1

Parks, Park Connectors, and Biodiversity

Forest Friends in Our Midst

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Images as credited

A total of 90 species of birds, 57 species of butterflies, and 22 species of dragonflies were recorded from the 10 transects on survey days.

Background

The fragmentation of natural habitats into isolated patches is a process highly characteristic of urban areas and typically detrimental to native biodiversity. Connectivity has the potential to mitigate this threat, through increasing the survival rates of inhabitants in patches as well as increasing the colonisation rates of species that have been lost from a patch.

Greenways in urban areas serve multiple functions, which may be tough to reconcile. In Singapore, the function of the Park Connector Network is primarily to provide Singaporeans with user-friendly routes between parks and secondarily to link major parks and spaces as wildlife corridors. However, the presence of a greenway itself does not guarantee benefits to biodiversity; the usage of the park connectors by fauna is still being documented. Furthermore, a narrow two-metre-wide planting strip considered in isolation is evidently insufficient for the movement of truly forest-associated species. A study in 1996 by the National University of Singapore (NUS) examined the bird communities of green corridor systems and linear habitats. National Parks Board (NParks) has conducted further studies to expand knowledge of park connectors as habitats and corridors for birds, butterflies, and dragonflies.

In 2012, the senior author of this paper studied the biodiversity along 400-metre-long transects in 10 different park connectors, conducting monthly surveys for one year. They were separated into “urban” and “rural” connectors. Birds were recorded up to 50 metres on each side of the park connector, and butterflies and dragonflies up to 10 metres on each side. Direct and indirect usage of the park connectors were analysed separately. Surveys for birds started at 7.30am, while surveys for butterflies and dragonflies started at 9.30am, because the latter are more active in warm sun. By covering a range of park connectors over one year, the quantitative data collected can be used to elucidate factors influencing park connector biodiversity, formulate guidelines to improve the Park Connector Network as wildlife habitat and connectors, and create outreach material for the public. This is only one of the aspects of connectivity that have been studied by NParks; others range from theory-based computer modelling of least-cost pathways to the practical implementation of differing planting patterns.

What We Found

A total of 90 species of birds, 57 species of butterflies, and 22 species of dragonflies were recorded from the 10 transects on survey days. These figures do not include individuals that could not be conclusively identified nor sightings reported on non-survey days.

Birds

The birds recorded are generally common to urban, park, and disturbed forest-edge habitats. Interestingly, some locally uncommon species typical of forest habitats were also recorded, but only park connectors bordering forested land contained species found in forest edges. A number of these species had not been formally recorded at the survey sites previously, and their presence in such urban settings is notable. Omnivorous species were the most abundant across all connectors.

Out of 90 bird species, 28 were migrants. It is likely that these stopped by vegetation patches along park connectors to rest and feed en route to and from wintering grounds. There was a trend of higher mean abundance, mean diversity, and total diversity for birds in rural transects than urban transects.

Many species obtained food along the Park Connector Network. The presence of flowering or fruiting trees attracted large numbers of birds, in particular frugivores and omnivores. Some birds appeared to hold territories along it, as territorial calls were regularly heard from some species. The male advertising songs of these species also indicate mate attraction, a precursor to breeding. A few bird species, notably those commonly found in urban areas and parks, were observed to be breeding along the park connectors. Active nests of the Striated Heron, Pink-necked Green Pigeon, and Olive-backed Sunbird as well as young birds

Migrants worldwide are declining due to dwindling stopover sites for the birds to rest and feed. Food sources at park connectors can provide migrants with some food resources to replenish their energy and continue their journey.

of numerous species were seen. This suggests that despite the narrow planting edge, some urban-adapted species are able to use the park connectors as breeding sites and were thus successfully colonising them, not just using them as travel routes.

Butterflies

Most of the 57 butterfly species recorded are common to urban, park, and open grassland habitats. Urban-adapted park species dominated the numbers, while forest-associated butterflies were recorded at the more rural transects. Urban-adapted butterfly species that were consistently recorded at all park connectors were those that occur in more than one habitat type and have more than one host plant.

There was a trend of higher mean abundance, mean diversity, and total diversity for butterflies in rural transects than urban transects. Most were seen feeding at flowering shrubs and trees along the park connector, suggesting that food provisioning is a major function of park connector vegetation for butterflies too. Even if breeding did not take place directly within park connector vegetation, the planting of nectar-rich plants and presence of flowering trees attracted butterflies. Even flashy species that were previously restricted to more natural areas have now spread to urban parks and gardens with suitable planting schemes.

Dragonflies and other creatures

All 22 species of dragonflies recorded are common in disturbed habitats, with the exception of the locally uncommon Dingy Duskhawker, a forest-associated species, and the Grenadier, found at forest edges near shaded drains. Both were recorded only at Ulu Pandan next to secondary forest. The only species recorded at all transects was the Wandering Glider, hovering above the park connectors on clear, sunny days. As the overall dragonfly numbers and species recorded were very low, a comparison between sites has not yet been done.

A number of common mammals, reptiles, and amphibians were recorded and provide an idea of the type of fauna present. Long-tailed Macaques that are habituated to humans can be a nuisance when they harass people for food, which has happened in the past at the Ulu Pandan Park Connector. If established along park connectors, measures may be required to enforce a no-feeding rule. None of the snakes seen are venomous to people, but negative public perception of snakes may result in snakes being killed. The Changeable Lizard is an introduced species that is outcompeting the native Green Crested Lizard especially in urban areas.

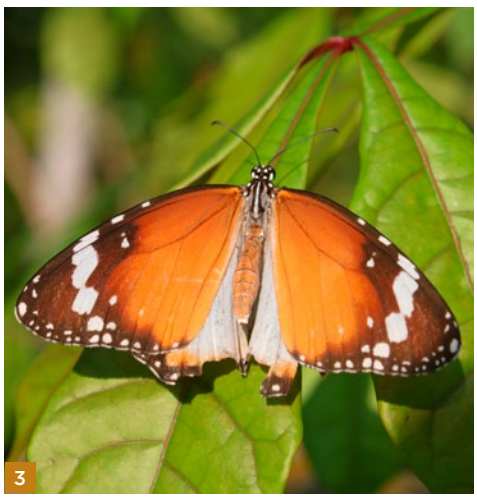
Factors Affecting Biodiversity

Vegetation density

Wildlife does use the vegetation within the park connector. High planting density did not necessarily reflect high biodiversity, but a lack of plants resulted in a lack of fauna. In our study, there was no clear statistical correlation between species abundance and diversity for birds and butterflies, nor between species abundance and the number of mature trees or estimated shrub cover.

Planting schemes

The type and state of plants within the park connector directly



1. The Central Catchment Nature Reserve ensures that the park connector along Mandai Road retains its rural atmosphere in spite of being near busy traffic (Photo: Geoffrey Davison).
2. Damage to the leaf tip of a Bird's Nest Fern has created an interesting sight for park connector users (Photo: Geoffrey Davison).
3. The Plain Tiger (*Danaus chrysippus*) is one of the 57 species of butterflies so far recorded making use of flowering shrubs along the Park Connector Network (Photo: Geoffrey Davison).
4. If they are positioned so that sticky fruits do not fall on pedestrian pathways, trees such as *Flacourtia rukam* can provide a rich source of food for wildlife (Photo: Geoffrey Davison).

5

6

influence the number of individuals present. Species abundance within 10 metres of the Park Connector Network was consistently higher when plants were flowering and fruiting. Floral diversity had a strong positive influence on pollinator diversity. The presence of suitable host plants was important too. It is also important to note that imported ornamental plants harbour eggs and can serve as host plants for non-native species such as the Leopard Lacewing and Lime Butterfly, which then establish populations in urban areas.

Maintenance

Frequent and intrusive maintenance works are disruptive to fauna, especially during breeding. Reducing the impact and frequency of maintenance would therefore be beneficial to biodiversity. Breeding within 10 metres from the path was observed mostly at rural transects that had lower levels of maintenance. Likewise, butterfly abundance dropped when surveys took place shortly after grass-cutting had removed the flowers of common weed species.

Waterside habitats

Park connectors that run along drainage culverts contained an impoverished community of water-associated species adapted to human-modified, open waterways, but added to the total diversity of species associated with the Park Connector Network. At such disturbed sites, species with more specific requirements tended to be passage migrants or winter visitors that stop by to feed. During the migration period, the White Wagtail, Little Ringed Plover, Common Sandpiper, and Black-capped Kingfisher were recorded hunting for fish or feeding at algal patches within the canal boundaries. Dense vegetation of merely two metres in width could preserve and enhance the resident riparian bird community along such park connectors. Therefore, riparian vegetation reinstated by beautification projects would in theory attract more waterbirds, but for the high levels of human activity.

Adjacent land use and habitat diversity

The type of land use adjacent to the park connector affects the avian species composition, diversity, and abundance along the park connector itself. Transects adjacent to natural and suburban areas had greater species diversity and an even spread of abundance within the park connector. Source populations from surrounding landscapes determine the wildlife community, with wildlife in adjacent habitat patches emerging to forage in park connector vegetation, resulting in a spillover effect. As such, park connectors function as buffer zones for natural and suburban habitats.

Natural vegetated areas contain greater habitat diversity than urban manicured or built-up environments, potentially supporting a more diverse and robust wildlife community. Some park connectors are bordered by a mix of secondary forest patches and residential areas. The different habitats cater to species with various preferences. While such a diversity of habitats is beneficial for species diversity, care must be taken to keep the existing habitat patches intact.

Park connectors near urban areas possessed the lowest bird diversity. There were high densities of omnivores, frugivores, and introduced species due to the planted fruit trees and presence of human food waste. Urban connectors were dominated by human-associated birds such as the Eurasian Tree-Sparrow, Javan Myna, Feral Pigeon, and House Crow, even where wildlife-attracting plants have been added.

High levels of human activity (for example, insecticide fogging, loud music, and feeding of feral animals) result in reduced

5. Ulu Sembawang Park Connector is popular with those wishing to get away from the bustle of urban Singapore (Photo: Geoffrey Davison).
6. Clear signage is essential for users, to guide them on their way and to ensure safe and proper use of the facilities (Photo: Geoffrey Davison).
7. Even along roadsides, park connectors may benefit organisms beyond birds and butterflies and create interesting and unusual patterns in nature (Photo: Geoffrey Davison).

diversity and adversely affect the behaviour of wildlife. Native bird activity was restricted to crown foliage when large numbers of people were using a park connector. Increased movement along the lower level was observed when human activity ceased towards the later part of the morning.

The Value of Park Connectors

The greatest value of park connectors is as a food source; most wildlife within the Park Connector Network was recorded foraging and feeding. The quality and abundance of food—fruits and insects—attract birds from habitat patches nearby, regardless of whether they held territories within the park connector. Likewise, plants in bloom that are food for butterflies attracted large numbers of butterflies. As insects are a crucial food source, the presence of a healthy insect community at the park connector would in turn attract more birds. Planting suitable food plants is thus proving to be a successful strategy to attract both urban-adapted and forest-edge species to use the park connectors and enliven them with their presence.

Urban habitat patches are crucial for the survival of migratory birds. Migrants worldwide are declining due to dwindling stopover sites for the birds to rest and feed. Food sources at park connectors can provide migrants with some food resources to replenish their energy and continue their journey. Dense tree cover, like that along Bishan and Ulu Pandan transects, is likely to attract and support migrants even in urban areas.

A complete habitat must provide suitable breeding conditions, in addition to adequate food resources. For birds, the successful colonisation of the park connector habitat was indicated by territory defence and successful breeding. In this respect, park connectors are limited as habitats. It is unsurprising that active nests within the park connector are uncommon, as narrow corridors increase nest visibility and vulnerability to predation. Findings show that only urban-adapted birds can exploit the park connector to its full potential as a habitat.

On the other hand, butterflies and other invertebrates operate on finer scales than vertebrates and are thus capable of exploiting smaller patches. Apart from records of feeding invertebrates, the presence of caterpillars and ovipositing dragonflies indicate breeding to be taking place. Furthermore, species such as the Common Birdwing, Malayan Eggfly, and Centaur Oakblue that were previously restricted to natural habitats are now regular occupants of urban gardens due to planting of their host plants. Urban green spaces, including park connectors, can thus be of high conservation value for butterflies, supporting endangered species if managed appropriately.

For birds, forest-associated species were notably absent from park connectors that merely link forest patches but lack adjacent forests; poor colonisers and species vulnerable to urbanisation are unable to utilise park connectors as movement corridors. If the full potential of park connectors as wildlife movement corridors is to be realised, their planting width requires widening, simulation of more forest-like conditions, and “borrowing” of flanking greenery.

Urban-adapted generalists that already use such corridors as habitats or food sources may naturally disperse along them. Movement along park connectors thus allows generalists to establish in urban habitat fragments. More detailed work through tagging individuals is necessary to fully understand their movement along park connectors.

Butterflies appear to readily utilise park connector vegetation as movement corridors. Connectivity is a major influence on the

8

species composition and richness in urban areas. The long grass habitat along Zhenghua Park extends to the mature grasslands and secondary forest at Dairy Farm Nature Park, providing connectivity between fragmented habitats and enabling species to colonise the park's suitable habitats from source populations. This results in Zhenghua's diverse butterfly community. Park connectors have high potential to link butterfly habitats and hence enhance the diversity in urban areas.

What More Can Be Done?

Optimising the design and planting of park connectors maximises their potential to support biodiversity. Minimising the frequency and area of maintenance not only makes park connectors more conducive for wildlife but also helps cut costs. Information boards that highlight the biodiversity present and explain the wildlife-friendly features of the park connectors are great outreach opportunities that also manage user expectations, especially in areas with reduced maintenance.

Successful features for urban areas can be replicated across the Park Connector Network. Planting heterogeneous layers (as at Bukit Panjang Park Connector and Kolam Ayer) that include existing mature trees and layers of small trees and shrubs creates diverse habitats. This also provides shade for human users. The extension of the Park Connector Network concept into Nature Ways is in line with this heterogeneity.

Features such as butterfly gardens (as at Pangsua Park Connector) provide nodes of interest for human users and increase the habitat potential of park connectors. These biodiversity focal points can be situated away from high-density residential areas, allowing for denser planting and lower levels of maintenance. Care needs to be taken to ensure that these features are linked through continuous vegetation stretches.

Planting food plants, including species with nectar-rich flowers and succulent fruits, has proven to be effective in drawing wildlife to the park connectors. The flowers are often brightly coloured and aesthetically attractive to human users too. To minimise any inconvenience from bird droppings and falling fruit, larger fruiting trees are planted further away from the path when possible.

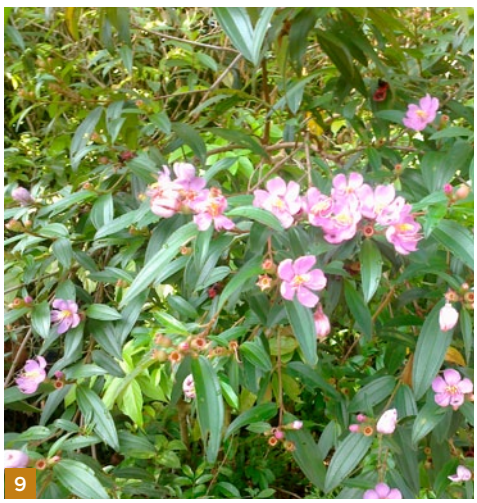
Continuous stretches of vegetation are more effective than isolated pockets and provide greater connectivity for the movement of urban-adapted species. Planting mixed species

Ulu Pandan Park Connector—15 Years On

In a study of Ulu Pandan by NUS in 1997, 60 species of birds were recorded along the park connector, 17 fewer than in this study. The bird community remains very similar, comprising resident bird species of forest-edge and park habitats, waterbirds, and migrant species. Abundance in the NUS surveys ranged from 79 to 174 individuals, not greatly different from our study, which recorded 69 to 122 individuals.

Some uncommon species recorded 15 years ago were not seen recently, but probably still occur from time to time. Waterbirds such as the Slaty-breasted Rail, Wood Sandpiper, and Yellow Bittern were missing from this study, as were forest-associated residents such as the Abbott's Babbler and Banded Bay Cuckoo. Land use intensification and conversion could have led to their disappearance.

Records of passage migrants often depend on luck. In our study, species such as the Chestnut-winged Cuckoo, Asian Paradise Flycatcher, and Ashy Minivet were recorded. Today, the introduced White-crested Laughingthrushes and possibly introduced White-eyes have also become established along the park connector. Raptor diversity has increased since 1996. Four of seven raptors recorded here have resident breeder status locally. While no nests were recorded, the White-bellied Fish Eagle and Brahminy Kite are suspected to hold territories there. Of particular interest is the presence of the locally rare Grey-headed Fish Eagle. Consistent with our results, the NUS study noted feeding to be the principal activity in the park connector as well as the occurrence of territory defence. The authors also propose bird abundance to be more influenced by vegetation and habitat structure than by the degree of human activity.


9


10


11

8. Well-shaded for joggers and cyclists, the Ulu Pandan Park Connector is flanked by Pink Trumpet trees (*Tabebuia rosea*) on one side and a canal on the other (Photo: Geoffrey Davison).
9. The Straits Rhododendron (*Melastoma malabathricum*), a common wild shrub, is both attractive and provides fruits and nectar to a range of insects and birds (Photo: Geoffrey Davison).
10. Amongst the smallest yet commonest of birds using park connectors is the Common Tailorbird (*Orthotomus sutorius*) (Photo: Cai Yixiong).
11. Positioning park connectors near to canals and waterways can increase their value by sharing space. Otherwise a White-bellied Sea Eagle (*Haliaeetus leucogaster*) could hardly be expected along such a narrow corridor (Photo: Cai Yixiong).

Key Messages

- Even linear park connectors provide some additional habitat for a range of urban species.
- While transient movements and foraging account for most observations, some species can use the Park Connector Network for breeding.
- Forest-dependent wildlife can only be anticipated where a park connector runs adjacent to existing forest.
- Park connectors "borrow" value from neighbouring land and vice versa.
- One quarter of Singapore's bird species have been sighted in or close to park connectors.

together (like at the butterfly garden at Pangsua Park Connector) instead of multiple pockets of one species creates more diversity to support a greater range of species, especially of invertebrates.

The overall idea behind rural park connectors is to leave the existing vegetation intact with minimal maintenance. Additional planting of wildlife-attracting food plants will enhance the habitats, but this should not be at the expense of existing vegetation. Native species are preferred, but cannot be used exclusively.

While our park connectors may have significant recreational and wildlife value, they alone may be insufficient in sustaining the wildlife sighted there due to their extremely narrow planting verge. Such narrow strips of vegetation can scarcely be utilised by more sensitive and at-risk forest-associated species to move from one patch to another. The biodiversity present within parks connectors is largely determined by habitats beyond the park connector rather than within the connector itself; any forest-associated species present probably originated from adjacent forest patches.

Nonetheless, park connector habitats do provide valuable resources for those more tolerant, urban-adapted species and can provide alternative habitats for species traditionally present in parkland. Increasing the presence of wildlife at such highly visible and oft-visited sites enables the public to enjoy Singapore's astonishingly rich native urban biodiversity. Information boards and guided walks are examples of useful outreach avenues to increase awareness, engagement, and support for conservation in urban areas.

Features that attract and enhance biodiversity within park connectors include continuous plantings in heterogeneous layers that include large, mature trees with overlapping crowns. Planting food plants has proven to be successful in attracting fauna and extending the area and diversity; interspersing multiple species during planting can increase their effectiveness. As surrounding landscapes support important source populations, retaining the existing natural habitats within and adjacent to park connectors is as important as enhancing the vegetation of the park connector itself.

There is reason for optimism regarding the role of park connectors for urban biodiversity. Small but good-quality habitat patches in a network matrix are especially crucial in a dynamic urban environment such as Singapore's. Optimal park connector habitats hence have the potential to provide habitat refuges within an otherwise challenging urban environment. NParks has since progressed to complement the Park Connector Network with densely planted Nature Ways and the forthcoming Round Island Route. CG

Island Biodiversity

Urban Ecosystems

While our nature reserves and natural areas boast a rich biodiversity, our urban areas are just as important to biodiversity. In Singapore, the extent of urban habitats is significantly greater than our nature areas, and enhancing urban areas to provide habitats for native species will help to protect our biodiversity by giving them more viable habitats.

Nature Ways

As part of the City in a Garden initiative, NParks has been creating Nature Ways to facilitate the movement of animals from one natural habitat to another. These green corridors are planted with specially selected flora to attract biodiversity (e.g. plants that provide food or shelter). They support our urban biodiversity by providing linkages between habitats. Currently there are 38 kilometres of Nature Ways in Singapore. By 2015, NParks hopes to increase this to over 60 kilometres.

12

12. National Parks Board is adding further to the Park Connector Network by developing a much greater variety and density of planting along a selection of Nature Ways (Image: National Parks Board).