days), the peak numbers on most <i>gei wai</i> occur on the third day of draining. To make the results comparable between <i>gei wai</i>, all surveyed <i>gei wai</i> will be drained to reach the optimal level (about 10-20cm water depth remain in the water channel at 2 sides) on the third day and surveys will be conducted on the third day.</p>
MANAGEMENT PLAN TARGET	By 2024, numbers and composition of the ardeid and spoonbills remains stable.

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Binoculars (8x magnification or above). 2. Voice recorder or paper with pen.
Equipment (optional)	<ol style="list-style-type: none"> 1. Telescope and tripod. 2. Hand tally counter. 3. Bicycle.

Sampling site(s)	<ol style="list-style-type: none"> 1. <i>Gei wai</i> #12, #13, #14, #18b, #19b, #22 and pond #16b to be surveyed each winter during drawdown (October - March). 2. Other <i>gei wai</i> to be surveyed each winter during drawdown (tentative schedule: 2019/20 – #23a, 2020/21 – #10, 2021/22 – #23a, 2022/23 – #10, 2023/24 – #23a). 3. Other <i>gei wai</i> to be surveyed each summer during drawdown (tentative schedule: 2019 – #3&4, #8b, #21, 2020 – #6, #7, #16/17, #11, 2021 – #3&4, #8b, #21, 2022 – #6, #7, #16/17, #11, 2023 – #3&4, #8b, #21, 2024 – #6, #7, #16/17, #11).
Sampling technique	<ol style="list-style-type: none"> 1. Any <i>gei wai</i> being monitored should be drained to reach the optimal level on the third day. Surveys should be conducted on the morning of the third day of draining. Sluice gate operators should avoid disturbing birds during the count period. 2. Surveyors should arrive at a monitoring location providing a clear view over the open areas of the <i>gei wai</i> at least 15 minutes before the count is scheduled to start (i.e. 15 minutes after sunrise), to minimize disturbance to birds during the count. 3. During the count, the number of individuals of each species of spoonbills and ardeids observed using (foraging or roosting) the <i>gei wai</i> should be recorded. Birds flying over without using the <i>gei wai</i> should not be counted; birds using the bunds, mangroves or other perching locations within the <i>gei wai</i> should be recorded. 4. Two counts should be made, one at 30 minutes after sunrise, the other at 60 minutes after sunrise. The count to be recorded is the maximum of each species from these two counts. 5. For most <i>gei wai</i>, the entire area of open water will not be visible from a single location. In these cases either two surveyors should co-ordinate the counts from each end of the <i>gei wai</i> or one surveyor should move between each end of the <i>gei wai</i> between counts. Surveyor should avoid disturbing the birds when moving between locations. 6. If the count requires a single surveyor to move between each end of the <i>gei wai</i>, counts should start at the busier end of the <i>gei wai</i> at 30 minutes and then the surveyor should count the quieter end of the <i>gei wai</i> before start of the second count at 60 minutes. 7. Any sources of disturbance or other factors affecting the count should be recorded.
Sampling time of year	8 <i>gei wai</i> in winter (including #12, #13 and #14 in November-January) and at least 3 <i>gei wai</i> in summer.
Sampling time of day	Surveys should be conducted at 30 and 60 minutes after sunrise.
Sampling frequency	Surveys should be conducted on each <i>gei wai</i> on the third day during drawdown.
No. of samples	At least 11 surveys per year (8 in winter, 3 in summer).

Repeat interval	Annually
Weather conditions	<p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count.</p> <p>When visibility is especially poor (misty or heavy rain), such that the recorder can not see clearly into the central areas of the <i>gei wai</i>, the count should be rescheduled.</p> <p>Under any unusual or exceptional circumstances that the count is interrupted for a prolonged period of time, the current count should be abandoned and rescheduled for later the same day or for the following day.</p>

FM09. Adult Odonata Count

FEATURE	Adult odonata
PARAMETERS	Abundance and diversity of all odonata species around rain-fed ponds.
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To provide data on adult odonata abundance to inform habitat management decisions; 2. To provide data on the overall species diversity of odonata around rain-fed ponds at MPNR.
BACKGROUND	Observation of adults is an easily-surveyed indicator to the health of aquatic ecosystem. This provides information on the abundance of adults along fixed transect, so that the number and diversity of odonata using the rain-fed ponds can be monitored in the long term. Changes in species abundance or diversity allow a rapid assessment to identify whether habitat management is required so that this can be implemented promptly.

METHODOLOGY

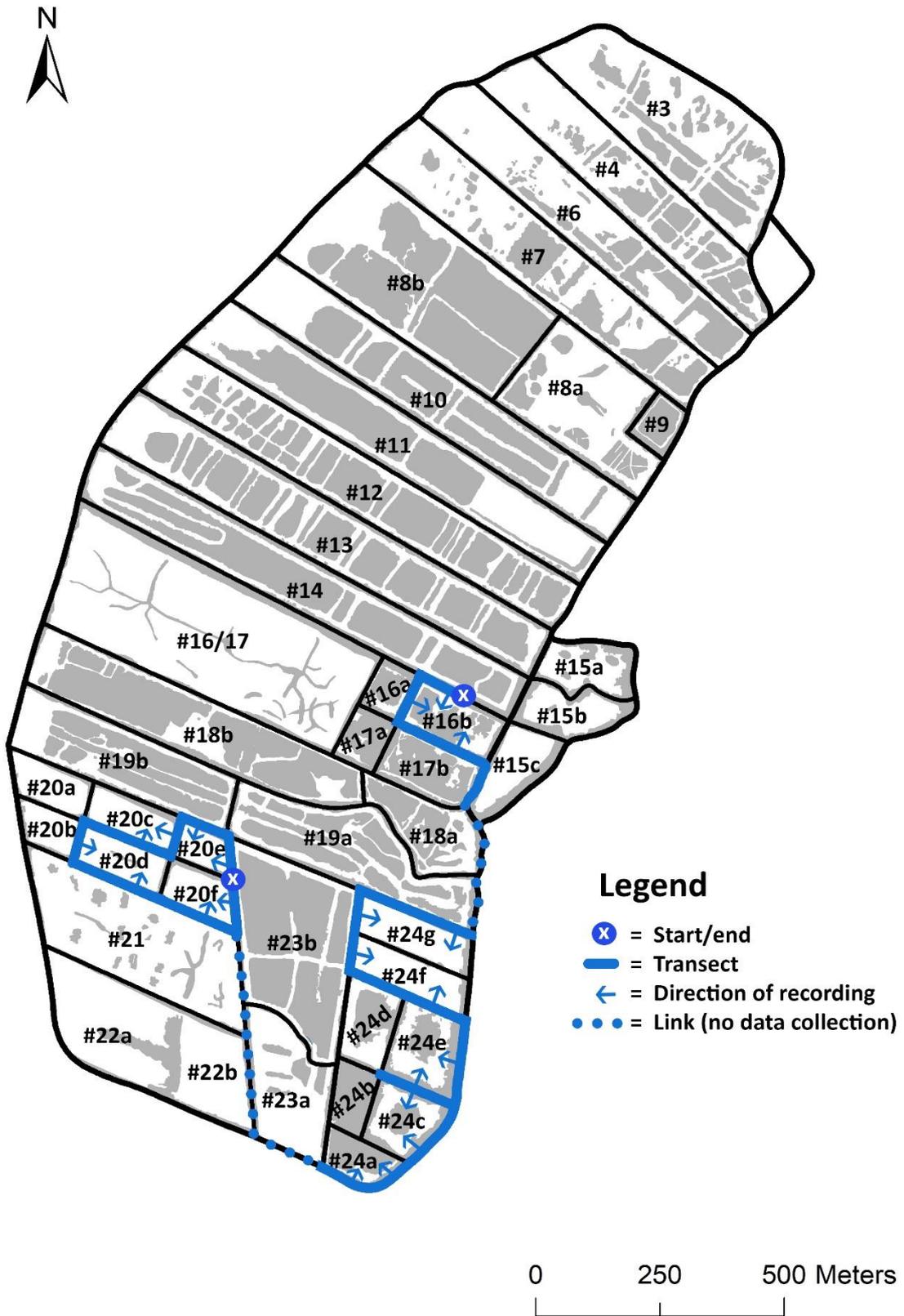
Equipment (essential)	<ol style="list-style-type: none"> 1. Binoculars (8x magnification or above) 2. Voice recorder or paper with pen 3. Watch
Equipment (optional)	<ol style="list-style-type: none"> 1. Odonata field guide 2. Hand tally counter 3. Camera
Sampling site(s)	<p>A 2.68km transect running along pond bund of 10 rain-fed ponds (Pond #16b, Pond #24a,c,e-g and Pond #20c-f) divided into three sections. Data is not collected between these sections. See Figure 1</p> <p>Section A – Pond #16b</p> <ul style="list-style-type: none"> - Start of section: northern end of boardwalk at Pond #16b - End of section: southern end of boardwalk at Pond #16b <p>Section B – Pond #24</p> <ul style="list-style-type: none"> - Start of section: north-east corner of Pond #24g - End of section: south-west corner of Pond #24a <p>Section C – Pond #20</p> <ul style="list-style-type: none"> - Start of section: north-east corner of Pond #20f - End of section: south-east corner of Pond #20e <p>Direction of the transect should be rotated each month.</p>

Sampling technique	<ol style="list-style-type: none"> 1. The entire transect (Fig FM09-1) should be walked from start to finish at a speed slow enough to enable positive identification of all adult odonata. Surveys should not exceed a total of 2.5 hours with equal effort upon each sub-pond. 2. All odonate adults within 3m on the specified side of the transect should be recorded for each bund along the transect. Care should be taken to avoid double-counting of individuals moving during the course of the survey. <ol style="list-style-type: none"> 1. All factors likely to significantly influence the data (for example any drained pond, recent vegetation cutting on bund, etc.) should be noted. 2. Additional notes should be recorded of species seen ovipositing or as a tandem or copulating pair.
Sampling time of year	<p>From 16th March to 15th October</p> <p>(Section C should only be surveyed from 16th April onwards to avoid disturbance to wintering Anatidae.)</p>
Sampling time of day	<p>Morning count: 10:00-13:00</p> <p>Afternoon count: 15:00-18:00</p>
Sampling frequency	<p>Two samples should be collected each month.</p>
No. of samples	<p>14 per year</p> <p>(12 per year for Section C)</p>
Repeat interval	<p>Twice every five years. Surveys are scheduled for 2020 and 2023.</p>
Weather condition	<p>The count should not be carried out during heavy rainfall and should be abandoned if persistent rain occurs before completion.</p> <p>The count should not be started when temperatures are below 15 °C or when winds are strong. Preference should be given to days with less than 50% cloud cover.</p> <p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p>

<p>If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count.</p>
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<p>If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable.</p>

Figure FM09-1: Transect route of adult Odonata count



FM10. Infra-red Camera Mammal Survey

FEATURE	Non-flying terrestrial mammals, in particular Eurasian Otter <i>Lutra lutra</i>
PARAMETER(S)	Species diversity and distribution of terrestrial mammals (in particular Eurasian Otter) at MPNR
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To systematically record terrestrial mammal species present at MPNR 2. To find out the distributions of terrestrial mammals, in particular Eurasian Otter, in different habitats in MPNR
BACKGROUND	<p>Mai Po Inner Deep Bay Ramsar Site and nearby area is holding the only population of Eurasian Otter in Hong Kong and probably the only one in South China. This species is a 'Near threatened' species list in the IUCN red list and has a high conservation value locally and internationally. Information on this species in Mai Po and nearby area is limited and more surveys are needed to find out the current status of the species their habitat preference in Hong Kong.</p> <p>Besides Eurasian Otter, other mammals like Leopard Cat <i>Prionailurus bengalensis</i>, Small Asian Mongoose <i>Herpestes javanicus</i> and Small Indian Civet <i>Viverricula indica</i> can be also found in Mai Po. However the records of these mammals are incidental and systematic surveys are needed to collect baseline information of these mammals.</p> <p>Eurasian Otter and other mammals are scarce and shy and therefore difficult to be surveyed by direct sighting. By using infra-red cameras, the terrestrial mammals can be surveyed with minimal disturbance to the animals and with a higher encounter rate.</p> <p>Moreover, feral dogs and cats are known to be a threat to wildlife. Monitoring the occurrence of such feral animals would help to evaluate the need and effectiveness of the control of feral animals in the Reserve.</p>

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Infra-red camera 2. AA batteries (for each camera, fully charged) 3. SD card (Empty) 4. GPS (for marking locations of the cameras) 5. Python locking cable and key
Sample site(s)	10 infra-red trigger cameras are deployed along set transects that covers different habitats at MPNR. Location shown in Figure FM10-1. Exact locations of the cameras are decided by WWF-Hong Kong staff on site; camera locations are reviewed approximately every 2 months, and adjustment of the camera position may be made.

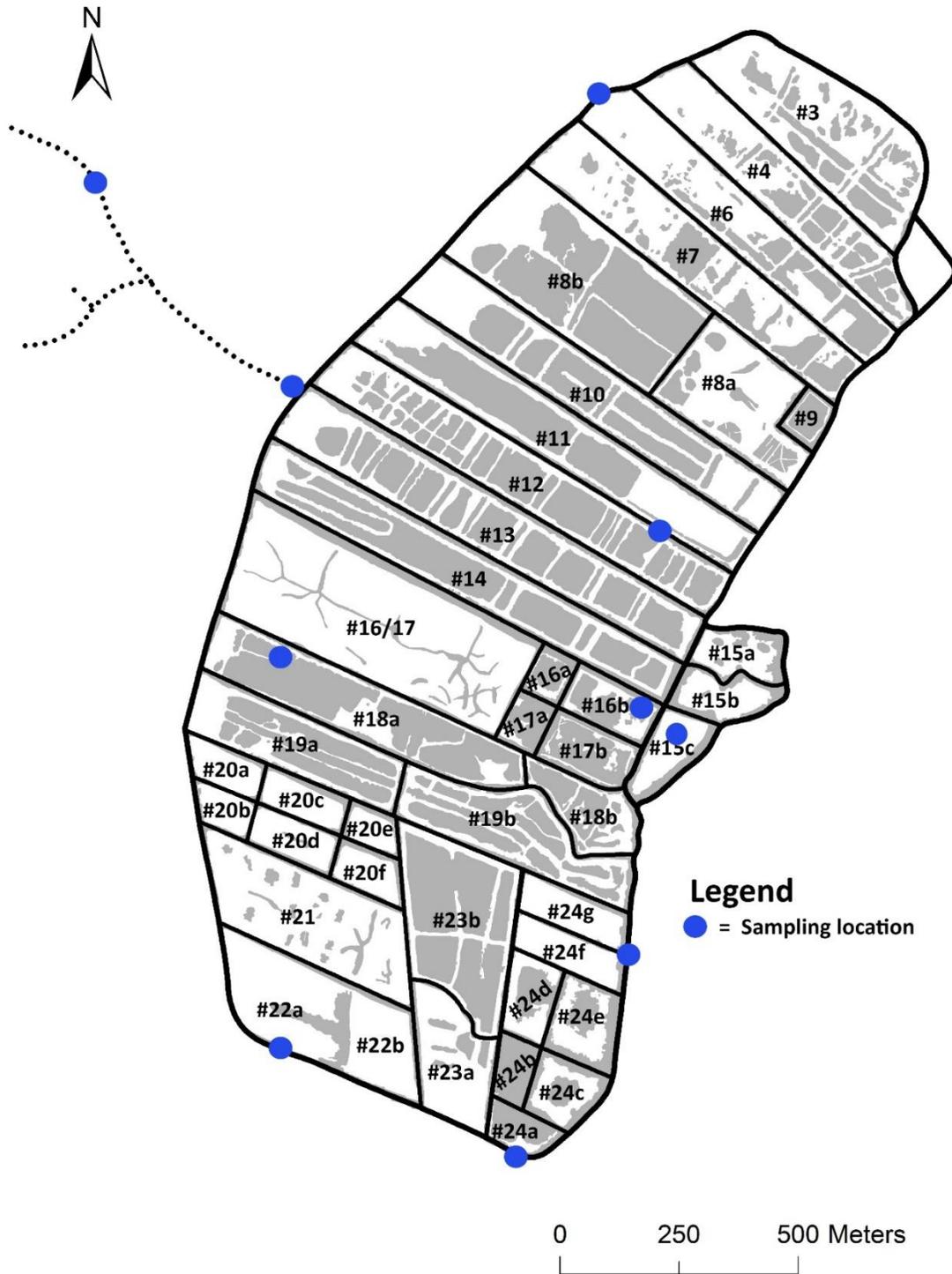
<p>Sampling techniques</p>	<p>1. Camera Deployment</p> <ul style="list-style-type: none"> a. Camera Preparation <ul style="list-style-type: none"> i. Make sure the correct date and time are programmed in the cameras. ii. Camera should be set to take one time-lapse photo every 12 hours for the determination of the date the camera stopped working in case when the camera stops functioning before the end of the deployment. iii. Check the battery level in the camera menu. Replace 12 batteries that are fully charged if the level is lower than 70%. b. Mounting and alignment <ul style="list-style-type: none"> i. Camera should be mounted on a tree or pole at around 30-40cm above the ground with a clear view of the ground. ii. There should not be any objects or vegetation within 1-2m from the camera sensor or lens. c. Walk test and arming <ul style="list-style-type: none"> i. Set the camera to 'walk test' mode and run the test to ensure the camera is aimed exactly to the study area to capture animal activity. <p>Then the camera can be armed and start monitoring. Create a photo record of the start of the deployment by walking in front of the camera. Start date of deployment shall be recorded.</p> <p>2. Camera Retrieval The surveyor should walk in front of the camera to obtain a photo record of the end time of deployment, and then unlock the padlock and turn off the camera. Battery level and number of photographs captured shall be recorded.</p> <p>For the camera that continue to be deployed at the same location, retrieve the SD card from the camera, store properly, and replace with an empty SD card; Clean the surface of the cameras and make sure the lens is clean. Then repeat step 1.</p> <p>3. Camera Cleaning and Storage Before storing the camera, the SD card and batteries must be removed and the camera should be clean and dried. If the camera is wet, the camera needs to be dried with opened case and placed in a drying closet (but not air conditioning) for at least 24 hours.</p> <p>4. Photo processing Surveyor shall go through all photos and record the mammal species, number of animals, location, date and time of photos.</p>
<p>Sampling time of year</p>	<p>All months of year</p>
<p>Sampling frequency</p>	<p>Cameras work throughout the day automatically, checking of cameras should be done every month</p>
<p>No. of samples</p>	<p>10 cameras deployed on-site</p>
<p>Repeat Interval</p>	<p>Annually</p>

<p>Weather conditions</p>	<p>The camera deployment and retrieval works should not be carried out during heavy rainfall and should be abandoned if condition persistent rain occurs before completion.</p> <p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the surveyors should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count.</p> <p>If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable.</p>
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SUPPORTS

<p>Supports from other parties and citizen scientists</p>	<ol style="list-style-type: none"> 1. WWF-Hong Kong staff: Decide the locations of cameras, provide trainings and other necessary supports for citizen scientists 2. Citizen Scientists: After training, citizen scientists assist the routine checking of all the cameras deployed, checking and storing data into proper locations
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Figure FM10-1: Infra-red camera locations



FM11. Four-spot Midget Count

FEATURE	Four-spot Midget
PARAMETER(S)	Abundance, distribution and habitat preference of Four-spot Midget in the inter-tidal mangrove forest adjacent to MPNR
OBJECTIVE(S)	To provide data on Four-spot Midget abundance and distribution in inter-tidal area mangrove forest adjacent to MPNR
BACKGROUND	<p>Four-spot Midget is a small damselfly listed as 'Near-threatened' in the IUCN red list. This is a species which could be only found in coastal areas of eastern Asia including Japan, Hong Kong, Taiwan and Korea. This species was only known from a very small number of sites and there has been a decline in habitat area at the known Japanese sites therefore it is important to know the current status of the species in Deep Bay Area.</p> <p>The species was found in MPNR in 1991, which is also the first record in Hong Kong and outside Japan. The species was found using the intertidal mangrove adjacent to MPNR. Ongoing surveillance of the species is needed for conserving the species.</p>
MANAGEMENT PLAN TARGET	By 2024, the distribution of Four-spot Midget in the Reserve is stable.

METHODOLOGY

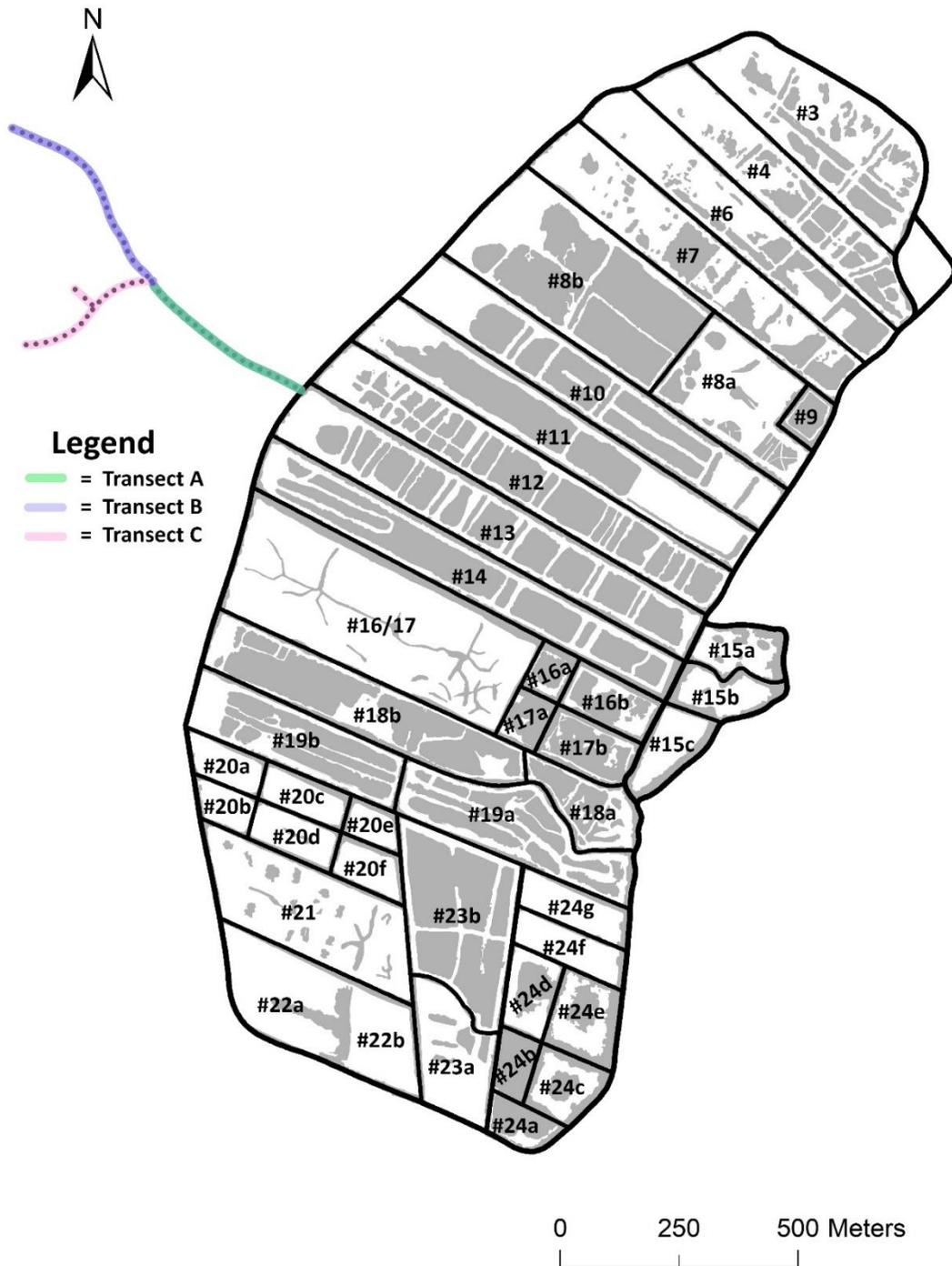
Equipment (essential)	Binoculars (8x magnification or above)
Equipment (optional)	<ol style="list-style-type: none"> 1. Hand tally counter 2. Pen and paper 3. Camera
Sample site(s)	All sections of fixed and floating boardwalk located at the intertidal mangrove within the Frontier Closed Area (Fig. FM11-1)
Sampling techniques	<ol style="list-style-type: none"> 1. The entire transect should be walked from start to finish at slow speed to enable positive identification of all Four-spot Midget. Surveys should not exceed 1 hour with equal effort upon each sections. 2. All Four-spot Midget adults within 3m on the specified side of the transect should be recorded for each bund along the transect. Care should be taken to avoid double-counting of individuals moving during the course of the survey. 3. Additional notes should be recorded of species seen ovipositing or as a tandem or copulating pair. In case of ovipositing, the GPS of location should be recorded.
Sampling time of year	April to September
Sampling time of day	15:00-18:00
Sampling frequency	Two samples should be collected each month. There should be at least a 7-day interval between successive counts.

No. of samples	12 per year
Repeat Interval	Annually
Weather conditions	<p>The count should not be carried out during heavy rainfall and should be abandoned if condition persistent rain occurs before completion.</p> <p>The count should not be started when winds are strong. Preference should be given to days with less than 50% cloud cover.</p> <p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count.</p> <p>If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable.</p>

SUPPORTS

Supports from other parties and citizen scientists	<ol style="list-style-type: none"> 1. WWF-Hong Kong staff: Provide training and supports for citizen scientists 2. Citizen Scientists: conduct surveys after training
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Figure FM11-1: Survey routes of Four-spot Midget count



FM12. Hong Kong Bent-winged Firefly Count

FEATURE	Hong Kong Bent-winged Firefly
PARAMETER(S)	Abundance, distribution and habitat preference of Hong Kong Bent-winged Firefly in MPNR
OBJECTIVE(S)	To monitor the numbers of Hong Kong Bent-winged Firefly in MPNR
BACKGROUND	<p>Hong Kong Bent-winged Firefly was first discovered in Deep bay area in 2010. The species was new to science and is the only species in the Genus <i>Pteroptyx</i> found in mangrove area in South-east Asia. The species is endemic to Deep Bay and therefore its population in the Deep Bay is of a high conservation value.</p> <p>WWF-Hong Kong has conducted a pilot study of the species in MPNR in 2012. However, more surveys are needed to obtain a baseline dataset for understanding the pattern of occurrences and habitat preference of the species.</p>
MANAGEMENT PLAN TARGET	By 2024, the major populations of Hong Kong Bent-winged Firefly and their habitat conserved and secured.

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Binoculars 2. Torch (For lighting along the transect) 3. Pen and datasheet
Equipment (optional)	<ol style="list-style-type: none"> 1. Camera 2. Hand tally counter
Sample site(s)	<p>Two routes are set to cover most of the brackish water <i>gei wai</i> and intertidal channels surrounding MP (Fig. FM12-1).</p> <p><u>Transect A</u> From Peter Scott Field Study Centre to AFCD warden post and along FCA fence from <i>Gei wai</i> #3 to <i>Gei wai</i> #22a</p> <p><u>Transect B</u> Path surrounding southern MP from Pond #15c to <i>Gei wai</i> #22a</p>
Sampling techniques	<p>The entire transect should be walked from start to finish at slow speed to enable positive identification of all Hong Kong Bent-winged Firefly.</p> <p>All flashing Hong Kong Bent-winged Firefly adults within 100m of the transect should be recorded with reference to the grid number (Fig. FM12-2). Care should be taken to avoid double-counting of individuals moving during the course of the survey.</p> <p>All factors likely to significantly influence the data (for example any drained pond, recent vegetation cutting on bund, etc.) should be noted.</p>
Sampling time of year	Late April to September

Sampling time of day	Survey should be conducted between 30-90 minutes after sunset (i.e. 1 hour duration) when the fireflies are most active.
Sampling frequency	Two samples should be collected each month
No. of samples	11 per year
Repeat Interval	Annually
Weather conditions	<p>The count should not be carried out during heavy rainfall and should be abandoned if condition persistent rain occurs before completion.</p> <p>The count should not be started when winds are strong. Preference should be given to days with new moon.</p> <p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count.</p> <p>If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable.</p>

SUPPORTS

Supports from other parties and citizen scientists	<ol style="list-style-type: none"> 1. WWF-Hong Kong staff: Provide training and supports for citizen scientists 2. Citizen Scientists: conduct surveys after training
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Figure FM12-1: Survey routes of Hong Kong Bent-winged Firefly count

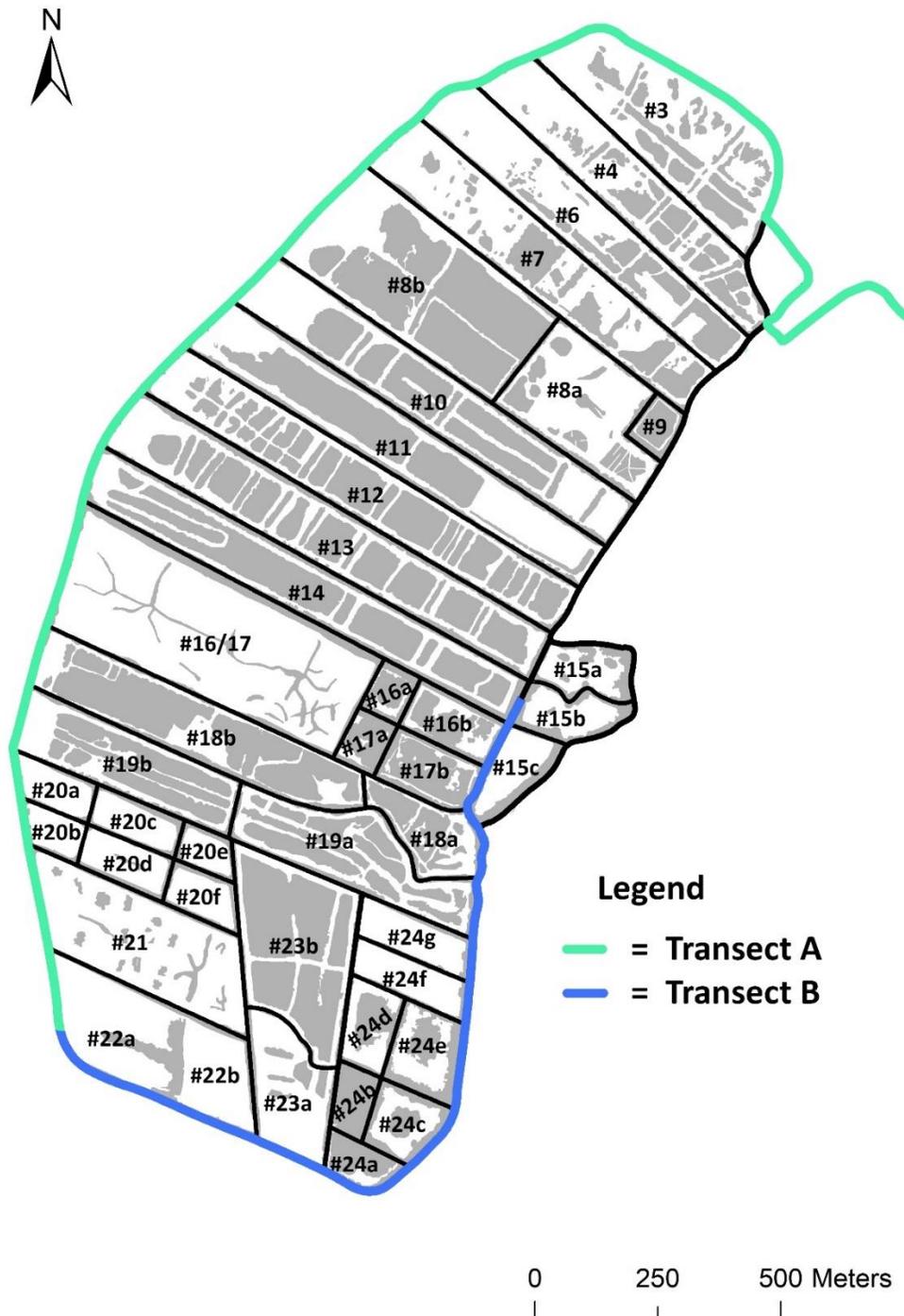
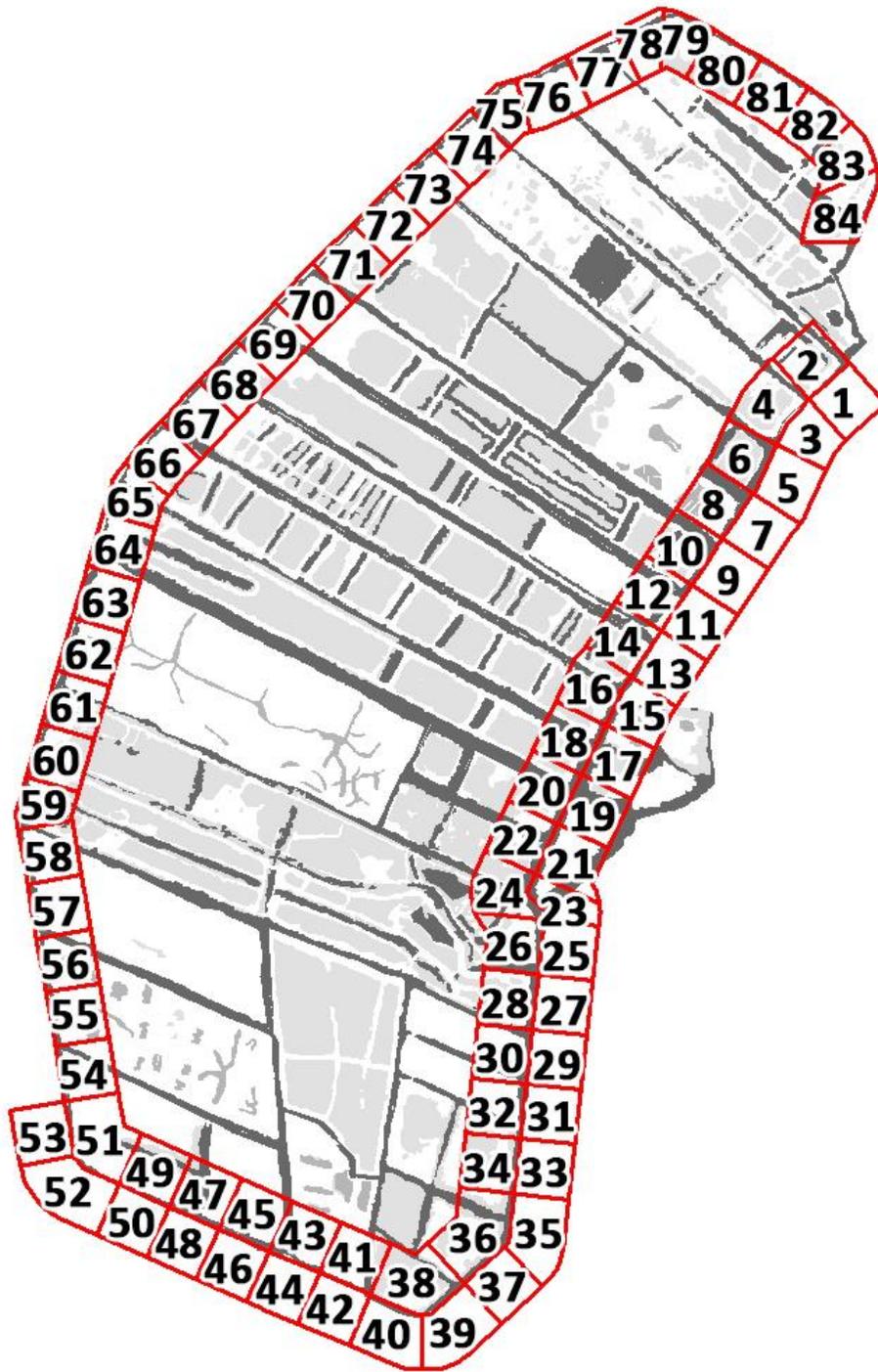


Figure FM12-2: Grid numbers along survey routes



FM13. Shrimp Harvest Recording

FEATURE	Shrimps in <i>gei wai</i>
PARAMETER(S)	Catch per unit effort (CPUE) of shrimps in <i>gei wai</i>
OBJECTIVE(S)	To monitor the amount of shrimp harvested in MPNR
BACKGROUND	<i>Gei wai</i> are maintained in MPNR as a traditional, sustainable practice of wetland management for aquaculture and an important habitat for wildlife in the Reserve. Every summer, shrimp harvesting tours are organized to demonstrate sustainable management and wise use principles of such traditional aquaculture practice to the public. Monitoring the harvest provides data on the productivity of the <i>gei wai</i> and helps to inform the management and sustainability of the <i>gei wai</i> .

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Shrimp harvesting tools 2. Torch (For lighting)
Sample site(s)	Traditionally-managed <i>gei wai</i> (#12-14, #18, #19) and any <i>gei wai</i> opened for shrimp harvesting
Sampling techniques	Samples shall be collected during shrimp harvesting tours. Following traditional harvesting technique, upon the opening of the sluice gate for shrimp harvest, shrimps are collected in the net placed at the gate of the <i>gei wai</i> as water flows out to the sea at low tide. Total weight of shrimp collected and duration of the catch shall be recorded.
Sampling time of year	May to August
Sampling time of day	Throughout shrimp collecting period during the shrimp harvesting tours (ie. 19:30-20:00)
Sampling frequency	Whenever shrimp harvesting tour takes place
No. of samples	Whenever shrimp harvesting tour takes place
Repeat Interval	Annually
Weather conditions	The recording should not start if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed according to the prevailing local conditions.

FM14. Dog count

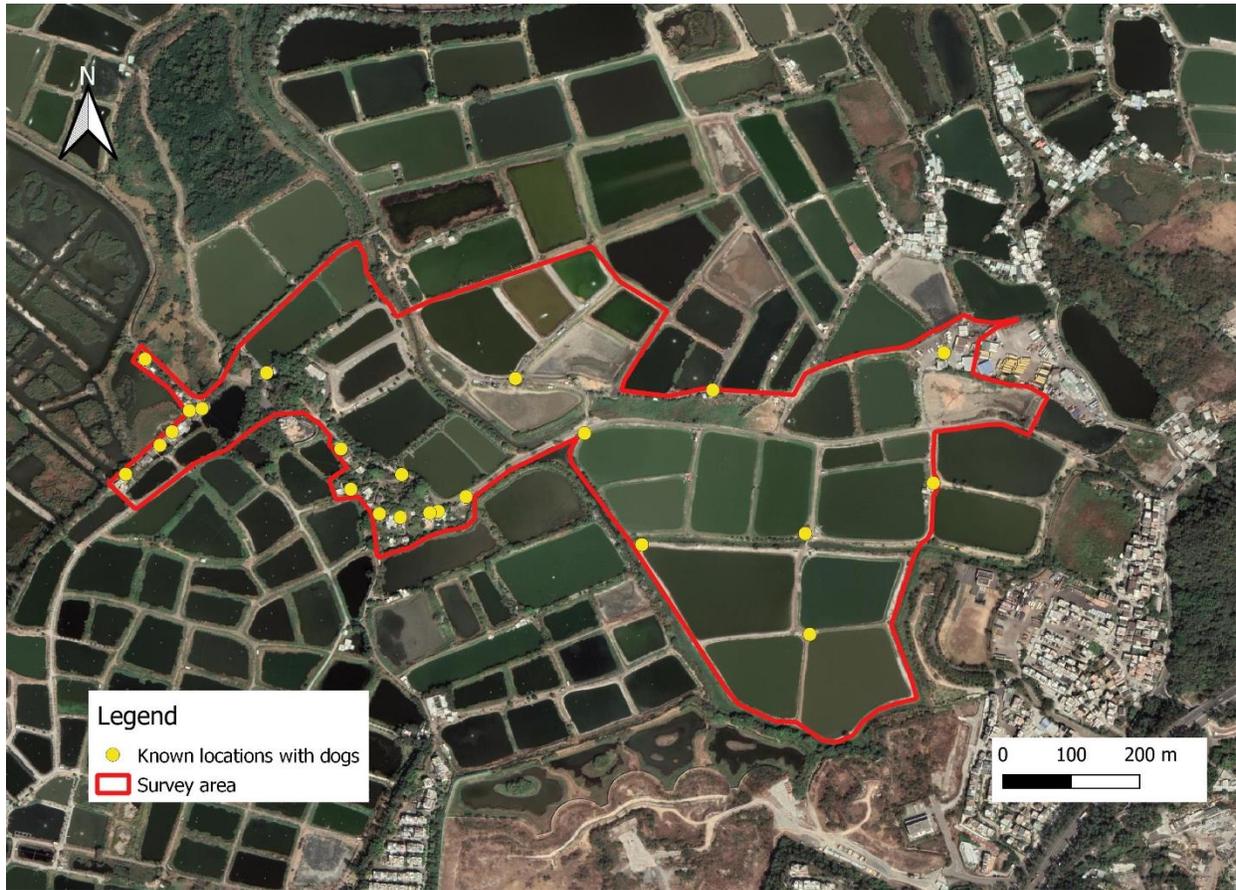
FEATURE	Dog
PARAMETERS	Number and distribution of dogs in the surrounding village and fishponds of MPNR.
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To monitor the dog numbers including both owned and unowned dogs in the surrounding village and fishponds of MPNR; 2. To facilitate dog management decisions by identifying new adult dogs and puppies in the area.
BACKGROUND	<p>Domestic dogs (<i>Canis lupus familiaris</i>) have been identified as an ongoing threat to wildlife in MPNR. With easily accessible food and shelters, fishponds around MPNR are favourable habitats for dogs to survive and reproduce. With low ownership awareness and irresponsible actions of local villagers and fishpond operators, and also ineffective regulation and enforcement, free-roaming dogs are frequently recorded in the fishponds and may enter MPNR from time to time. By regular monitoring of dogs through individual identification and communication with the locals, a greater understanding on the dog population, distribution and their ownership level around MPNR would allow formulation of better dog control measures and help inform dog management decisions in MPNR and the surrounding area.</p> <p>Dog counts would be carried out in areas outside MPNR as dog presence within MPNR would be noticed by staff or visitors. The Yeung's operating fishponds are also omitted from dog counts as dogs rarely linger in their area.</p>

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Binoculars (8x magnification or above) 2. Long lens camera 3. Paper with pen 4. Bicycle
Equipment (optional)	NA
Sampling site(s)	See Figure FM14-1 for survey area with usual records of dogs.
Sampling technique	<ol style="list-style-type: none"> 1. Surveyor should cycle along Tam Kon Chau Road and walk along fishpond bunds to check the fishpond areas and houses for dog presence based on existing knowledge of the dog distribution in the area. Information gathered by observation and communication with the locals during non-survey days could also be used to facilitate identifying new locations of dogs. 2. All dogs seen within the survey area shall be recorded with their locations as a group/ individual dog. Dogs seen together would be regarded as dogs associating in the same group. If new adult dogs or puppies are encountered, sex and neuter status would be assessed visually or by communication with the locals. Ownership would be checked with the fishpond operators or villagers nearby.

	<p>3. Photos of the dogs shall be taken for identifying individuals.</p> <p>4. Additional notes of the behavior of the dogs shall also be recorded to help identifying dog resting/feeding areas.</p>
Sampling time of year	All months of the year.
Sampling time of day	9:00-11:30
Sampling frequency	Once a month
No. of samples	12 survey per year
Repeat interval	Every year
Weather condition	<p>The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the surveyor should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count, the surveyor should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count.</p>

Figure FM14-1: Known locations of dogs in the survey area



Annex J2 - Environmental Monitoring (EM)

EM01. Water Quality

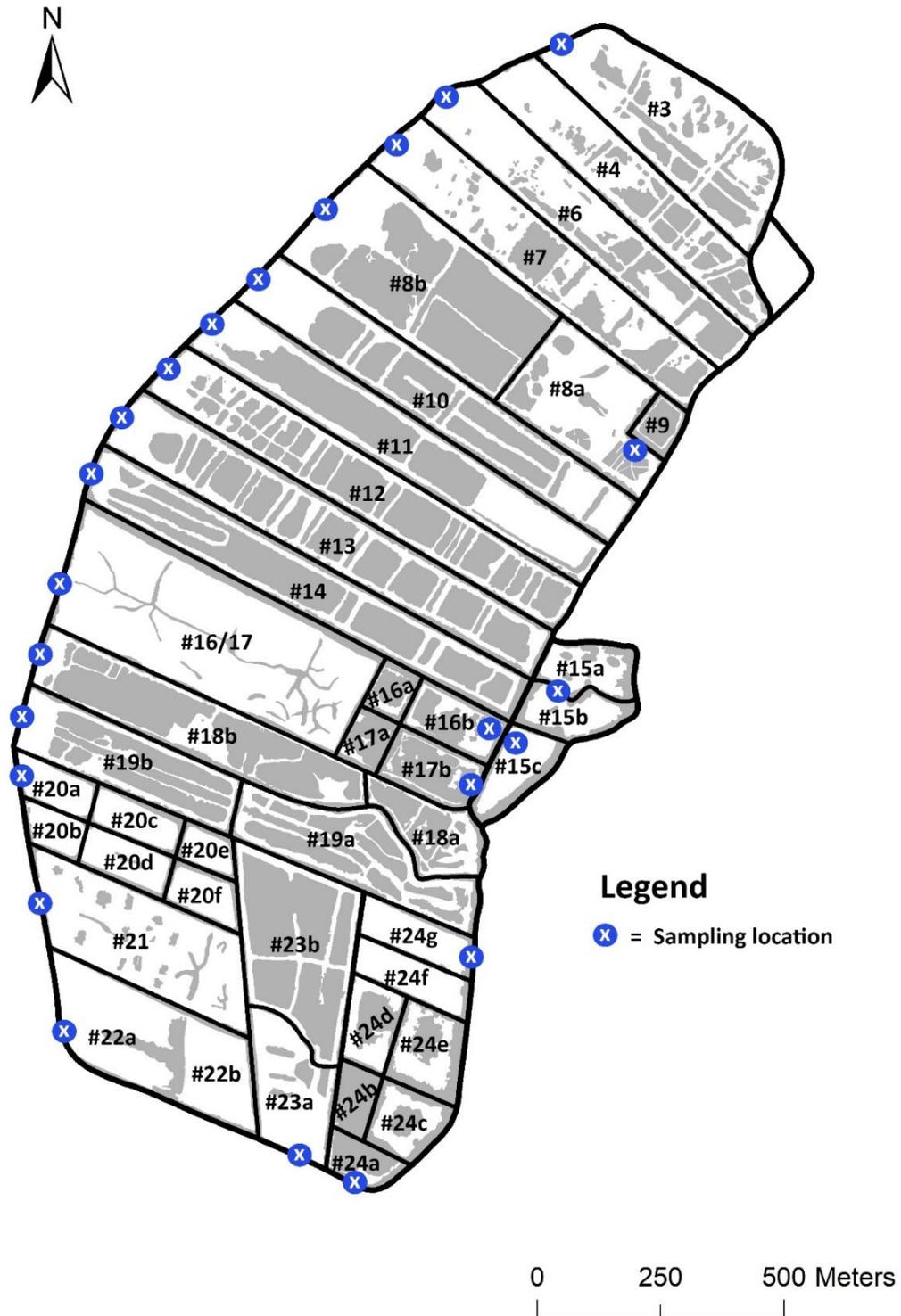
FEATURE	Water quality
PARAMETERS	Temperature Salinity pH Dissolved Oxygen Nitrates Phosphates Turbidity Chlorophyll-a Blue-green algae
OBJECTIVE(S)	To monitor water quality in MPNR.
BACKGROUND	<p>Water quality has a significant impact upon the life living within a waterbody, including plants and aquatic fauna, which can have further knock-on impacts to other species relying on a wetland. Regular testing of water quality is therefore beneficial in wetland management so that any changes can be identified early which may affect the ecology of the wetland, and action can be taken if this is considered necessary. Regular monitoring of water quality will help to inform management practices in each waterbody, including identifying any need for water exchange or pumping of water between rain-fed ponds.</p> <p>Water quality has been routinely monitored in most waterbodies of MPNR in recent years which form a baseline that can be used for future study of the interaction between water quality and site ecology.</p>

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Water quality probes for measuring temperature, salinity, pH, dissolved oxygen, turbidity, chlorophyll-a and blue-green algae. 2. Water quality test kit for nitrates and phosphates. 3. Clean bottles for collection of water samples.
Sampling site(s)	<p>Water quality locations distributed across the Reserve to represent brackish <i>gei wai</i>, brackish waterbird roosts and rain-fed ponds.</p> <p>See Figure EM01-1 for the sampling locations.</p>
Sampling technique	<p>Before any water quality sampling, the test machinery should be checked and calibrated according to manufacturer's instructions.</p> <p>Samples (for monitoring of nitrates and phosphates) should be collected in clean bottles, which should be rinsed with water from the <i>gei wai</i>/pond prior to sample collection. After sample collection, bottles should be allowed to stand for 1 minute to allow the release of trapped air.</p> <p><u>Temperature, Salinity, pH, dissolved oxygen, turbidity, chlorophyll-a and blue-green algae</u></p> <ol style="list-style-type: none"> 1. At each <i>gei wai</i>/ pond, the probe of the meter should be fully submerged while the parameters are recorded by the device. 2. Data should be collected from three replicate sampling points in each location. 3. Upon returning to the lab, all data from the water quality meter should be downloaded to computer for analysis. 4. The value for each <i>gei wai</i>/pond should be the mean of the three replicates. <p><u>Nitrates, Phosphates</u></p> <ol style="list-style-type: none"> 1. One sample shall be collected from each <i>gei wai</i>/pond. 2. Concentrations of nitrates and phosphates should be calculated according to the manufacturer's instruction for the test machine. <p>Any factors which might affect the measurement should be noted (e.g. draining, recent heavy rain)</p>
Sampling time of year	Throughout the year

Sampling time of day	Surveys should be conducted in the morning before 10 am.
Sampling frequency	Every second month (January, March, May, July, September, November)
No. of samples	Three replicates per waterbody for temperature, salinity, pH, dissolved oxygen, turbidity, chlorophyll-a and blue-green algae.
Repeat interval	Annually
Weather condition	<p>The survey should not be carried out during periods of heavy rainfall, when conditions may affect the water quality readings or may be unsafe for staff carrying out measurements.</p> <p>The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the survey, the recorder should decide to either continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey.</p> <p>If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable. If the survey has been partially completed but is abandoned, the remainder of the survey should be completed in the same timeslot on the first available date.</p>

Figure EM01-1: Water quality sampling locations



EM02. Habitat Monitoring

FEATURE	Habitat
PARAMETERS	<ol style="list-style-type: none"> 1. Distribution of habitats at MPNR. 2. Area of habitats at MPNR.
OBJECTIVE(S)	To provide information on the distribution and total area of each habitat type at MPNR for assessment of targets and to inform habitat management decisions.
BACKGROUND	<p>Mapping of MPNR is essential to calculate the total area of each habitat type present in each <i>gei wai</i>/pond and on the Reserve. This information is important for habitat management decisions, to determine whether a particular habitat is increasing or decreasing and to decide what changes should be made to maximise the ecological value of the reserve.</p> <p>Mapping also visualises the long-term changes of the habitats on the reserve, so that differences between years can be identified and management measures can be taken if required. Such long-term and gradual changes may not be readily visible by relying upon visual observation.</p>

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. ArcGIS 2. Up-to-date aerial photos covering the reserve
Sampling site(s)	Entire Reserve
Sampling technique	<ol style="list-style-type: none"> 1. Habitat mapping should initially be conducted from aerial photos by marking all discrete habitat patches using GIS software. Mapping should be carried out as accurately as possible using the aerial photographs available. Wherever possible, habitats should be assigned to a category (some categories may require ground-truthing). 2. Habitat categories to be mapped include: <ul style="list-style-type: none"> - Open brackish water - Open rain-fed area - Trees - Bund vegetation

	<ul style="list-style-type: none"> - Island - Reedbed - Mangroves - Emergent sedges - Waterlilies <i>Nymphaea</i> spp. - Other emergent vegetation <p>3. Once desk-top mapping has been completed, printed maps should be taken into the field for ground-truthing of existing conditions. Ground-truthing should cover the entire Reserve. During ground-truthing all habitats should be checked to see whether the desktop mapping is correct, and any habitat patches which could not be identified from the aerial photographs should be checked to confirm the appropriate habitat category.</p> <p>4. Desktop GIS maps should be updated to reflect the findings of the ground-truthing surveys.</p> <p>5. Areas of each habitat patch should be calculated using GIS software, and areas for each habitat should be summed for individual <i>gei wai</i> / ponds, and for the Reserve as a whole.</p>
Sampling time of year	Depend upon availability of aerial photos. Ground-truthing to be conducted during Jun – Aug to minimize disturbance to wintering waterbirds.
Sampling time of day	2021 and 2024 Ground-truthing should avoid high tide periods to minimize disturbance to roosting waterbirds.
Sampling frequency	Twice over the course of the Management Plan.
Weather condition	Aerial photos to be used should be clear from cloud. Ground-truthing can be conducted in any weather provided that visibility is suitable to see all habitats within each waterbody (periods of heavy rain and dense fog should be avoided).

EM03. Habitat Fixed Point Photography

FEATURE	Habitat
PARAMETERS	Habitat condition
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To monitor changes in degree of open landscape, habitat coverage and quality over time by generating a time series of photographs at the same locations in successive years; 2. To facilitate habitat management decisions by comparing changes in habitat quality over time.
BACKGROUND	<p>Changes to habitat distribution and quality generally take place over a time period of several years. Such gradual changes can be difficult to assess through visual inspection, as direct comparison between years is not possible.</p> <p>Fixed point photography creates a time series of photographs from the same location in each year, so that changes in habitats at that location can be monitored over a longer time period and habitat condition can be evaluated.</p>

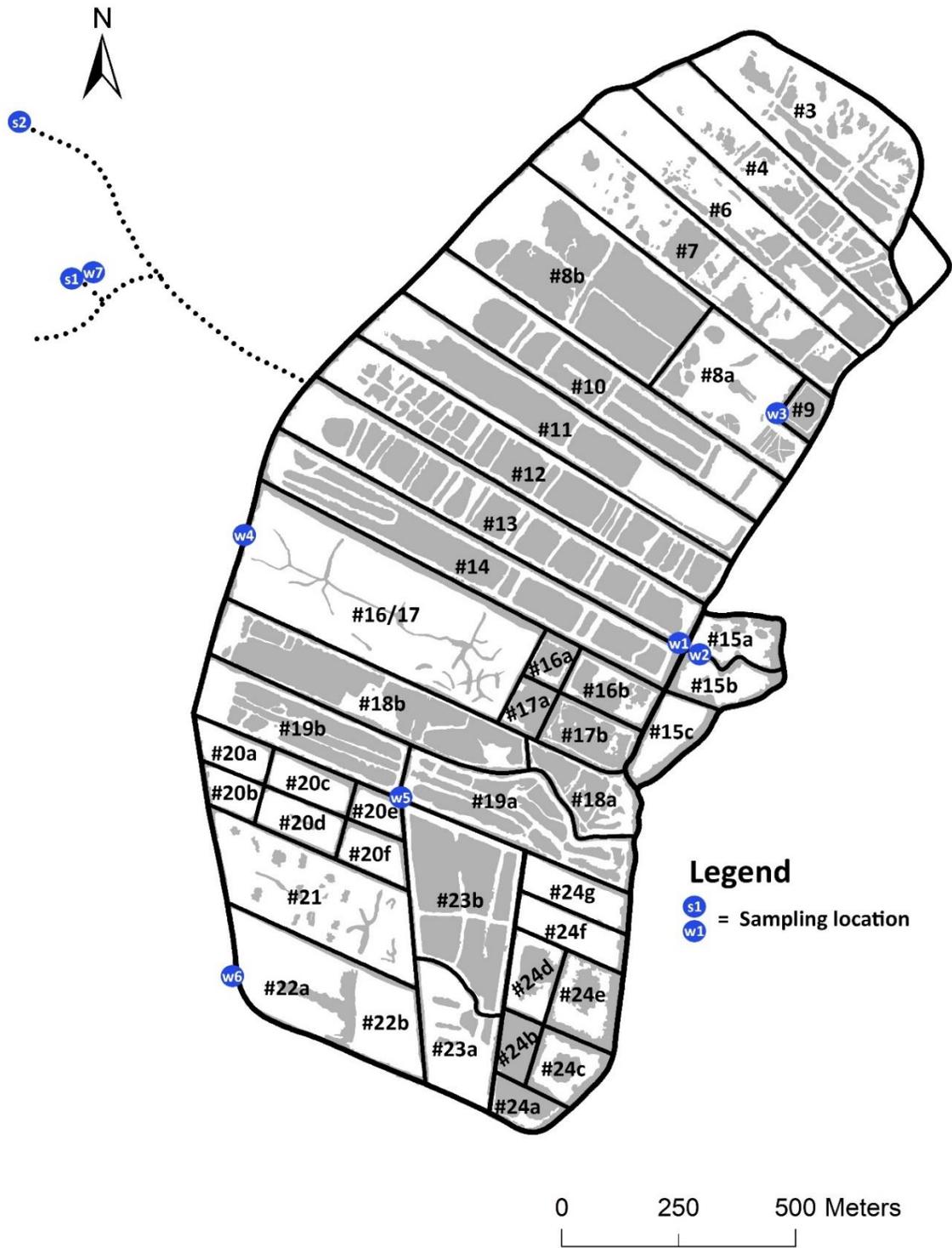
METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Digital camera
Sampling site(s)	<p><u>See Figure EM03-1 for all Fixed Point Photography locations.</u></p> <p><u>Winter set (Reserve and mudflat):</u></p> <p>W1. South-west corner at the roof of the Education Center - <i>Gei wai</i> #14 and beyond</p> <p>W2. South-east corner at the roof of the Education Center - Pond #15</p> <p>W3. Middle of the 1st window on the left at the top floor of the Tower Hide - Pond #8a and beyond</p> <p>W4. In front, at the middle of Hide #7</p>

	<p>- <i>Gei wai</i> #16/17</p> <p>W5. In front, at the middle of the new Tower Hide at #19/20 bund (2021 onwards)</p> <p>- Pond #20 and beyond</p> <p>W6. From the Tower at the helicopter pad at the southern end of MPNR</p> <p>- <i>Gei wai</i> #22 and beyond</p> <p>W7. In front, at the middle of the 3rd window on the right at the Rotary Floating Bird Hide</p> <p>- Intertidal mudflat</p> <p><u>Summer set (mudflat only):</u></p> <p>S1. In front, at the middle of the 3rd window on the right at the Jockey Club Floating Bird Hide</p> <p>- Intertidal mudflat</p> <p>S2. In front, at the middle of the Northern Floating Bird Hide</p> <p>- Intertidal mudflat</p>
<p>Sampling technique</p>	<ol style="list-style-type: none"> 1. All sampling sites listed should be visited and a panoramic photograph should be taken at each, facing in the direction specified for each sampling site. 2. In most locations a clear view is already present. If vegetation obscures the view, some may be removed, but this should be kept to a minimum, and should be confined to essential clearance in the immediate surroundings of the photographer only to provide a view of the location being photographed, 3. Care should be taken to minimize disturbance to waterbirds and to visitors to the Reserve. 4. Panoramic photographs should be taken.
<p>Sampling time of year</p>	<p>Winter set: first or second week of December</p> <p>Summer set: second or third week of July</p>
<p>Sampling time of day</p>	<p>Photographs should not be taken early or late in the day, when the sun is low to the horizon.</p> <p>Mudflat photographs should be taken at low tide (<1.6m) to minimize disturbance to waterbirds and to ensure that vegetation on the mudflat is visible. Photographs at roost sites (especially W4 at <i>Gei wai</i> #16/17) should also be taken at low tide, to minimize disturbance to roosting waterbirds.</p>

Sampling frequency	Every second year: Dec-2019, 2021, 2023
No. of samples	One photograph from each of the survey locations.
Repeat interval	Every second year.
Weather condition	<p>Sampling should be carried out on clear, sunny days. On no account should the survey be carried out when visibility is poor (for example torrential rain or dense fog).</p> <p>If weather forces the cancellation of sampling (for example, onset of heavy rain), that survey should be rescheduled for the first available date when weather conditions are suitable.</p>

Figure EM03-1: Photo-taking locations



EM04. Water Channel Depth

FEATURE	Water depth
PARAMETERS	Water depth in <i>gei wai</i> channels
OBJECTIVE(S)	To monitor water depth in <i>gei wai</i> channels so that channels requiring dredging can be identified as early as possible.
BACKGROUND	Sediment is imported into the <i>gei wai</i> on a regular basis, resulting in the gradual siltation of the channels within the <i>gei wai</i> . As the channels become shallower, this affects the rate of water exchange and leads to problems with water quality and shrimp productivity within the <i>gei wai</i> . <i>Gei wai</i> channels require dredging approximately every 10-15 years to maintain a suitable depth. Monitoring of water depth in these channels will help to identify which are becoming shallow and are most in need to dredging, so that this can be planned accordingly. The target level is set as 60cm, and the aim of the monitoring is to identify areas shallower than this depth, therefore the survey methodology identifies water less than 60cm, rather than measuring actual depth throughout the <i>gei wai</i> .
MANAGEMENT PLAN TARGETS	Water depth of <i>gei wai</i> channel shall be greater than 60 cm.

METHODOLOGY

Equipment (essential)	Habitat map of each <i>gei wai</i> .
Equipment (optional)	Unmanned aerial vehicle
Sampling site(s)	All brackish <i>gei wai</i> and brackish waterbird roosts at MPNR (<i>Gei wai</i> #3, #4, #6, #7, #8b, #10, #11, #12, #13, #14, #16/17, #18, #19, #21, #22, #23a).

Sampling technique	Water level should be lowered to 60 cm below normal operation level and allowed to stabilize over the course of 24 hours. Area covered by water should be estimated and mapped for the entire <i>gei wai</i> .
Sampling time of year	Conducted during May-July to minimize disturbance to wintering waterbirds.
Sampling time of day	Survey should be conducted in late morning/early afternoon to minimize disturbance to waterbirds feeding in <i>gei wai</i> during early morning and evening.
Sampling frequency	Each <i>gei wai</i> to be surveyed once during 2019-2024 (surveys scheduled to be conducted in 2024).
No. of samples	One
Repeat interval	Every five years
Weather condition	<p>Surveys should avoid periods of rainfall when possible to avoid potential influence of heavy rain on survey methodology.</p> <p>The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count.</p> <p>If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable. If the survey has been partially completed but is abandoned, the remainder of the survey should be completed in the same timeslot on the first available date.</p>

EM05. Reedbed Monitoring

FEATURE	Reedbed
PARAMETERS	Reedbed coverage and quality
OBJECTIVE(S)	<ol style="list-style-type: none"> 1. To monitor changes of reedbed area and health condition over time by generating a time series of photographs at the same locations; 2. To facilitate habitat management decisions by comparing changes in reedbed condition over time.
BACKGROUND	To ensure reedbeds in the designated areas are maintained in good condition while the spreading of reed in non-reedbed designated areas is under control, close monitoring on the reedbed coverage and quality is needed. Since areas with reedbed are not always easily assessable on foot, aerial photographs shall be taken at fixed points to facilitate comparison of changes over time. If reedbed condition is not ideal, follow-up actions, such as die-off evaluation study, would be done case-by-case.
MANAGEMENT PLAN HABITAT CONDITION WHICH REQUIRE MONITORING	Reed health condition in BMZ 2 (gei wai #8b, #9, #10, #11b, #23b) and gei wai #12 and #14, and spreading of reed in other areas of the Reserve

METHODOLOGY

Equipment (essential)	<ol style="list-style-type: none"> 1. Unmanned aerial vehicle (DJI Phantom 4 Pro V2) 2. At least 3 batteries of the drone 3. Ipad with DJI app to help control the drone
Equipment (optional)	NA
Sampling site(s)	<p><u>See Figure EM05-1 for the survey areas.</u></p> <p><u>Health condition of specific reedbed</u> Only the areas designated for reedbed conservation or research shall be surveyed, that includes reedbed in BMZ2 (gei wai #8b, #9, #10, #11b, #23b), gei wai#12 and gei wai#14. See Figure EM05-2 for the flight path and assessment of October shall use the same set of drone photos from reedbed spreading survey.</p> <p><u>Reedbed spreading in entire Reserve</u> The whole Reserve shall be surveyed. See Figure EM05-3 for the flight path.</p>
Sampling technique	<ol style="list-style-type: none"> 1. Photographs should be taken by drone at 90m above ground with the route and photo-taking locations being set in the associated DJI app. 2. The same route and photo-taking locations shall be used every survey.

Sampling time of year	<p><u>Health condition of specific reedbed</u> 1st January-31st December with assessment of October using the same set of drone photos from reedbed spreading survey.</p> <p><u>Reedbed spreading in entire Reserve</u> For monitoring overall reedbed condition in the Reserve, surveying after the annual habitat works have been finished is preferred (i.e. October) so that the management work results could also be recorded.</p>
Sampling time of day	<p>Photographs should be taken at low tide (<1.3m) to minimize potential disturbance to waterbirds.</p> <p>Early morning or late evening is not preferred to avoid long shadow of vegetation.</p>
Sampling frequency	<p><u>Health condition of specific reedbeds</u> Every month with assessment of October using the same set of drone photos from reedbed spreading survey.</p> <p><u>Reedbed spreading in the entire Reserve</u> 1 survey per year</p>
No. of samples	<p><u>Health condition of specific reedbeds</u> 11 surveys using the flight path in Figure 1 per year with assessment of October using the same set of drone photos from reedbed spreading survey.</p> <p><u>Reedbed spreading in the entire Reserve</u> 1 survey per year</p>
Repeat interval	Every year
Weather condition	<p>Surveys should be carried out on non-raining days when wind speed is below 10 m/s (for DJI Phantom 4 Pro V2). On no account should the survey be carried out when visibility is poor (e.g. rain or dense fog).</p> <p>The drone should not be operated if Rainstorm Warning, Tropical Cyclone Warning or Strong Monsoon Signal is in force. In case of thunderstorm warning, the surveyor should decide whether to proceed with the survey according to the prevailing local conditions.</p> <p>If weather forces the cancellation of any survey (for example, onset of rain or strong wind), that survey should be rescheduled for the first available date when weather conditions are suitable. If the survey has been partially completed but is abandoned, the remainder of the survey should be completed on the first available date.</p>

DATA MANAGEMENT

Data format	<ol style="list-style-type: none"> 1. Digital photographs in JPEG format. 2. Polygons of reed shall be drawn in ArcGIS/QGIS and saved in shapefiles. 3. For spreading of reedbed in the Reserve, orthophotos shall be prepared using appropriate formatting software (e.g. Pix4D mapper).
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Location of data	All photographs and shapefiles are stored in the “Research and Monitoring Share” under the Mai Po Server.
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Figure EM05-1: Areas for monitoring the health condition of specific reedbeds (in orange) and spreading of reedbeds (in green)

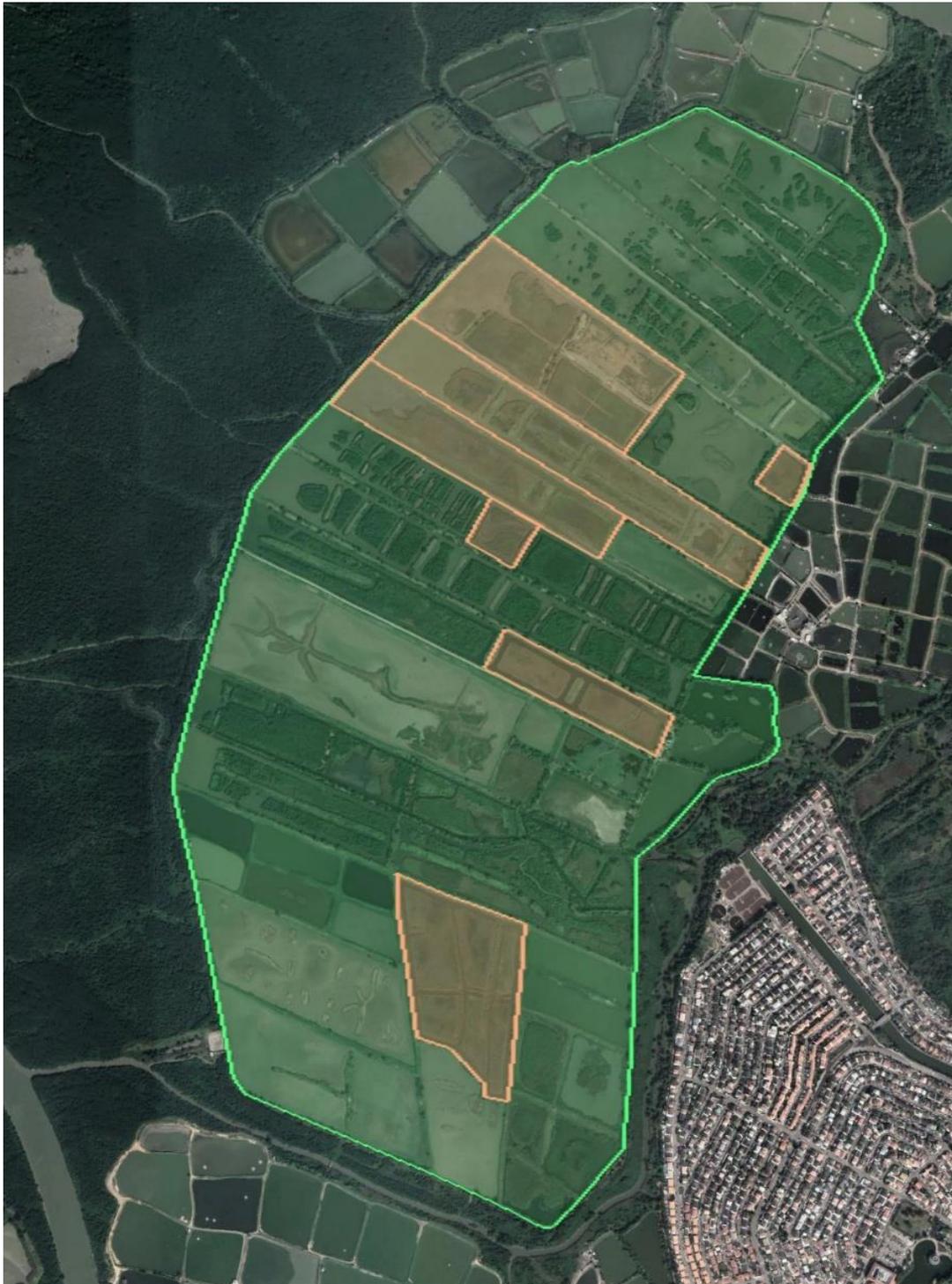


Figure EM05-2: Flight path for monitoring the health condition of specific reedbeds (areas to be covered are in blue and drone paths are in green)

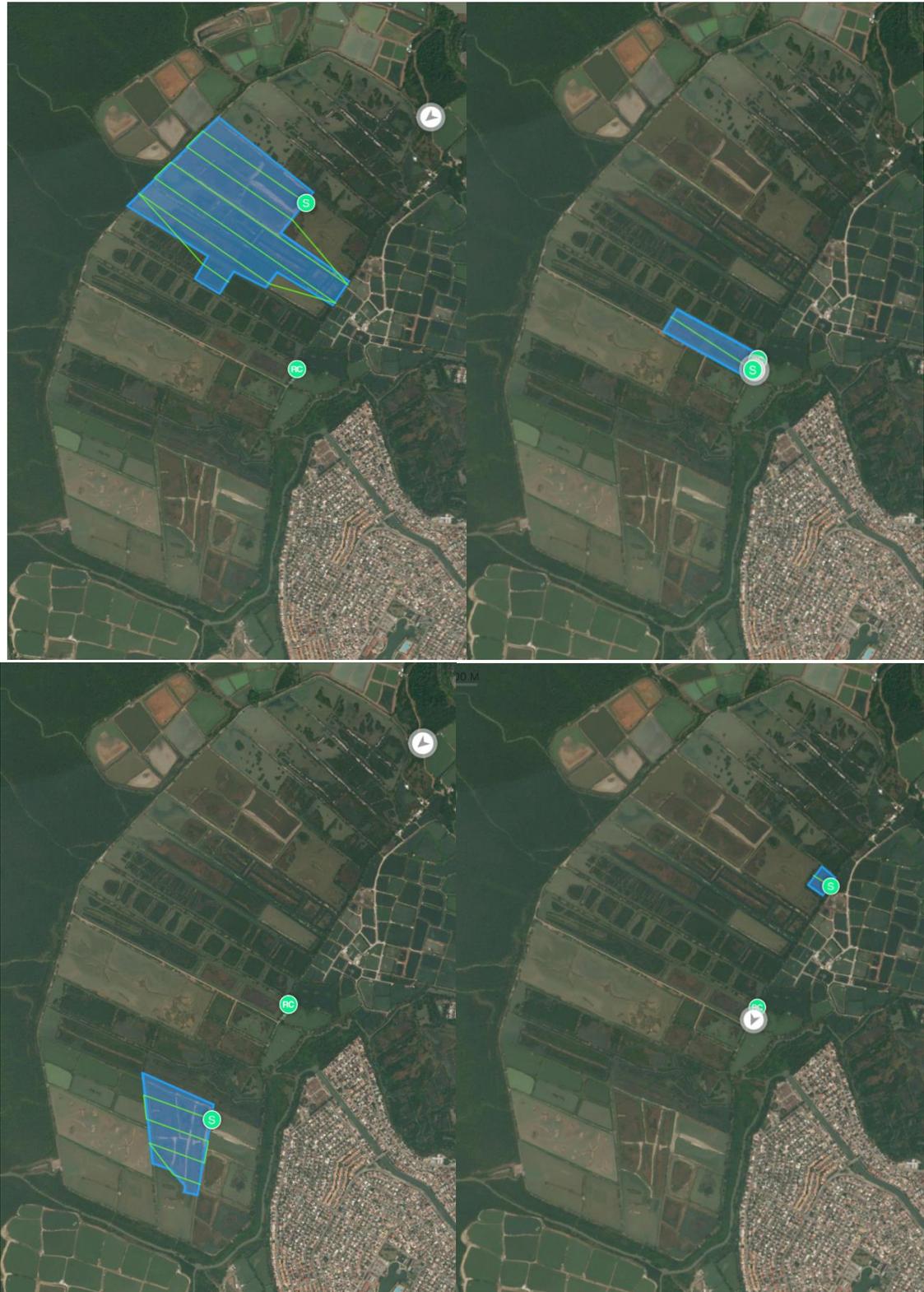


Figure EM04-3: Flight path for monitoring the spreading of reedbed in entire Reserve
(areas to be covered are in blue and drone paths are in green)

