Cross Island Line

Discussion and Position Paper

The Cross Island Line is proposed to pass through the southern section of the Central Catchment Nature Reserve. The purpose of nature reserves is for the conservation of native flora and fauna, they should not to be seen as vacant State land through which transport corridors may be placed. The Nature Society believes that engineering investigation and construction works for the Cross Island Line will severely degrade pristine habitats within the nature reserve and recommends that the design alignment be adjusted to avoid crossing the reserve.

18 July 2013
Front cover: Rainforest stream within the MacRitchie Forest.
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In February 2013 the Singapore Government released the Population White Paper\(^1\) and along with it proposed a new 50 km MRT service known as the Cross Island Line (CRL)\(^2\) that connects Tampines with Jurong and passing through the Central Catchment Nature Reserve (CCNR) near the MacRitchie Reservoir. The Nature Society (Singapore) argues that the alignment should not pass through the CCNR or the Bukit Timah Nature Reserve (BTNR) due to the potential for damage to highly valued ecosystems due to soil investigation and other associated engineering works. This discussion and position paper explains the reasons for the NSS adopting this position and proposes an alternative southern route.

1 Executive Summary
The Nature Society (Singapore) objects to the use of nature reserve for transport infrastructure as proposed by the Land Transport Agency (LTA) with respect to the CRL. Our opinion is that nature reserves have been gazetted for a clear reason and that is for the conservation of fauna and flora. The nature reserve should not be treated as vacant State land available to be used for the convenience of transport infrastructure or other purposes. Such usage would be against the spirit and intention of the both the Parks and Trees Act and National Parks Board Act and most importantly is counter to public trust doctrine that holds that the Government has an obligation to hold and use public land on trust for the citizens and as trustees it has a moral (if not fiduciary) duty to use land in accordance with its intended purposes.

While the CRL is intended as an underground corridor our greatest concerns are related to degradation of the forest habitats due to soil investigation and other related engineering works that will be required on the surface. The surface works are expected to result in clearing of forest, compaction of soils along the length of the CRL alignment, toxic material spillage, erosion and siltation due to excavations resulting in serious damage to if not complete loss of one of the most pristine stream ecosystems within the CCNR.

Our fragmented forest habitats cover some 20 km\(^2\) of the BTNR and CCNR (excluding reservoirs and special use areas) and are made up of 2 km\(^2\) of Primary Dipterocarp forest or 0.5% of original primeval coverage, 1.2 km\(^2\) of wetland forest or 1.7% of original primeval coverage with the remaining 16.8 km\(^2\) represented by regrowth forests ranging in age from 100-150 years. With such great losses of primary forest habitat over the past 200 years it is absolutely essential that we maintain a zero-tolerance stance against developments that negatively affect these habitats. Almost our entire remaining native flora is represented within 3.2 km\(^2\) of primary dipterocarp and wetland forests. All remaining forest dependent fauna is represented within these primary forest fragments as well as the mature regrowth forests which have recovered sufficiently in the past 50 years to support the expansion of fauna into these areas. Managing genetic diversity of flora and fauna across this complex and fragmented landscape against an ever increasing recreational demand due to population growth is a significant challenge for the National Parks Board (NParks).

Building a transport corridor through the nature reserve is not without cost, ecosystem and services valuations need to be properly accounted for in the overall cost analysis of the project in the same way that commercial or residential property acquisition is considered within the cost analysis for such a project. Ecosystems such as those under threat by the CRL are generally valued at their replacement cost. Given the limited available land opportunity and our limited technical ability to duplicate these unique habitats, the cost of ecosystem and ecosystem services lost due to such a project can be expected to dwarf the acquisition of alienated property of comparable land area.

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Nature Society (Singapore)
The Nature Society recommends an alternate route that passes around the nature reserve to the south via Lornie Road which we estimate would add an extra four minutes of travel time only. The diversion of transport systems to avoid nature reserves is not without precedent and we cite two specific cases in our discussion.

2 Cross-Island Line Proposal

The Alignment proposed by the LTA is indicated on a map titled Rail Network Expansions under Land Transport Master Plan 2013 and passes through approximately 1km of nature reserve from the west beginning at the Singapore Island Country Club (Bukit Location) to the east in the vicinity of the Venus Drive.

Figure 1 – Cross Island Line derived from Land Transport Master Plan 2013

LTA Transport engineers have indicated\(^3\) that due to the variability of below surface geology it will be necessary to undertake soil investigations that involve the drilling of core bore samples at regular intervals along the proposed CRL alignment.

When the proposed alignment obtained from the LTMP 2013 is superimposed on a map of the Central Catchment Nature Reserve we find not only that it passes through some of the oldest regrowth forest in Singapore, it also passes through two patches of primary forest and fully within four stream systems, some of which are the most pristine on the island.

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\(^3\) Straits Times 6 May 2013, “50 km Tampines-Jurong MRT route runs deeper underground: LTA”
NSS Position and Reasoning

The Nature Society (Singapore) supports the reasonably planned economic development of Singapore including the development of transport, housing and industrial infrastructure providing this is undertaken in a way that does not unduly impact the important natural resources or protected habitats. Nature Reserves in particular should be considered off-limits for all development activities.

In the case of the CRL the NSS is opposed to the alignment crossing Nature Reserves as it will have a detrimental impact on natural habitats and biodiversity for which the Nature Reserves are meant to protect. We also believe that a viable alternative route to the south is available that does not transit lands gazetted as Nature Reserve.

The proposed alignment passes through an area of 150 year old regrowth forest containing a significant proportion of Singapore’s remaining primary lowland Dipterocarp Forest and including one of Singapore’s two most pristine rainforest stream systems. This area which we refer to as the MacRitchie forests represents some of our best natural habitat and is known to be rich in biodiversity as a result of fauna and flora surveys undertaken by NSS and NParks over the past 20 years.

It is the position of the Nature Society that soil investigation activities involving the core drilling of 70 metre deep bore holes along the alignment will cause tremendous permanent damage to the habitat including:

- Loss of flora and soil disturbance due to access roads required for placement of equipment;
- Excavation of working platforms for equipment along with batters (excavated slopes on the uphill side of platforms) will result in an almost continuous linear fragmentation of the habitat along the proposed alignment of the CRL;
- Top soil will be transported from areas of disturbance into the stream system during rain events. The pollution of stream systems will result in loss of rare flora and fauna that rely on these specific micro-habitats;
- Once the surface is broken through soil investigation activities, future erosion risk is very high;
- The Nature Reserves are already severely fragmented – further fragmentation cannot be accommodated;
- Risk of contamination of soil and streams by toxic materials used during drilling (diesel, lubricating oils and drilling slurry). Should these materials escape into the environment they will be severely detrimental to the health of the habitat;
- Human invasion of habitat will be detrimental to fauna. The area through which the proposed alignment passes is designated as a core zone, members of the public are not permitted to enter this area due to the uniqueness and sensitivity of habitat.

While mitigation options may be proposed, none can completely resolve the risks of damage anticipated due to soil investigations and impact will be significant and undesirable. Mitigation techniques would additionally contribute to loss of habitat due to the extra space required. The Nature Society views mitigation and impact as two completely different matters; mitigation does not equal no impact.

The following sections of this discussion paper provide the reader with a more detailed understanding of the forest habitats of the CCNR including development history, geology, flora and fauna followed by discussion of the specific risks that CRL construction activities pose for the nature reserve.

Nature Society (Singapore)
4 Geography and Biodiversity of the Central Nature Reserves

4.1 Land Development and Habitat Loss on Singapore Island

Starting with some 410 km$^2$ of primary dipterocarp forest prior to settlement during the early 19th century we are now left with 2km$^2$ consisting of a number of small isolated patches. These patches of primary forest represent almost our entire native flora and much of our forest dependent fauna. We cannot afford to lose any more.

Over the past 200 years Singapore’s natural environment has been subjected to and affected by several different land uses, land management practices and population pressures. During the 19th century Gambier and Pepper planters almost completely destroyed the entire 410 km$^2$ of Primary Dipterocarp forest covering the island. Increasing population on the island resulted in high demand for firewood and food resulting in the logging of mangrove forests for firewood and the conversion of wetland forests for seasonal crops such as rice, pineapple, cotton and sugarcane. By 1867 construction of the Impounding Reservoir (later renamed to MacRitchie Reservoir) had been completed in response to increasing demand for water and along with it a Municipal Catchment area for the preservation of water quality was gazetted. This was the first time that a significant amount of forest had been formally reserved and it was generally referred to at that time as the Reservoir Jungle.

By the year 1884 Nathaniel Cantley, working under instructions from Governor Weld established fifteen Forest Reserves over what was considered the best remaining productive native forest stands on the island. The boundaries of these reserves were drawn to encompass as much of the remaining fragments of native dipterocarp forest that remained at that time and which were not already alienated. Out of 15 original forest reserves established by Cantley, the Bukit Timah and Chan Chu Kang Forest reserves along with the Reservoir Jungle were responsible for conserving the remaining primary forest fragments that we now find within the CCNR and BTNR today.

The map (Figure 2) and Table 1 below demonstrate the magnitude of losses of primary forest habitat sustained over the past 200 years.

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4 Nathaniel Cantley was the second Superintendent of the Singapore Botanic Gardens, he was tasked by Governor Sir F.A. Weld to establish forest reserves for the purpose of conserving and managing the remaining state forest resources.

5 Some areas of primary forest that were within current leases such as those within the Chasseriau Estate could not be included.
### Table 1 – Comparison of total forest losses over past 200 years

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Total Primeval Coverage (km²)</th>
<th>Remaining Coverage (km²)</th>
<th>Remaining Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry land Primary Forest</td>
<td>410</td>
<td>2.01</td>
<td>0.49%</td>
</tr>
<tr>
<td>Wetland (freshwater) forest</td>
<td>74</td>
<td>1.22</td>
<td>1.65%</td>
</tr>
<tr>
<td>Mangrove Forest</td>
<td>87</td>
<td>5.7</td>
<td>6.55%</td>
</tr>
</tbody>
</table>

At the time of maximum forest clearance about the turn of the 19th century, much of our larger native fauna such as Tigers, leopards, Hornbills etc. became extinct while the smaller reptiles, birds and mammals have managed to “hang on by their fingernails” in the small patches of primary forest remaining. These populations face risk of extinction due to their small size and the fact that they are separated from each other due to the fragmented nature of the forest habitat. As such even small disturbances could result in disastrous losses of large proportions of our remaining fauna.

#### 4.2 The Central Catchment Nature Reserve

Towards the end of the 19th century, the Kalang and Seletar reservoirs were on the drawing boards and by 1901 a Municipal Catchment Reserve was declared covering the watersheds of the Seletar and Kalang rivers as well as the Reservoir Jungle which surrounded the MacRitchie Reservoir. All agricultural activity within the catchment area ceased at this time and pioneer species of plants began to reestablish themselves in the former agricultural areas.

In 1951, the total area of the municipal catchment was declared as the Central Catchment Nature Reserve and the management of natural resources was placed into the care of the newly formed National Parks Board. The Bukit Timah Forest Reserve became Nature Reserve at the same time. In 1967 the original Seletar Reservoir was increased to its present day size (and later renamed to Upper Seletar Reservoir) and in the mid 1970's the Upper Pierce Reservoir was constructed immediately above the Kalang (now Lower Peirce) Reservoir. While both of these reservoir projects were responsible for destruction of a substantial amount of the remaining primary wetland forest habitat, as well as significantly contributing to further fragmentation of the central catchment forests, they also facilitated the continued preservation of the only remaining primary dipterocarp forest fragments. Figure 4 below illustrates the patchwork of different forest types that make up the Central Catchment and Bukit Timah Nature Reserves.

Today the remaining primary dry land dipterocarp (0.49% of original) and wetland forests (1.65% of original) are fully enclosed within the BTNR and CCNR.

#### 4.2.1 Vegetation of the Central Nature Reserves

The primary forest patches are scattered in small clusters throughout the forests of the BTNR and CCNR. Regrowth forests have recovered to the point where they can support a range of native forest dependent fauna. We cannot afford to risk the loss of any primary forest nor interfere with the continued progression of the regrowth forests to higher levels of biodiversity.

The vegetation of the BTNR and CCNR is not one contiguous patch of jungle, rather it is a patchwork of different vegetation types that range from primeval dry land dipterocarp and wetland forest through different grades of regrowth forest to Resam Fern (*Dicranopteris linearis*) areas featuring sparse tree cover. The proportions of these forest types are illustrated in Figure 3 below.

For our purpose we classify the vegetation types as follows:

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NSS Discussion & Position Paper - Cross Island Line

Primary Forest

This class represents the species rich dry lowland and coastal hill dipterocarp forest that covered much of the island prior to development beginning in the early 19th century. Typically areas classified as Primary Forest have never been subject to any agricultural activities, however it is possible they could have been previously logged or exploited for firewood during the 19th century and as such some may be devoid of the large emergent trees that we associate with primeval forests. The continuity of forest occurrence on these sites however results in a richer flora than even the oldest regrowth forests.

Wetland Forest

Wetland Forest is a distinct habitat that is either permanently or occasionally inundated and is typically found in the flat alluvial plains of our drainage system. The species found in these forests is restricted to those that can thrive in these conditions. It is thought that some 600 species (approximately 30% of the flora) can be found in wetland forests with 400 species shared with the dry land forest, and an estimated 200 species that are endemic to the wetland habit. Some of the wetland species have special adaptions to this unique habitat featuring one or more adaptions such as floating fruits, complex stilt roots or plank buttresses for stability in the soft ground, and pneumatophoric roots for gas exchange in stagnant and waterlogged soils. The largest contiguous area of wetland forest is found inside the CCNR and is generally known as the Nee Soon Freshwater Swamp Forest. There are also small remnant patches of swamp forest within the streams about the edges of the reservoirs. Outside the CCNR most wetland forest had been converted for seasonal crops during the 19th and early part of the 20th centuries. Urbanization and associated canalization have further obliterated almost all of the remaining wetland forests outside the nature reserves.

Regrowth Forest A

This forest type is typically 100-150 year old regrowth forest most of which has reasonably diverse species makeup and with fully grown trees. It is thought that these forests occur in areas associated with gambier and pepper plantations during the early 19th century.

Regrowth Forest B

This is species poor forest, typically Tiup Tiup (Adinandra dumosa), Cicada Tree (Ploarium alternifolia) and Silverback (Rodamnia cinerea) and a limited number of other hardy species (Macaranga spp and Elaeocarpus spp) that are able to grow on poor soils. It is thought that these forests are the result of recent agriculture and or denuded soils resulting from earlier intensive agricultural practices.

Resam

Some areas of the reserves are covered in Resam Fern (Dicranopteris linearis) as a result of intensive agriculture involving Tapioca and Liberian coffee plantations dating from the later part of the 19th century. These Resam areas also feature a sparse tree population. It is thought that these areas do not represent a normal regeneration situation and it is hoped that over time these may be reforested.

Wetland Marsh

The most significant wetland marsh occurs at the head of the MacRitchie reservoir. This area is thought to have been previously forested (as wetland forest) however cleared and channeled as a result of the Kalang Tunnel project in the late 1800's.

The total area delimited by BTNR and CCNR boundaries is estimated at 3205 ha. Out of this areas classified as Reservoir, Non-forest, Wetland Marsh and Resam account for 1195ha (37%) leaving 2010 ha (63%) of regrowth, wetland and primary forest. Primary forest and wetland forest habitat account for 322 ha (10%) of the total area delimited by Nature reserve boundaries while Regeneration forest accounts for 1688 ha (52%) of the whole reserve. These proportions are illustrated below in Figure 3.
Figure 3 – Proportions and areas (rounded to nearest hectare) of vegetation types of the BTN and CCNR.

Since the point of maximum clearance about the turn of the 19th century, regrowth forests have fared well within the nature reserves however they remain floristically impoverished compared to primary forests. The factors contributing to this situation include inability of major forest species such as the dipterocarps to distribute seeds outwards into the regrowth forests as well as loss of seed dispersal agents (birds, mammals, fish) due to extinctions. The mature regrowth forests that surround the primary forest fragments are critically important for protecting them from detrimental edge effects. Exposed primary forest is subject to humidity loss and this in turn causes demonstrable deterioration of the primary forest habitat. In turn the regrowth forests have the best chance of recovery when they are adjacent to primary forest patches due to the greater opportunity for dispersal of seeds compared to isolated secondary forests.

The highest conservation priority must be given to the remaining primary forests which support most of the remaining native flora, as well as to the mature regeneration forests with which they are surrounded. Non-forested or poorly forested areas should be reforested.6

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Figure 4 – Vegetation Types and other significant aerial features of the Central Nature Reserves
4.2.2 Fragmentation of the CCNR

Fragmentation has resulted in isolated patches of high biodiversity within the nature reserves resulting in the risk of genetic degradation of individual clusters of flora and fauna. The extant mature secondary forests are essential spaces into which the isolated clusters of flora and fauna may extend. Secondary Forests are not second class habitats and need to be protected to the same degree as primary forests.

The forest cover of the CCNR is not homogeneous, rather it is a patchwork of different forest types resulting from land use and management practices since the 19th century. In addition to this the contiguity of forest cover is broken by reservoirs, pipelines, sealed roads, military facilities and security fences resulting in 24 fragments. This fragmentation limits the ability of species to distribute themselves naturally throughout the reserve resulting in islands of high biodiversity in primary forest areas interspersed with regrowth areas featuring lower biodiversity. As a result of sound habitat management practices over the past half-decade we are now able to observe significant increase in the quality of regrowth forests within the reserves and indications that some fauna groups are starting to expand their occupation zones outwards from the primary forest areas. Evidence of improved habitat quality is demonstrated with the significant expansion of range of the Banded Leaf Monkey (Presbytis femoralis femoralis), formerly restricted to the primary wetland forests near Upper Seletar Reservoir. As a result of the Nature Reserves Fauna surveys (2010) increased numbers of Slow Loris (Nycticebus coucang), and two species of flying squirrel (Hylopetes spadiceus and Iomys horsfieldii) were observed in greater numbers in regrowth forest areas.

The map in Figure 5 below illustrates the extent of hard fragmentation zones, those that are delimited by impervious or near impervious features such as water bodies, water supply infrastructure, military facilities, security fences, expressways and sealed roads that service significant daily traffic. Besides these hard limits, there are also fragmentation factors such as trails, pipelines, and reservoir parks which introduce lesser fragmentation effects.

The proposed CRL alignment and its associated soil surveys will effectively bisect a contiguous zone (zone 1 in Figure 5) that contains the largest tract of lowland dipterocarp forest in Singapore and which is floristically distinct from the primary hill dipterocarp forest that is found in the Bukit Timah Nature Reserve.

Given that the forest environment is already significantly fragmented, it is not desirable to introduce further fragmentation effects such as can be expected due to surface engineering activities for the CRL. Such disturbance and fragmentation will certainly have a detrimental effect on the biodiversity currently supported by the nature reserves.

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4.3 Flora and Fauna MacRitchie Forest
The area through which the proposed CRL alignment passes is known as the MacRitchie Forest and is a unique habitat consisting of our largest cluster of lowland dipterocarp forest as well as mature secondary forest, a legacy of early (1867) Municipal Catchment area for the MacRitchie Reservoir. The area features the most pristine streams in Singapore and is known to be rich in flora and fauna. The MacRitchie forest is considered a core area within the nature reserves; public access is limited only to trails that skirt the periphery of the area.
4.3.1 Flora

The Nature Society recognizes the MacRitchie forest as one of the most important areas within the nature reserves and with special and unique floristic attributes. The rich forest habitat provides refuge to much of our native fauna. Any disturbance of this area will be perilous to the health of these forest habitats.

The published CRL alignment runs through or very close to two study plots established in a Nature Reserves inventory survey conducted by Wong et al. (1994). These are plots 10 and 13, which were designated as Type 3 and Type 4 forest, respectively, in the classification system used by Wong et al. Type 3 refers to tall forest in an advanced stage of regeneration (Regeneration A in Figure 4), what many ecologists might call mature secondary forest. Type 4 forests (Primary Forests in Figure 4) are those that are in an original (i.e. unlogged) or near-original condition in terms of species composition and forest structure. Type 4 forests are also characterised by the presence of the family Dipterocarpaceae, the signature trees of Asian tropical forest.

Plot 13 of Wong et al. (hereafter simply “Plot 13”) is well known to those in the Singapore forest ecology community as arguably the most exceptional patch of forest in Singapore. Wong et al. wrote that a “very interesting and indeed surprising find is the presence of Seraya (Shorea curtisii) in Cluster 13 of the Catchment Reserve. The forest type in which this cluster occurs is essentially Lowland Dipterocarp Forest (LDF), sense Symington (1943) and in Peninsular Malaysia this species is not known to grow in LDF.” *Shorea curtisii* typically is found on inland mountain ridges from about 300 – 800 metres above sea level. Although the species approaches sea level in coastal hill forests, of which Bukit Timah is an example (and where *S. curtisii* is found), prior to the discovery of the species in Plot 13, this well-known tree had never been reported from lowland dipterocarp forest prior to the report by Wong et al. (1994).

Genetic analysis of the Plot 13 *Shorea curtisii* population (Lum and Pan, unpublished data) confirmed its long isolation from the Seraya populations of Bukit Timah, as the Plot 13 trees did not show the same range of genetic variation as those from Bukit Timah. In all likelihood, *S. curtisii* in Plot 13 represent the last descendants of a larger Seraya population that occupied a series of ridges when the Central Catchment Area was an inland hill during the Pleistocene, when sea levels were over 100 metres lower than they are today.

Plot 13 contains the highest concentration of big trees measured in the Central Catchment tree survey of Wong et al. It has a rich and evenly distributed species composition with typical elements of primary forest, including dipterocarps (at least 6 species), nutmegs (family Myristicaceae), ebonies (genus Diospyros), tropical elms (*Gironniera* spp.), terap species (genus Artocarpus), kedongdongs (family Burseraceae), and much more. It is comparable to any similarly sized primary forest patch in the region for species diversity and composition.

The secondary forest through which the Cross Island Line alignment runs is the oldest regenerating example of forest in Singapore. In addition to remnants of pioneer species such as *Rhodamnia cinerea* (silverback) and *Adinanandra dumosa* (tiup tiup), there are genera of Lauraceae (*Beilschmedia, Litsea, Nothaphoebe*), *Calophyllum* spp., Rhizophoraceae (*Gymnothrix acclarius, Pellaralyc* spp.) and other species characteristic of later stages of forest recovery. Surveys of the area (Lum, unpublished data) have also documented saplings of primary forest species in the area. These include *Shorea macroepetra, Dyera costulata* (Apocynaceae), *Gluta wallichii* (Anacardiaceae), various nutmeg species in the genera *Horsfieldia* and *Knema* (Myristicaceae), *Irvingia malayana* (Irvingiaceae), *Diogyros* spp. (Ebenaceae), and many other examples of primary forest flora.

In addition to tree species, the forest understory is rich in palms, herbaceous plants, and ferns. This is a very healthy forest ecosystem that, if left to continue to regenerate, will gain species, structural complexity, and greatly increase its stored carbon in the decades ahead. This forest should in the future be able to support an even richer animal community than it does even today, given the general positive relationship between plant diversity and animal diversity.

In comparison to other examples of their respective forest types, the sections of forest that may be impacted by the Cross Island Line are botanically unique, very interesting, and ecologically important. The proposed Cross Island Line that was unveiled to the public in January 2013 somehow managed to run through one the most remarkable forests in Singapore and Peninsular Malaysia.

Nature Society (Singapore)
Figure 6 – A selection of Primary Forest trees.

Reference:


4.3.2 Vertebrate Fauna (Non-Avian)

The Nature Society is most concerned for the survival of the rare fauna occupying the CRL affected stream systems. Silt and pollutants that will be released into these streams as a result of soil investigation works can permanently destroy these pristine stream habitats resulting in substantial loss of native fauna.

The CCNR is home to some 44 mammals, 72 reptiles, 25 amphibians and all 34 remaining native freshwater fish species. NSS Vertebrate Study Group members and National Parks Board have conducted joint forest field surveys in 1993-1997 and again in 2008-2010 throughout the CCNR resulting in a considerable amount of knowledge on the occurrence and relative abundance of our native species for the various habitats.

Most of the mammalian, reptilian and amphibian species are forest dependent and specialized to surviving in this habitat. The internationally threatened Malayan Pangolin *Manis javanica* has a highly specialised diet of termites and ants; and the major stronghold of this scarce mammal is MacRitchie. Other mammals like Malayan Colugo *Galeopterus variegates peninsulae*, the small Horsfield's Flying Squirrel *Iomys horsfieldii davisoni*, Greater Slow Loris *Nycticebus coucang* and the Raffles’s Banded Sunili (*Presbytis femorals femorals*) feed mainly on leaves and fruits of the primary and secondary forests. The Lesser Mouse Deer *Tragulus kanchil fulviventer* consumes fruits and seeds that have been dropped on the forest floor. In recent years, the Leopard Cat *Prionailurus bengalensis* has been seen in our catchment forest and it is heartening to note that the CCNR forest is once again viable for a mammalian carnivore to exist. Most of the mammals are bats and comprise of both fruit bats and insectivorous bats. Most species such as the Trefoil Horseshoe Bat *Rhinolophus triglomanus* and Blyth’s Horseshoe Bat *Rhinolophus lepidus* are fully forest dependent. The Grey Large-footed Myotis *Myotis adversus* is found over reservoirs and adjacent channels. The insectivorous bats are efficient controller of insects helping to maintain the balance of the ecosystems.

Reptiles are not easy to detect however we have detected 72 species during our surveys of which 35 are forest species and twenty-eight species are confined to the Central Nature Reserves. Of the many reptile species, only a few are testudines. The Malayan Forest Softshell Turtle *Dogenia subplana*, Asian Leaf Terrapin *Cyclemys dentata* and Spiny Terrapin *Heosemys spinosota* and Malayan Flatshell Terrapin *Notostelys platynota* are species that are forest dependent. They eat vegetation that on forest floors as well as aquatic plants in the wetland areas and as such are highly dependent on the health of the habitat for their survival.

Of the larger lizard species, the Clouded Monitor Lizard *Varanus nebulosus* is a forest species and the MacRitchie forests are the stronghold for it. It is often seen clinging to tree trunks. Some lizards such as gekcoes, agamids and skinks are forest dependent too. The Brown Tree Skink *Dasia grisea*, Striped Sun Skink *Eutropis rugiferus* and Malayan Swamp Skink *Sphenomorphus spp* are all forest specialists. The elusive swamp skink was found recently at a stream in MacRitchie and close to the proposed CRL alignment and is the only second record for Singapore. The pristine stream habitats of the MacRitchie forest represent a significant portion of the remaining viable habitat for this species.. The Earless Agamid *Aphaniotis fusca*, Black-bearded Flying Dragon *Draco melanopogon* and Lowland Dwarf Gecko *Hemiphyllodactylus typus* are some other species that exist only in forest. The Green Crested Lizard *Bronchocela cristatella* used to occur in parks and wooded areas but is now surviving in the forest due to competition from the more aggressive introduced Changeable Lizard *Calotes versicolor*.

Many species of snake have been recorded during surveys in the CCNR but of particular interest, from the MacRitchie Forest are Iridescent Earth Snake *Xenopeltis unicolor*, Bigeye Green Whip Snake *Ahaetulla prasina prasina*, Gold-ringed Cat Snake *Boiga dendrophila melanota*, Jasper’s Cat Snake *Boiga jaspidea*, Twin-barred Tree Snake *Chrysopelea pelias*, Haa’s Bronzeback *Dendrelaphis haasi*, Barred Kukri Snake *Oligodon signatus,* and Blue Malayan Coral Snake *Calliophus bivirgatus flaviceps.* All are dependent on the health of the habitat and all are at risk should surface engineering activities cause disturbance to the area.

Amphibians are more often heard than seen and during surveys, calls are recorded, as each species is identifiable by its distinct call. Of the 25 indigenous species of amphibians, 18 are forest species so conserving forest is of utmost important...
to their survival. The Black-eyed Litter Frog *Leptobrachium nigrops*, Masked Rough-sided Frog *Pulchra laterimaculata*, Four-ridged Toad *Ingerophrynus quadriporcatus*, Maleesian Frog *Limnonectes malesianus* and Cinnamon Bush Frog *Nycticealus pictus* are examples of these forest dependents. MacRitchie forest, with her pristine stream systems and primitive forest, supports the majority of forest frog specialists, and is an important stronghold for some like the Golden-eared Rough-sided Frog *Pulchra baramica*.

The streams of the MacRitchie area are some of the most pristine in the Nature Reserves, due to good forest throughout their catchments. Along with the swamp habitats at the lower reaches, these streams are a critically important series of ecosystems that support many specialized aquatic and semi-aquatic animals, including locally threatened vertebrates like the native turtles, terrapins, frogs, snakes and, of course, fish.

Native freshwater fish have suffered greatly over the past few decades, from canalization, pollution, poaching, habitat-loss and competition from introduced non-natives. Only certain pristine freshwater eco-systems within the Central Catchment Nature Reserve, such as those in the MacRitchie forests, still support highly vulnerable populations of our native fish. The Malayan Pygmy Rasbora *Boraras maculates* is confined only to the MacRitchie streams and the Nee soon Swamp Forest. Other important forest fish found in the MacRitchie streams include Harlequin Rasbora *Trigonostigma heteromorpha*, Forest Walking Catfish *Clarias leiacanthus*, Slender Walking Catfish *Clarias nieuhofii*, and Sunda Leaf Fish *Nandus nebulosus*.

These vertebrate species occupy different niches and any further fragmentation can cause significant loss of population. They play an essential role in the ecology of the forest as predators, herbivores and seed dispersal agents.

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**Figure 7** – Some of the rare vertebrate fauna at risk and residing within the pristine MacRitchie stream habitat

Nature Society (Singapore)
NSS Discussion & Position Paper - Cross Island Line

Reference:

4.3.3 Avian Fauna

The CCNR and BTNR together represent one of three Important Bird Areas (IBA) for Singapore as recognized by Birdlife International. 222 species of birds have been recorded in these nature reserves which are recognized as globally important for the birdlife of lowland tropical rain-forest by Birdlife International.

IBAs are identified as "key sites for conservation – small enough to be conserved in their entirety and often already part of a protected-area network. They do one (or more) of three things:

- Hold significant numbers of one or more globally threatened species
- Are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species
- Have exceptionally large numbers of migratory or congregatory species”.

The critical role of Birdlife International’s program of identifying and monitoring the world’s birds and the key sites for their conservation has been emphasized by the UN in its newly published 2010 UN Millennium Development Goals (MDGs) report. Goal 7 of the report is “to ensure environmental sustainability, and the report uses IBAs to assess the degree to which key habitats for threatened species are adequately protected. It recognises that IBAs are critical sites for the conservation of the world’s birds and other biodiversity and that protecting all of these areas would significantly contribute to the Convention on Biological Diversity’s target to safeguard areas of biological importance”.

In terms of Singapore’s birdlife richness, the MacRitchie Forest has been identified as one of the most important sites within the BTNR and CCNR. Over the last 30 years, 152 species of birds have been recorded within the area. These make up 68% of the species recorded within these reserves. The list includes 36 species known to be nationally threatened. Of these, one is classified in The Singapore Red Data Book (2008) as “vulnerable” (VU), eleven as “endangered (EN)” and twenty-five as “critically endangered (CR)”, which is the last stage prior to extinction within Singapore.

Of the thirty-six (36) resident species here that are nationally threatened, twenty-one are forest-dependent species, constituting 57% of the nationally threatened list in the area concerned and most are classified as critically endangered (18 species). The term “forest-dependent species” here applies to those species whose habitat is restricted specifically to the forest. These include the White-bellied Woodpecker Dryocopus javensis, Blue-rumped Parrot Psittinus cyanurus, Malaysian Eared Nightjar Eurostopodus temminckii, Grey-headed Fish Eagle Ichthyophaga ichthyaetus, Greater Green Leafbird Chloropsis sonnerati, Black-headed Bulbul Pycnonotus atriceps, Moustached Babbler Malacopteron magnirostre, Yellow-eared Spiderhunter Arachnothera chrysogenys - to name some of them. The large number of forest-dependent species that are critically endangered makes the MacRitchie sector of the Central Forest of the highest priority in conservation attention for Singapore.

The soil investigation survey and associated access roads will cause a great deal of disturbance to the forest-dependent bird. Any vibration caused during tunneling or subsequent train operation will also potentially affect the avifauna. It is anticipated that soil investigation will require the clearing of obstructive trees and undergrowth for the purpose of placing core drilling machines. Thus, although high-flying birds such as eagles, parrots and pigeons may not be adversely affected, those species that are ground-moving, or otherwise dependent on the undergrowth for food and nesting will be especially impacted severely by the intrusion of works (machinery noises and influx of workers) as well as any alien features, temporary or permanent, erected along the alignment in the deeper recesses of the forest, which are refuges for the shyer species.

---8 BirdLife International is a global Partnership of conservation organisations - including Nature Society (Singapore) - that strives to conserve birds, their habitats and global biodiversity, working with people towards sustainability in the use of natural resources.

Understory dwelling forest birds that we expect to be affected include the White-rumped Shama *Copsychus malabaricus* (critically endangered), Moustache Babbler *Malacopteron magnoirostre* (critically endangered), Chestnut-winged Babbler *Stachyris erythroptera* (endangered), Orange-bellied Flowerpecker *Dicaeum trigonostigma* (common), Rufous-tailed Tailrobird *Orthotomus sericus* (uncommon), etc. In addition to these, birds that feed along the ground such as the Short-tailed Babbler *Malacocincla malaccensis* (common), Siberian Blue Robin *Luscinia cyane* (winter visitor), Blue-winged Pitta *Pitta moluccensis* (winter visitor), Hooded Pitta *Pitta sordida* (winter visitor), etc, will also be affected.

Construction is also anticipated to affect the fragile water bodies in the catchment and this may adversely affect the survival of specialists of riverine and swampy habitats such as Blue-eared Kingfisher *Alcedo meninting* (critically endangered), White-chested Babbler *Trichastoma rostratum* (critically endangered), and also species that tend to forage along their edges like the Straw-headed Bulbul *Pycnonotus zeylanicus* (endangered) and/or use them for bathing like the Red-legged Crake *Rallina fasciata* (vulnerable).

Of international significance in the area are three species listed in the IUCN Threatened List: the Long-tailed Parakeet *Psittacula longicauda* (common resident but globally near-threatened), Japanese Paradise Flycatcher *Terpsiphone atrocauda* (rare passage migrant, globally near-threatened), Straw-headed Bulbul *Pycnonotus zeylanicus* (endangered resident and globally vulnerable) and the Brown-chested Jungle-flycatcher *Rhinomylas brunneata* (winter visitor, globally vulnerable). The last two are both regularly recorded in the area.
Chestnut-bellied Malkoha (*Phaenicophaeus sumatranus*)  
Red-crowned Barbet (*Megalaima rafflesii*)

Figure 8 – Some forest dependent birds found in the MacRitchie forests.

References


5 Specific Concerns Related to the CRL

5.1 Soil Investigation Erosion Concerns

Soil investigation for the CRL is our greatest concern, the placement and operation of boring machines within the forest will be highly destructive for the following reasons:

- Each borehole site needs a clear working platform approximately 20 m$^2$ to be cleared and leveled where gradient of land requires it. The platform needs to accommodate the boring machine, diesel/hydraulic power plant, fresh water and slurry tanks, grinding sludge, bore pipes and working space for the operators. Refer to Figure 9 to Figure 11 for photos of typical bore hole drilling layout.
- Each machine needs to be serviced with fresh water and removal of grinding sludge on a regular basis while drilling is in operation resulting in the need for vehicular access. This will require a road to be constructed linking the drilling sites along the alignment or from existing access points to the drilling locations. Access roads will result in clearing of forest and compaction of soil and will also lead to erosion risk due to the disturbed topsoil.
- The borehole site illustrated below includes two diesel engines, one driving the drilling rig, the other operating a pump that delivers water into the bore hole for flushing of grinding debris. The hydro-carbon based fluids used by these motors (diesel, hydraulic fluid and lubricating oils) are highly toxic materials and should they be released into the environment through spillage during servicing/refueling, normal leaking of joints or by rainwater washing over the equipment the effects on the ecosystem will be disastrous.

![Figure 9 – Boring Machine in operation](image)

![Figure 10 - Diesel power unit driving a pump](image)

![Figure 11 - pipes will be connected together down hole](image)
5.1.1 Bore Holes along Alignment
It has been reported\(^\text{10}\) that for soil investigation works, bore holes are required every 15-20 metres. Such a density of bore holes is considered by the Nature Society to be excessive for a site that is expected to have a homogeneous geological profile. Nevertheless, even a single core boring machine set up in the forest represents an unacceptable risk to the delicate forest and stream ecosystems within the CCNR forests.

The diagram below represents a typical long section profile section 50 meters in length along the alignment with bore hole machines located on excavated work platforms 20 metres apart.

![Diagram showing bore hole machines at 20 metre spacing along with work platform.](Image)

Figure 12 – Long section profile showing bore-hole machines at 20 metre spacing along with work platform.

5.1.2 Soil Erosion Risk
The soils of the CCNR are shallow and leached out, they are particularly vulnerable to erosion once the leaf litter or shrubs and trees are damaged or removed. There are many examples of gully erosion caused by disturbances throughout the nature reserves that support our concern on this matter. The placement of core drilling machines and associated access roads will provide many opportunities for run-away gully erosion to occur. The problems that are expected from erosion events includes:

- Inability for shrubs and trees to establish themselves within the unstable erosion scar;
- Loss of flora at gully erosion sites as the head of the eroded gully moves upstream;
- Siltation of streams resulting in damage to the fragile stream ecosystems.

Past experience\(^\text{11}\) shows that current mitigation schemes to contain erosion and siltation are not sufficiently rigorous to avoid the problem of siltation in the Nature Reserves.

The Public Utilities Board (PUB) has implemented an island wide water collection system such that almost every stream will eventually feed into a storage reservoir. The PUB are most concerned about siltation of streams and the effect it has on water quality within the reservoirs and have published a substantial guide on the best practices for erosion avoidance and control of siltation. They also require engineering consultants /contractors to prepare a detailed Earth Control Measures (ECM) plan for all phases of projects that involve erosion risks. This plan is required to be submitted to PUB for approval. Siltation is a serious problem for water reticulation and it is treated seriously by PUB.

\(^{10}\) IBID 3

\(^{11}\) In 2010 a silt spillage from a PUB pipe jacking project near the BKE/PIE interchange resulted in many cubic metres of sludge to be drained into the Rifle Range Stream causing damage to fish and amphibian life along that stream.

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There are many examples of erosion within the nature reserves, all resulting from different disturbances, including tree fall in lower grade forest, old WW2 gun sites and foxholes, unauthorized trail building, unauthorized use of trails by hikers and mountain bikers, water runoff from existing roads and trails, and natural erosion that occurs along stream lines. Following are three examples of erosion caused by disturbance of natural environment.

5.1.3 Lower Peirce Erosion Site
The Lower Peirce area was formerly gambier and pepper plantation, where cleared forest resulted in higher rates of water run-off which resulted in substantial erosion within the minor stream systems. Erosion emanating from World War 2 gun placements (the guns no longer in place) is also apparent; the images below illustrate erosion due to disturbances attributed to former gun placements.

Initial gouge due to soil disturbance
Exposed felspar clay - plants have difficulty reestablishing
Deep gouge further down the erosion line
Deep gouge with exposed soil

Figure 13 – Example of soil erosion in at Lower Peirce due to soil disturbance

5.1.4 Sime Trail Erosion Site
The Sime trail is a metalled road that has been in existence since the 19th century. Along its length there are various examples of erosion due to excess water runoff from the road. The most serious case of erosion occurs at the location of the Petaling hut where the Petaling trail joins the Sime Trail. Water runoff has contributed to gully erosion which if allowed to continue will bring a nearby Dipterocarpus grandiflora into danger of toppling.
5.1.5 Slope Failure near Kalang Ranger Station
A slope outside the Kalang Ranger station completely failed approximately 10 years ago. The failure was caused by run-off waters from a nearby PUB facility as well as excess rain water run-off from an adjacent Sime Trail. The slope failure was realized by a number of landslides resulting in loss of plants and topsoil along with the danger of the trail itself collapsing into the valley. Significant remedial work was required to repair the slope and today it is paved with grass. The stream bed and side drains have been concretised to accommodate the excessive water flows during rain events. This is an example of what can happen when disturbances (such as roads and clearings) result in a faster rate of water run-off than would be the case if the area was completely covered in healthy forest, it is the faster run-off that causes the damage.
Concrete channel replacing original stream

Concrete channel carries road water runoff to main channel

5.1.6 Slope Analysis

The topsoil in the Central Nature Reserves is thin and leached out. They are particularly vulnerable to erosion wherever the top layers of leaf litter, or trees and shrubs are disturbed. The area through which the CRL passes is no exception. The map in Figure 14 below illustrates the critical slopes through which the CRL passes. In areas of the steeper slopes (Moderate to Highest), any excavation, road building or clearing will result in high risk of erosion and silt run-off. The erosion will eventually consume valuable forest habitat while the siltation will severely damage the pristine stream habitats indicated in Figure 15. Siltation will also result in water quality concerns for the MacRitchie Reservoir.

Figure 14 – Slope and Soil Erosion map.

The map below (Figure 15) illustrates the stream systems affected by the CRL line. Streams 1, 2 & 3 are considered pristine streams with high degree of biodiversity within and around them. We need to avoid damaging these stream habitats. Stream 4 is outside of the nature reserve and passes through a former rubber plantation and as such has been subjected to some degradation in the past, nevertheless it still supports a moderate degree of stream and forest fauna and needs to be also considered for preservation.
5.2 Siltation Risk

Siltation is probably the greatest direct threat to the stream ecosystems of the CCNR due to the anticipated core drilling operations. Disturbed leaf litter, likelihood of some amount of excavation for the drilling sites and construction and usage of access roads guarantee that soil will be washed into the stream systems surrounding the drill sites no matter what mitigation works are installed. With most of the streams entering swampy flat land towards their terminus with the reservoirs, sediments can be expected to deposited and not carried away resulting in a change in stream substrate overwhelming stream flora and degrading the health of the stream dependant fauna.

The effect of fine sediments on stream biota has been recognized for decades and is the subject of many studies, mainly associated with road construction; as such the effects of siltation are most predictable. It has been found that fine sediment pollution from road construction can immediately alter macroinvertebrate and fish communities reducing the overall abundance of stream fishes by over 50%\(^{12}\). Another study reported that the abundance of bottom-feeding fishes is initially reduced, but recovers after fine sediment deposition rates decline. Fish and invertebrate communities begin recovering after the fine sediment loads are reduced and deposits wash downstream, but full recovery may require years\(^{14}\).

Fine sediment pollution degrades stream biotic communities through a variety of mechanisms. Stream periphyton and macrophytes are abraded, suffocated, and shaded by fine sediment\(^{15}\). Fine sediment loads impact macroinvertebrates by inducing catastrophic drift\(^{16}\), damaging individual’s respiratory structures\(^{17}\) and reducing habitat by clogging interstitial spaces in streambeds\(^{18}\).

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Fine sediment can also clog the gills of fishes and reduce the quality of their habitats for feeding by impairing visibility and reducing prey abundance\(^\text{19}\). It is possible that engineering activities interfere with a variety of feeding strategies; another study found that fine sediment deposition reduced populations of both insectivorous and herbivorous fishes\(^\text{20}\); this can result in imbalances in stream dependant insect populations with flow-on effect to other stream dependant fauna. In addition, fine sediment suspended in the water can lower reproductive success of fishes\(^\text{21}\). For example, egg survival of some species depends on substrate that is permeable to water flow\(^\text{22}\).

Within the limited confines of our own pristine stream systems the ability of the endangered species to recover after siltation losses cannot be guaranteed, non-recovery is a more highly likely due to already small populations and fragmented habitats compared to the areas where the aforementioned studies were undertaken.

### 5.3 Toxic Materials

Boring machines use a diesel power plant illustrated in Figure 10 above. There are three significant hydrocarbon based toxic materials used by this plant, they include Diesel, Engine lubricants and hydraulic oil. Each may be accidently spilt during servicing, refueling, and assembly/disassembly of the plant. Rain water washing over the equipment and stored fluids will also carry the toxic materials into the surrounding soil. Careless handling of these materials can result in spillage and contamination of the water catchment, even small amounts can be disastrous. The molecules will leach into the streams where they will poison the fragile flora and fauna that depend on the pristine streams.

A large body of research into the effects of hydrocarbon molecules in stream habitats is available due to concerns of the effects of rainwater runoff from road systems. For this paper we simply cite two examples. One study has demonstrated that the components of hydrocarbon fuels and lubricants such as Benzo(a) Pyrene (BaP) can cause morphological abnormalities in stream fish fauna\(^\text{23}\). Typical abnormalities include insufficient yolk sacs in eggs, lack of body pigment, kyphosod (skeletal) and abnormalities or absence of eyes among some fish hatchlings.

Another study found that Total Petroleum Hydrocarbon concentrations between 1,858 and 4,632 mg/kg in sediments reduced macroinvertebrate species richness, and concentrations exceeding 4,632 mg/kg led to a severely impoverished fauna\(^\text{24}\). The aquatic macroinvertebrates in the field-based experiments were affected by high–molecular weight (>C16) hydrocarbon with concentrations as low as 840 mg/kg.

Given the poor state of maintenance and care of operation for equipment currently being used in the field, (refer Figure 10) along with unfamiliarity by rig operators with operations in ecologically sensitive areas, our concerns of toxic pollution are indeed very realistic.

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\(^{23}\) Hannah *et all*, Benzo(a)pyrene-induced morphologic and development abnormalities in rainbow trout, archives of Environmental Contamination and Toxicology 1882 Vol 11 Issue 6 pp727-734

\(^{24}\) Pettigrove and Hoffmann, Effects of Long-Chain Hydrocarbon–Polluted Sediment on Freshwater Macroinvertebrates, Environmental Toxicology and Chemistry, Vol. 24, No. 10, pp. 2500–2508, 2005
5.4 Mitigation technologies

Mitigation does not equal no impact, these are two completely different concepts.

Soil erosion and silt water management standards published by the Public Utilities Board (PUB) are suited to general construction sites. The application of these to soil investigation works within the nature reserve is considered by Nature Society to be inadequate for use in an ecologically sensitive area.

In summary, the code of Practice on Surface Drainage provides that effective earth control measure (ECM) must comprise 2 aspects:

- Erosion Control to minimise bare earth surfaces
- Sediment Control to contain, storage and treat silt sediments and shall comply with Clause 6.3 of the Code of Practice on Surface Water Drainage

The management of runoff and silt treatment includes these aspects.

Containment

- To provide perimeter lined cut-off drains
- To provide perimeter silt fences along perimeter cut-off drains
- To provide turbidity curtain for work alongside rivers & waterways
- To protect earth slopes/surfaces with closed turfing, milled waste, concrete, erosion control blankets, polythene sheets or other suitable materials

Storage

- To provide adequate size and number of sedimentation sumps or storage tanks before treatment of silty water
- To provide adequate size and number of sedimentation sumps or storage tanks before discharge and along the perimeter cut-off drain

Treatment

- To provide treatment unit / coagulant unit to treat silty water before discharge

Maintenance

- To maintain sediment control facilities at least once a week and after every storm event

Inclusion of silt traps, silt fences, cut-off drains will be highly intrusive in a nature reserve and their effectiveness depends on the rate of water flow they are designed for as well as quality of construction. Drains and sediment collection ponds have no place in the nature reserve and will result in further damage.

In 2010 a PUB pipe jacking project located at the BKE/PIE interchange spilled a massive amount of silt into the Rifle Range stream system resulting in sedimentation of the sandy substrate stream and impacting forest fish and amphibian fauna. Three years later silt from the spillage may still be found in the stream and formerly resident fauna have not fully recovered, it is uncertain if the stream fauna will ever recover due to the trapped silt. This incident underlines the concern of the Nature Society regarding the suitability of current erosion mitigation strategies for use in sensitive areas.

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Nature Society (Singapore)
6 Consideration of Alternate Routes

Nature Reserve should not be viewed as vacant state land; it has recognized value in the conservation function and ecosystem services it provides. If ecosystem and services valuations were considered in the cost analysis of the CRL project a southern alternate route should become an attractive design option.

The determination of the route of an MRT line must take into account the residential catchment it is required to serve, land acquisition costs, geology which significantly affects construction costs, and future operational efficiency which includes travel time, maintenance costs etc. The CRL is the first MRT service that is proposed to cross nature reserve and as such there are issues that have never before been encountered in Singapore that need to be dealt with by the design teams.

6.1 Nature Reserve is not Vacant State Land

The most important issue is the need to recognize that nature reserve is not equivalent to vacant state land, designing infrastructure to bisect the reserve is not something that should be taken lightly. Nature reserve is gazetted for the purpose of conservation of native flora and fauna and as such it has value far beyond that of vacant land. There are techniques used by economists to determine this value in monetary terms and these are quite well documented. Design authorities need to take into account the value of ecosystems and ecosystem services (potentially lost) in their cost/benefit analysis in the same way they would consider the cost of private property acquisition.

Factoring ecosystem costs into the design process is practiced in other countries when planned infrastructure potentially impacts nature areas. For the CRL case it is likely that the opportunity cost of ecosystem and ecosystem services lost through soil investigations and other associated engineering works would justify the extra length of tunnel required for the alternate routes.

6.2 Availability of Alternate Routes

There are two alternate routes illustrated in Figure 16 below:

- **Northern Alternative**: The Northern Alternative transits north of the main body of Nature reserve and follows Mandai Road, joining up with the northern end of the Jurong Region Extension lines representing an estimated extra 10 kilometres of line;

- **Southern Alternative**: The Southern Alternative transits south of the Nature Reserve following Lornie Road and joining up with the Jurong Region Extension at the same location as is currently planned. This alternative represents an extra 1.7-2.0 km of line depending on routing.

Of the two alternatives the southern option would seem the most promising with the apparent additional cost of an extra 1.7-2.0 km (this will vary depending on detailed alignment determination) and the opportunity of servicing extra catchment in the vicinity of Adam Road and MacRitchie Reservoir Park. The Northern Alternative does not seem viable for reasons of extra distance and little opportunity to service extra catchment along the way.

The Nature Society believes that the cost of lost or damaged ecosystems should be considered in the design considerations and expects that the extra 1.7-2.0 km of line represented by the Southern Alternative would be attractive from an economic point of view. We also believe that the opportunity for an extra commuter catchment provided by the Southern Alternative is of value even if it is not realized immediately; the opportunity would be realised as the population increases. There is also opportunity to place a station at MacRitchie Reservoir park – servicing the needs of residents who use the park for recreation and exercise.
Figure 16 – Alternate Routes that require consideration.

In terms of travel time the southern alternative will increase travel time by 4 minutes for an average station-station velocity of 30 km/h, this represents an estimated 4% increase for the total travel distance of 50 km. We believe this to be a conservative estimate as it should be expected that trains will reach higher velocities over this section of track.

Figure 17 – Time taken to travel 2 kilometers for speed range 10-80 km/h
6.2.1 Ecosystem Valuation in Route Determination
Ecosystem valuation is an important matter in evaluating the opportunity costs of alternate routes for the CRL\textsuperscript{26}, the current proposed alignment has no doubt been arrived at without considering the ecosystem cost of destructive soil investigation works required along its length. It is also doubtful that ecosystem costs were taken into account when the Bukit Timah expressway was constructed in the 1980’s completely disconnecting the Bukit Timah and Central Catchment Nature Reserves.

6.2.2 Dollar Measure of Ecosystem Value
In Conventional economics it is generally accepted that measures of economic value should be based on what people want, and that individuals not government should be the judges of what they want. There are three generally accepted approaches for estimating dollar values for ecosystems or ecosystem services, they include:

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Market prices (Revealed Willingness to Pay)</td>
<td>For ecosystems that produce food (fish, honey etc.), commercial timber or other items that are directly traded in the marketplace, market price valuations may be easily determined. For other ecosystem services, such as aesthetics, desire for conservation, etc. that are not directly traded in markets can be valued based on the premium people are prepare to pay to live near (or inside) an ecosystem, or their willingness to take time to visit the ecosystem. These measures can be used to determine a lower bound of the value of an ecosystem or its services. For Singapore nature reserves, visitor numbers may be used a measurement, extra marginal cost of housing next to Nature reserves would be another consideration.</td>
</tr>
<tr>
<td>Circumstantial Evidence (Imputed Willingness to Pay)</td>
<td>The recognized methods for determining values by this category include the Damage Cost Avoided, Replacement Cost, and Substitute Cost methods. These are related methods that estimate values of ecosystem services based on either the costs of avoiding damages due to lost services, the cost of replacing ecosystem services, or the cost of providing substitute services. These methods do not provide strict measures of economic values, which are based on peoples’ willingness to pay for a product or service. Instead, they assume that the costs of avoiding damages or replacing ecosystems or their services provide useful estimates of the value of these ecosystems or services. For the CRL case the cost of reestablishing the pristine streams at another location or restoring the pristine stream systems to original condition could be considered a fair cost indicator.</td>
</tr>
<tr>
<td>Surveys (Expressed Willingness to Pay)</td>
<td>Many ecosystem services are not traded in markets, and are not closely related to any marketed goods. Thus, people cannot “reveal” what they are willing to pay for them through their market purchases or actions. In these cases, surveys can be used to ask people directly what they are willing to pay based on a hypothetical scenario. Alternatively, people can be asked to make tradeoffs among different alternatives, from which their willingness to pay can be estimated. In the case of the CRL, we may pose this question: “Are the people prepared to support through their taxes, the extra capital cost of constructing an alternative route around the Central Nature Reserve, and are they prepared to suffer the cost of extra travel time in order to retain the potentially affected ecosystem in its pristine state?”</td>
</tr>
</tbody>
</table>

In the case of the CRL, soil investigation by core boring at regular intervals along the proposed alignment will certainly have serious impact on the pristine stream system in the area. If the cost of replacing or repairing damage caused by this exercise is contemplated one would realize that the pristine forest habitats are actually priceless for it is impossible to replace them.

\textsuperscript{26} A good reference on the subject of Ecosystem Valuation may be found at \url{www.ecosystemvaluation.org}
6.3 Precedents of Re-Routing
There are two clear examples where transport infrastructure has been rerouted at design stages for the purpose of avoiding ecologically sensitive areas within the Nature Reserves; they include Seletar Expressway and Adam Road.

6.3.1 Seletar Expressway Diversion
During the design stage of the Seletar Expressway c. early 1990’s a section intended to pass through the Nee Soon Freshwater Swamp Forest near the Thomson Road exit, was rerouted to go around this section of primary forest at the instigation of NParks. The Nature Society is most thankful that this diversion was undertaken thus avoiding a further disastrous fragmentation of the single remaining contiguous area of wetland forest.

![Figure 18 – Seletar Expressway Diversion](image)

6.3.2 Lornie Road
The Lornie Road expansion was originally designed to encroach upon primary forest in the Central Catchment Nature Reserve near to MacRitchie Reservoir. Due to intervention by NParks the encroachment was avoided by redesigning the new road to pass through Bukit Brown cemetery. Despite the fact that the nature community is unhappy with the proposed alignment through the cemetery, the fact remains that primary forest habitat was spared destruction through this alteration in design.
7 Tunneling and Geology of the CCNR

During tunneling there is a risk of loss of tunnel pressure to the surface through faults in the granite structure. A blow through would require the movement of personnel and equipment into the affected area (anywhere along the alignment) for the purpose of grouting the vent. Such an activity could be highly destructive should it occur in forested areas.

The Central Catchment Nature Reserve is dominated by the Bukit Timah Granite Formation. In the area of the MacRitchie forests, granite hills rise to around 30 to 55 metres above sea level and with gentle slope gradients. Within the drainage system a localised deposit of the Alluvial Member overlies the granite in the area of the Sime Road Wetlands, this is variable sediment of unconsolidated (soft) clay, silt and sand.

7.1 CRL Tunnel Alignment

A cross-section summarizing the topography, geology and forecast CRL tunnel depth along an assumed alignment of a straight line from the PIE to Upper Thomson Road, along the line of the proposed CRL, is presented below in Figure 19.

![CRL MRT line: Geological Modelling](image)

Figure 19 – Cross Section of CRL Tunnel (assumed vertical alignment) showing relation to geological formations.

The forecast depth of the proposed CRL tunnel beneath the CCNR is 24 metres below sea level based on the following assumptions:

- CRL interchanges in the at King Albert Park and Sing Ming MRT stations, where ground elevations are 12m and 7m ASL respectively;
- 10 metre thickness between ground level and top of Downtown & Thomson lines at King albert Park and Sin Ming respectively;
- 7 metre tunnel diameter;
- 10 metre vertical spacing between base of Downtown & Thomson line tunnels and roof of CRL tunnel;
- Low gradient between exiting MRT stations, it is assumed the tunnel section directly beneath CCNR is at its lowest point and is horizontal;
Towards the west and east the tunnel is modeled to rise around 7 metres on the approaches to the interchange stations on either side of the nature reserve;

### 7.2 Granite Mineralogy

Granite is an igneous rock formed by cooling of a body of magma at depth. The mineralogy of typical granite comprises around 30% quartz crystals, 5% mica and 65% feldspar. During the very slow process of tropical weathering, feldspar is chemically converted to clay: once weathered, the rock matrix can disaggregate and is easily eroded and deposited elsewhere.

During cooling, granite masses develop **jointing**. A joint is defined as “a fracture in a rock between the sides of which there is no observable relative movement”. During earth movements, such as uplift of granite bodies, or slow erosion of overburden, changes in stress cause the development of **fractures**. A related set of fractures are often oriented in the same direction. An example of this can be seen at Hindhede Quarry. See Figure 20. Fractures can either be ‘open’ or ‘closed’. Dykes can also occur, which cut through the granite: dykes are localised planar features of different rock composition and different hardness, and may be up to a few metres thick.

### 7.3 Weathering along Jointing and Fractures

Weathering can preferentially occur along joints and particularly open fractures which further weaken rock strength, and provides conduits for the movement of ground water. In areas of complex jointing and fracturing, large granite blocks that are originally angular can be weathered into huge rounder boulders which either remain in situ or may tumble down unstable hillsides into valleys or gullies.

![Figure 20 - Oblique fracture set at Hindhede Quarry, 30 to 40 degrees from vertical. As evidenced by vegetation growth, some fractures are closed and some are open. The large fracture in the centre (marked by arrow) appears to be open as vegetation (ferns etc) appears to be finding water on which to thrive.](image)

In some granite areas, surface soils may overlay directly onto unweathered granite. In other areas there may be a weathered zone lying between the surface soil and the unweathered granite. This weathered zone may comprise a complex arrangement of unweathered granite boulders and weathered fractures infilled with sand or clay. There is often great uncertainty of the thickness of a weathered zone. In general, however, the weathered zone on hilltops is thin, and in gullies it is thicker and may be highly complex.

Granite outcrops in Singapore have variable weathered zones. At Hindhede Quarry, where Primary Forest sits on top of unweathered Bukit Timah Granite, the weathered zone appears thin to non-existent, and granite boulders are absent. This is the most likely situation on the hilltops of the MacRitchie Forest where surface boulders are absent.
In contrast, in Fern Valley in BTNR, which is a deeply incised stream gully laying to the west of Hindhede Quarry; a complex arrangement of steep granite slopes, large granite boulders (up to 5 metres across) and fractures is evident. Fern Valley is perhaps the steepest granite gully in Singapore, and the ‘weathered zone’ is estimated at around 10 metres. A 10-metre weathered zone can thus be applied to a geological model of MacRitchie North, and this would be a worst case estimate given that the weathered zone on hilltops is virtually nonexistent and that there are no steep gullies in region of the proposed CRL alignment. The existence of isolated deeply weathered complex fault zones intersecting with any proposed tunnel cannot however be completely discounted.

Figure 21 - Hindhede Quarry, Bukit Timah: forest directly overlies unweathered granite, and boulders are absent.

Based on the geological model (Figure 19), which uses a worst-case estimate of a 10-metre weathered zone, invasive site investigation such as boring or coring is of limited value on hilltops and gentle slopes. The CRL tunnel is likely to intersect solid granite 35 metres or more beneath the worst weathered zone. There is uncertainty as to the nature and thickness of the granite weathered zone hidden beneath the Alluvial Member and MacRitchie Wetlands. Based on extrapolation of the slope angle of the hillsides lying to the east and west of this gully, the thickness of the Alluvial Member is forecast at around 5 metres. Slope angles to the east and west of this area, however, are benign and the risk of complex boulder and fracture arrangements in the weathered zone is considered very low. Thus, assuming a worst-case 10-metre weathered zone in granite beneath the Alluvial Member, the deepest weathering will still lie 23 metres above the top of the assumed vertical alignment of the CRL tunnel.

7.4 Hard-Rock Tunneling

Tunneling through granite requires hard rock tunneling methods, and these are of two broad types. Traditionally drill-and-blast methods were used, which required extensive use of explosives at the tunnel face. Modern advanced methods use a full-face rotary Tunnel Boring Machine (TBM). A TBM would be the most likely method selected for any CRL tunnel. A Shielded Hard-Rock TBM would be used to prevent tunnel collapse in the case of possible fractured zones in the granite or unexpected ‘mixed-ground’ at the interface of granite and other, softer rock types. In Hong Kong, hard-rock tunneling now almost exclusively uses TBMs in granite formations.

Tunnels are excavated under positive air pressure. Movement of equipment and personnel to and from the rock face, and movement of excavated rock material out of the tunnel takes place through air locks. The tunnel is kept under pressure
all times: this is to prevent ingress of water into the tunnel when below the water table. Tunnel pressure is designed to exceed the hydrostatic pressure of water above the tunnel.

7.5 Environmental Impacts of Hard-rock Tunneling

Environmental impacts related to the tunneling phase are as follows:

- Removal of rock debris at the exit point of the tunnel. In the case of the CRL, this would not impact natural habitats as this would be expected to occur at Tunnel portals outside the nature reserve.

- Ground borne noise: based on studies from Hong Kong, with an expected depth of a possible CRL tunnel of between 35-75 metres below ground level, maximum noise level at surface is expected to be around 30 to 50 decibels. These values are close to or exceed Nighttime Noise Criteria under /Hong Kong’s Noise Control Ordinance (NCO) and requires special permitting in that country. This is a concern for the CCNR in view of potential disturbance of fauna.

- Unknown impact of high frequency equipment noise on bat species which rely on echolocation.

- Ground borne vibration: based on studies from Hong Kong, with an expected depth of CRL tunnel of between 35-75 metres below ground level, vibration of less than 0.015 to 0.3 mm/s (RMS Vibration, or Root-mean Squared Vibration) is to be expected. This is unlikely to be a concern for the CRL tunnel beneath the CCNR.

The biggest risk during tunnel excavation, however, is loss of pressure to surface. When an open fracture is encountered in granite below the water table, water within this fracture can flow into the tunnel under construction. Tunnel air pressure can then escape to surface, and surface sediments and soils are then blown away by the force of outrushing air creating a surface depression. Remedial action is then needed to plug the hole at surface including grouting with cement, and this requires the movement of personnel and equipment into the affected area. In an area of forest, an access path or road would need to be cut to gain access. Such problems occurred during the construction of the North-South MRT between Orchard and Newton stations in 1986.

7.6 Example of Loss of Tunnel Pressure

Tunneling between Orchard and Newton MRT for the North-South Line in 1986 encountered unexpected granite masses and associated granite boulders in an area of soft sediments. Tunnel pressure (around 15 psi) was lost to surface at Scotts Road most likely along a weathered fracture within the granite mass. The loss of pressure caused rock collapse, the formation of voids above the tunnel, and subsidence of Scotts Road. Should this type of incident occur within the Nature Reserve, the access roads, machinery and remedial work required would be highly damaging to the habitat.

Reference:


8 Nature Reserves as Inviolable Spaces

Parliament must have intended to create a “public trust” when lands were set aside as nature reserve. The Government has an obligation to hold and use public land on trust for its citizens and as trustees they have a moral (if not fiduciary) duty to use land in accordance with its intended purposes. Construction of the CRL through CCNR is not compatible with the intended purpose of the nature reserve.

The IUCN WCPA Guidelines (Dudley 2008) define a protected area as clearly defined geographic space recognized, dedicated and managed through legal and other effective means to achieve the long term conservation of nature with associated ecosystem services and cultural values (italics ours). Nature Reserves in Singapore like the CCNR are Protected Areas and globally they are recognized as essential tools to ensure the long term conservation of nature, biodiversity and ecosystem services.

In the Singapore context, Nature Reserves like the CCNR are formally protected under the Parks and Trees Act (PTA). The CCNR has been designated and set aside as a nature reserve pursuant to Section 7(2) of the Act read together with Part II of the Schedule of the Act.

Protected Areas legislation usually contain provisions identifying specific objectives of the law which are normally sufficiently clear to guide implementation and to serve as a framework for judging whether decisions are within the law. Alternatively, they could be used to assess whether the law is being properly applied. Section 7(3) of the PTA provides that nature reserves are set aside for the propagation, protection and conservation of the trees, plants, animals and other organisms of Singapore (whether indigenous or otherwise), the study, research and preservation of objects and places of scientific interest, and the study, research and dissemination of knowledge in botany, biotechnology and natural history. They can also be employed for other purposes like educational and recreational purposes. Thus it could be argued that the CCNR also provides ecosystem services.

Employing the IUCN Protected Areas categories, Singapore’s Nature Reserves (including the CCNR) are a hybrid between Category 1a Protected Areas (where human visitation, use and impacts are strictly controlled) and Category 2 Protected Areas that provide educational, recreational and visitor opportunities.

Nature Reserves in Singapore are in practice managed by the National Parks Board. The functions of the Board are set out in Section 6 (1) of the National Parks Board Act (hereinafter NPBA) and include the propagation, protection and preservation of the animals, plants and other organisms of Singapore and within the national parks, nature reserves and public parks to preserve objects and places of aesthetic, historical or scientific interest, advising the government on all matters relating to nature conservation and carrying out such other functions and duties as are imposed upon the Board by or under the Act or any other written law. Considering both Section 7(3) of the PTA and Section 6(1) of the NPBA, the construction of the MRT line through the CCNR does not seem to fit neatly into the objects and purposes of both the Nature Reserves and the authorities responsible for managing them.

It is also worth recalling that Singapore is a signatory to the Convention on Biological Diversity. Although the Convention does grant states flexibility in the implementation and interpretation of its provisions, the provisions of the

28 See Lausche, op.cit, p.149
29 Parks and Trees Act (cap 216), Act 4 of 2005
30 See Lausche, op.cit, p.119
31 Parks and Trees Act (cap 216), Act 4 of 2005
32 See Lausche, op.cit, p.147
33 National Parks Board Act. Paraphrases relevant portions of Section 6(1)
34 Individual provisions of the Convention on Biological Diversity contain the prefix “as far as possible and as appropriate”.

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treaty provide the philosophical basis upon which conservation efforts ought to be based and should be considered by parliament and policy makers. The relevant provisions of Article 8 of the Convention on In-situ Conservation are set out below:

Each Contracting Party shall, as far as possible and as appropriate:

(a) Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;

(b) Develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken to conserve biological diversity;

(c) Regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to ensuring their conservation and sustainable use;

(d) Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings;

In line with this, an issue that needs to be addressed, in the present context, is the extent to which the building of the MRT line and the undertaking of preparatory works will have an impact on the ability of the authorities to take special measures need to be taken to conserve biological diversity, regulate or manage biological resources important for the conservation of biological diversity, promote the protection of ecosystems and natural habitats within protected areas and maintain viable populations of species in their natural surroundings.

The various arguments raised above fall arguably within the scope of the Public Trust doctrine. In essence the doctrine holds that the state has an obligation to hold and use public land on trust for its citizens and as trustees they do have a moral (if not fiduciary) duty to use land in accordance with its intended purposes. The public trust essentially confers on the public a beneficial interest in the lands. The rights of the public include the rights of future generations (or inter-generational equity) and this is embraced by Principle 3 of the Rio Declaration that states that the right to development must be fulfilled so as to equitably meet the developmental and environmental needs of present and future generations.

Joseph Chun in his article “Reclaiming the Public Trust in Singapore” states that Parliament must have intended to create a “public trust” when lands are set aside and entrusted to the National Parks Board under the Parks and Trees Act for the specific purposes therein. The statutory power of the Board must be interpreted narrowly if he tries to alter the nature of these lands and that the Minister’s powers under s 62(1) should be narrowly construed.

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9 Historic Sites

Section 7(3) of the Parks and Tree Act specifies one of the purposes of nature reserves is for the *the study, research and preservation of objects and places of aesthetic, historical or scientific interest*. Since the area covered by the CCNR has been reserved since the turn of the 19th century, there are many sites of historical interest enclosed within that date from 19th and 20th centuries. A current research project is currently being undertaken to locate and document the historical artifacts within the nature reserve. These artifacts include the remains of shrines, roads, milestone markers, bridges, villages, graves, survey monuments, wells, plant & machinery, etc.

For the MacRitchie forest, there are two known historic sites which are in close proximity to the proposed CRL alignment, however the area has not yet been completely investigated and there could be more artifacts hidden in the Jungle. There is some risk that surface activities associated with the CRL could obliterate historic artifacts that have not yet been located and identified.

![Agricultural lease boundary marker dating from mid-1800's](image)

![Stationary steam engine site dating from later 1800's](image)

![Ceremonial bathing point – Shinto Shrine](image)

![Granite stairway – Shinto Shrine](image)

Figure 22 – Historical artifacts within the CCNR
10 Conclusion
This discussion and position paper has been compiled from the contributions of Nature Society members who together represent many years of experience in surveying, studying and enjoying the flora and fauna of the BTNR and CCNR, they also come from a diverse range of professions, many of which are directly relevant to the subject material herein.

We are very concerned that a transportation corridor could be proposed that intersects the nature reserve as if it were vacant State land and we predict that if the project proceeds as indicated we are at peril of losing a substantial portion of the small amount of natural forest habitat remaining on this island. The investments in conservation projects such as the Ecolink and substantial reforestation projects over the past several years demonstrates the intention of the Government to promote and improve the natural habitats of the CCNR and BTNR for the conservation of flora and fauna. Thus it is recognized that the nature reserves have an important purpose and introducing engineering projects that are counter to this would be most undesirable. We strongly recommend that ecosystem and services valuations be incorporated into the project viability assessment, consuming natural habitat should be viewed as a substantial project cost and is no different to consuming alienated land (which would need to be acquired at commercial value) for the CRL purpose.

Singapore is a signatory to the Convention on Biological Diversity (CBD), an international legally binding treaty dealing with conservation and sustainable use of biological diversity as well as the CITES convention which deals with limiting international trade in endangered species of wild fauna and flora. In addition to these two international treaties, Singapore is currently working towards a proposal for UNESCO world heritage listing for the Singapore Botanic Gardens. It is therefore demonstrable that the Singapore Government sees significant value in playing a role on the world stage with respect to biodiversity and heritage conservation. Placing a transport corridor such as the CRL through a nature reserve does not fit this image and will not be viewed positively.

Ultimately these representations of the Nature Society measured out in non-monetary units will be laid out and compared against the engineering feasibility studies which are measured out in units of Singapore dollars. The degree to which these can be directly compared is somewhat limited and ultimately a moral judgment will be required to resolve the question of where the alignment of the CRL will finally lay.

We hope the discussions within this document help the audience to appreciate the position and recommendations of the Nature Society and we request that the CRL be realigned to pass around the nature reserve rather than through it.