Green corridors and the quality of urban life in Singapore

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Abstract

Urban green corridor systems are readily accepted worldwide as a desirable recreational, wildlife and landscape resource and can bring many benefits to urban dwellers .The planning, design, use and management processes are critical factors in determining successes in meeting quality of life indicators. In Singapore, an island-wide network of park connectors is currently being implemented. This paper outlines the results of a two year research project to assess whether such provisions do meet people's needs and aspirations. Results indicate that such resources are popular and regularly used for many activities that range from the active to the passive. Critical factors are close proximity to habitation, good facilities for different users, convenient variety of access points, continuity of off-road trails, and attractive habitat and wildlife. Understanding people's deeper feelings including fears and delights, pleasures and worries in relation to urban corridors cannot be achieved through on site observations and questionnaires .The use of focus discussion groups is invaluable. The presence of birds in such corridors is not only dependent on habitat provision but also, on the nature of adjoining land uses, types of recreational activities, and numbers of users. It is concluded that designing such resources must include a combination of ecological and social research methodology in order to successfully capture the various needs, aspirations, and emotional reactions of users.

INTRODUCTION

Singapore is a highly urbanized island city-state that was once covered with dense tropical forest. Clearing of natural areas began in the late 19th century, and gathered momentum particularly in the post-1960's period after independence from the British Colonial authorities. With the advent of internal self-government in 1959, the Singapore government was confronted with a plethora of problems including rapid population growth, housing shortages, high unemployment and inadequate infrastructure. The economic and social programs that were initiated to address these problems included land use planning and land/building development. This often entailed the clearing of natural areas such as forests, ridges, swamps, coral-fringed coasts, and the damming of rivers for reservoirs. As a result, between 1960 and the mid 1990's, the portion of Singapore covered by forests decreased from 6.5% to 4.4%, and mangroves dropped from 7.9% to 2.4% (Hilton 1995). At the same time, the proportion of developed areas almost doubled from 27.9% in 1960 to 49.3% in 1996 (Wong 1989, Ministry of Information and the Arts 1996).

As Singapore's natural areas were cleared, they were replaced with other forms of nature "constructed" to satisfy a range of human needs: specially designed parks, roadside trees and shrubs, road dividers, open spaces such as car parks, walls and pedestrian bridges covered with creepers. Singapore's landscape was transformed from dense tropical forest to an equally dense built-up environment, entailing a sort of paradox. On the one hand, natural areas continue to be destroyed. However, on the other hand, policies and actions have been introduced to "green" the city. As a result, the form of nature most familiar to Singaporeans is managed messicol vegetation[1] planted deliberately to provide some balance in an increasingly urban environment. The average Singaporean has little contact with naturally occurring unmanaged vegetation and wildlife on the island.

In the *Revised Concept Plan for Singapore*, the Urban Redevelopment Authority (URA) included a *Green and*

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Blue Plan that identified areas of open space throughout the island designed to meet recreational needs, protect the natural environment, and improve biodiversity (Liu 1991). The Plan incorporated earlier proposals by the Nature Society of Singapore, which identified areas suitable for nature conservation (Briffett 1990). Subsequent to this, government agencies have sought to establish the overall nature of the island-wide network by carrying out master planning strategies and regional studies through Development Guide Plans, or by undertaking micro studies of parks, reserves or specific development sites. Plans for all 55 planning districts were completed in 1998. One study was a comprehensive overview of water body planning and design concepts, the purpose of which was to exercise a degree of planning control and to encourage developers to protect, improve, and enhance existing water body areas in Singapore (Urban Redevelopment Authority 1993).

After the *Revised Concept Plan* was adopted, the former Parks and Recreation Department of Singapore (now incorporated into the National Parks Board) published a proposal for an island-wide park connector network (Straits Times 1992) designed to meet the perceived growing need for a range of alternative recreational facilities. The implementation of the entire park connector program, which will ultimately extend for a total of approximately 300 km, was envisioned to take up to 30 years (Straits Times 1995). The park connectors were planned primarily along existing water drainage culverts and river systems to act as connectors to national, regional and local neighborhood parks and coastal areas throughout Singapore. They were intended as an open space facility for off-road cycling, jogging, exercise and walking across the island, away from the danger, inconvenience, and pollution of the main roads.

Considerable work is still required in the selection, formation, and implementation of connectors in order to bring about the original vision. This includes landscaping, trail construction, facilities such as lighting, seating and exercise centers, and in particular the construction of road crossovers at grade road cycle crossings, tunnels, and bridges (Straits Times 1996). Work on the network has begun, with priority to the outdoor recreation needs of the city-state's completely urban population. The potential to cater to wildlife as well as human recreational needs in the connector network was first put forward in 1993 in the *Singapore Green Plan - Action Programmes.* The original Green Plan, from which the action program was developed, was prepared by the Ministry of the Environment for the Rio Summit as its contribution to the blueprint for a global sustainable development action program. In this plan, the Ministry described Singapore's green network as "a tapestry of green to make parks and nature sites more accessible to the public and to provide corridors for the movement of bird life" (Ministry of the Environment 1993).

Urban park connector systems in other parts of the world today frequently incorporate recreational and wildlife requirements. A primary feature of these multi-purpose systems is the interaction between people and wildlife, and the many ways in which each influences the other. Corridor planning, design and management approaches have evolved accordingly to incorporate land planning and ecological factors into decision making. This study examined how the island-wide park connector network proposed by the National Parks Board of Singapore can be designed to meet the needs of human users and, by improving biodiversity, meet the needs of wildlife. As the island-wide park connector scheme is still in the early stages of implementation, it is an appropriate time to evaluate planning, design, and management criteria to better meet the needs of people and wildlife in the connector system.

PROJECT AIMS AND OBJECTIVES

This study explores human relationships with nature in Singapore. The population is totally urbanized and a scarce number of natural areas remain in their original form. An entire generation is growing up in an "urban jungle" rather than a more natural setting. We see this study as particularly relevant to Asia, where urbanization is taking place at an accelerating rate and, in our view, there is an urgent need to understand urban dwellers' relationships with nature.

The focus in this study is Singapore's green corridor. Specifically, how people use the corridors, what kind of wildlife and habitats are in these areas, and what the relationships are between human use and wildlife needs. The primary aim is to understand human-nature interactions which may inform policy making and the planning, design, use and management of Singapore's green corridor system. The research objectives were:

to assess the degree to which selected corridors in Singapore meet social, cultural, and recreational needs as well as wildlife habitat requirements;

to develop, test, and analyze monitoring techniques for assessing the effectiveness of corridor systems to meet human social, cultural and recreational needs, and wildlife habitat requirements; to ascertain the reasons for, and benefits of, creating open space corridors in urban settlements; to develop planning, design and management criteria for urban green corridors in Singapore.

An established green corridor along the Ulu Pandan Canal was chosen as the focus for site-related data. Household surveys were carried out in the neighborhood, and focus groups were convened for more wide-ranging discussions.

RECREATION SURVEYS

Three methods were used:

- observation at access points, along the canal and within the park connector, to characterize the users, time of use and user activites;
- on-site questionnaire surveys, to ascertain user views of the canal and the natural world;
- household surveys with users and non-users in estates adjoining the canal, to determine their views and preferences concerning nature in general and the canal in particular;

Observations at access points

A total of 4,087 people were observed entering the Ulu Pandan Canal park connector. Most visitors (70%) were male. Arrivals peaked before 9 a.m. (31.3%) and in the afternoon after 4 p.m. (50.9%). Over 70% of the people walked or jogged, 25% cycled and 3.7% drove and/or roller-skated. Most people (85%) were below 50 years of age, and the largest single age group was 21 to 30 years (25%). Singaporean men in this age group would be expected to keep fit as part of their army training. Most visitors were Chinese (78.5 %), followed by approximately 10% Malay, 4% Indians, and 5% Caucasians.

Observations within the site

Observations were conducted to determine what people actually do in the connector. This made possible a degree of correlation between recreational intensity and bird/habitat surveys. It also provided a measure of the popularity of areas.

Activities are defined as pursuits that involve energetic exertion in sport, exercise, play, and keeping fit. More passive behavior relates to deportment, moral conduct and treatment of others, or use of the senses. The results suggest that active pursuits such as jogging, walking and cycling are more common than passive activities such as resting, conversing or listening. Most users wish to indulge in constructive activity, which meets exercise and health objectives. There is also a strong bias toward activities which involve other people, such as conversation or people watching, rather than activities, which center on natural features such as trees, flowers, and wildlife.

A wide range of behaviors (43 types) were observed; from walking and talking, to listening to throwing stones into the water (Briffett et al, 1997). Problematic activities are relatively few and constituted less than 0.5 % of the total. This could result from design — the attractive and easy to use trail facilities – or from Singaporeans' general tendency to behave respectfully towards others. It may also be due to the openness and visibility of the area, or it may simply mean that, compared with people in other countries, Singaporeans tend to conform to the rules.

On-site questionnaire surveys

Using this method we obtained information on corridor users' opinions, desires, and preferences. Of those interviewed, 64% were male. Most (83.8%) lived in public housing, and 77% had visited the park connector on foot from nearby housing estates. 18% came on cycles and 2% drove cars to the park connector. Most (96%) stayed no more than 2 hours. For a small minority (3.3%), it was their first visit. About 85% of the visitors were regulars, visiting at least once a week. Most (97.7%) had come for walking, jogging and cycling. 67.7% of respondents gave "to get some exercise" as their main reason for visiting the place. About 27% of respondents learned about the park connector through friends or family, and the others learned about the park connector on their own when passing by or seeing it from their home. When asked to describe the place, 23.5% of the respondents said it is a good place for exercise; about 50% of respondents liked its environment, good air, quiet, and vegetation. Most respondents (80%) rated the park connector as quiet and a place that they like, and 75% rated it as safe. About 40% considered it valuable relaxation and recreation.

When asked about their dislikes of the place, 35% offered no comments. The strongest dislike was that the place was smelly (16%), and that there was a lack of shelter, lighting, and vegetation. There was also criticism of the construction development adjoining the corridor, and the inconsiderate behavior of certain cyclists. Changes suggested were: more and better facilities (30%), cleaning up the canal and more shelter and lighting. Among the natural elements users notice most on site are trees (99.7%), grass (99%), water (99%), flowers (94%), birds (86.5%), dogs (71%), butterflies (53%), mosquitoes (45%), frogs (32%), snakes (32%). Regarding interactions with natural elements, only 49 people said that they come into voluntary contact with birds. About the same number (50 people or 16.5% of respondents) was recorded for flowers, grass (14%), and trees (15.8%). The encounters with birds, flowers, trees, and water were generally considered to be pleasant.

HOUSEHOLD SURVEYS

This survey covered two groups: users and non-users. More in-depth information was obtained by this method compared to the on-site interviews, as it was possible to engage interviewees longer on the doorstep than in the middle of an outdoor activity.

Non-users

Among the 300 respondents surveyed, 124 (41%) had used Ulu Pandan Canal at least once, and 176 (59%) had never used it. Significantly more non-users (62%) are female than male. Just over half of the 176 non-users did not use the connector because they did not know about it. Others cited that it is not within walking distance (16%), and that other recreation options are nearby (12%).

Users

The results are broadly similar to those obtained in the on-site user survey and observations along the canal noted above. Proximity and opportunities for exercise and relaxation were the most common factors, or to simply "get out of the house for a while." Far less significant, though still important for a few (15%), is the opportunity to observe wildlife. Residents' views on and experience with plant and animal life, and users' views of nature were generally positive with 72% agreeing that nature contributes to their sense of well being. This is consistent with the statement that they enjoy observing greenery from afar (69%).

Those who appreciate getting closer to nature prefer contact with greenery to contact with wildlife. Nearly 67% said they enjoyed contact with greenery, only about 40% said the same about wildlife. Of those favoring greenery, 64% said they preferred walking through tidy and well-trimmed greenery rather than naturally growing vegetation. This could be because some 58% of users believe that dangerous insects and larger animals hide in tall grasses. Some aspects of nature, such as mosquitoes and ants, are considered irritating. Others, such as snakes and dogs, are thought to be frightening. Others such as birds, butterflies and trees and flowers are not only pleasant, but also elicit feelings of calm and peace, evoke surprise, and engender enthusiasm and interest. An overwhelming proportion of users (95%) evaluated its natural scenic beauty positively. Evaluations varied widely, however, in terms of specific elements in the developed environment.

Users are most concerned with improving facilities, mainly the provision of shelters, lighting, benches and exercise stations. Users were also asked about preferred connector designs, particularly paths, vegetation and water. Although users did not express a preference for straight or curved paths, a circular path (44%) was preferred slightly more than a one-way path (27%). Users showed a clear preference for paths more than 6 meters wide (75%), separate walking and jogging paths (72%), and paths with a number of access points rather than access only at each end (82%). More respondents preferred a combination of sloping and flat paths over sloping paths alone. As for vegetation, only slightly more users preferred a path well shaded by trees and shrubs planted near pathways (55%). By contrast, others preferred trees and shrubs further away so that all activity could be clearly seen (44%). 46% wanted a path with rows of flowering shrubs and a mixture of medium and high trees alongside, but 25% preferred short grass and 26% preferred natural growth. The responses show that people are ambivalent about the depth of water in the Canal, perhaps because some sections are smelly. Other kinds of water features, such as ponds, streams, waterfalls and fountains, are viewed favorably. Vegetation associated with water bodies (water lilies and tall reeds) is also generally welcomed.

ATTITUDES AND AWARENESS

Scope of study

Determining attitudes toward and awareness of nature is complex. Efforts were made to measure the extent to which users of corridor systems held affinity for nature and to assess their knowledge and experience. The surveys were conducted in three corridor locations at Pasir Ris Park, Bishan Park, and West Coast Park, and included interviews with users and a questionnaire.

In-depth focus group discussions were held with two groups of users and non-users to elicit the subtler and less tangible aspirations, perceptions and opinions giving rise to attitudes, values, and beliefs held in regard to nature. A full analysis of these discussions is published in Kong et al. (1997) and Kong et al. (1998).

Knowledge and experience of nature

Most respondents (87%) reported nature as one of their hobbies, even though only a quarter of them (27%) owned a pair of binoculars for bird/animal watching and an even smaller number (5%) were members of the Nature Society Singapore. Perhaps because of their interest in nature, almost half of the respondents (46%) said they were aware that the park was part of the island wide park connector system, and 67% knew that a bird sanctuary was located in the park. Many users were regular visitors to the particular park in which they were interviewed, and their satisfaction with the park as a nature resource seemed to have been confirmed in these answers. The majority who did not have a strong enough interest in such activities as birdwatching due to non ownership of binoculars, still derive much enjoyment in seeing, hearing and being close to nature. Knowledge of bird sanctuaries which they do not necessarily visit or use is interesting, and again confirms that many people may be prepared to support nature even without indulging in it or getting any direct personal gain from it.

Interest and awareness in nature was also measured by their knowledge of plants and animals. Interviewees were shown a set of picture cards and asked to identify some very common flowering shrubs (such as hibiscus, lily, ixora, bougainvillea and bauhinia), animals (such as squirrel, bat, lemur, lizard, frog, monkey, snake, rat), common birds (such as oriole, dove, kingfisher, starling, crow) and common trees (such as coconut, causarina and tembusu). Most respondents (63%) could accurately name five out of the eight animals shown. In the case of birds, flowers and trees however, there was much less knowledge with over 80% unable to name more than three. The results of the actual species identification were much worse with 87-93% unable to name more than two species correctly. Knowledge of animals and plants has probably been derived from sources outside the park such as television, school nature studies, and general educational sources such as books, magazines and newspapers. The few participants who received better scores in both lists across all species were generally found to be Nature Society members.

Most respondents reported a positive association with animals and plants. Over 56% of the respondents did not think that dangerous insects and/or animals were hiding in tall grasses. Over 96% of respondents said that they enjoyed contact with nature, and 68% enjoyed contact with wildlife. More than 86% of respondents like to know that there were green areas nearby, even if they did not visit these places. This could be because a high proportion of them (90%) believe that nature can contribute to their sense of well being. 44% of respondents preferred walking through naturally occurring unmanaged vegetation rather than well-trimmed tidy greenery, while the remaining were either neutral (24%) or preferred to walk through more manicured areas (32%). These results have implications for park connector planning as it was previously perceived that the vast majority of park connector users preferred formalized, well-managed vegetation and responded positively to such things as pretty flowering trees and flower beds. These results confirm that natural unmanaged vegetation may also be preferred. As this feedback is derived from a limited number of participants, we suggest that the views of a wider range of users be obtained before developing future management strategies.

The positive views of nature could have stemmed from the respondents' everyday proximity to nature. When asked about their contact with nature, most respondents said they would voluntarily come into close contact with various wildlife, though some species are preferred over others; birds (51%), squirrels (50%), butterflies (41%) and fish (49%) are preferred to rats (1%) and snakes (7%).

Given their high affinity with nature, it is not surprising that most of the respondents (84%) voted for the conservation of some areas of the park for wildlife. One possible reason for this is the recognition that undisturbed areas are crucial to maintain a large number of bird species in the park.

BIRD SURVEYS

Two separate surveys were conducted to determine species richness, abundance and activity patterns of birdlife, and to assess categories of habitats in the corridors and general environments in the surrounding adjoining matrix. The first pilot study was conducted along the Ulu Pandan Canal using (4) 400m transects. Subsequent surveys were conducted in 9 other corridor locations as defined below. The 10 sites selected for the bird and habitat surveys comprised 3 main categories: drainage culverts, linear parks and forest edges. All these sites are included in the island-wide park connector network of Singapore.

The aim of bird surveys was to determine the extent to which all sites were successful in attracting birds. The specific objectives were:

- to determine and compare the bird community diversity among the ten surveyed areas,
- to identify the characteristics (e.g. vegetation cover) of the linear areas that affect bird diversity and abundance,
- to make recommendations for the planning, design and management of park connectors.

Research methodology

Bird surveys were carried out between April 1996 and December 1997. Transects were chosen to represent different types of vegetation/habitat within each site. Each transect was visited 10 times at monthly intervals. All birds within 50 m of both sides of the transect were recorded. All birds seen or heard between 7am and 9am were counted on days without rain or heavy winds.

Bird community

The monthly mean number of individuals of each bird species was calculated for each site based on the transects surveyed. Species diversity was calculated by using the Shannon-Wiener formula; $H' = \text{å}p_i \times \log p_{I.}$ where p_i is the proportion of species *i* in the corridor. A cluster analysis was performed to determine the bird community similarity among sites.

Because the habitat characteristics both within and immediately surrounding a site affect bird community composition and abundance, 500 m radius circles were drawn from the center of each transect. These circles were drawn on 1:50,000 topographic maps obtained from the Urban Redevelopment Authority of Singapore. Within each circle, 2 independent observers estimated the percent cover of the built environment (buildings), open space (hardstandings, car parks, golf courses, roads, playgrounds and swimming pools), vegetation (unmanaged and managed vegetation, connector edges, and overgrown waste grounds) and water (sea, ponds, lakes and culverts). Estimates from both observers were averaged. To determine how site characteristics affect bird communities and abundance information was drawn from individual transects for a given site.

To determine which site characteristics (e.g. vegetation cover) affect the abundance of individual bird species a principal component analysis (PCA) was performed using the program SAS. Data matrix for PCA was the same used for the cluster analysis. Values of site characteristics were correlated with the first two principal axes using Spearman rank-order correlations (Jongman et al., 1987). Only characteristics that significantly correlated ($P < 0.05$) with the axes are discussed. To determine how the overall bird community size is affected by site characteristics, bird species numbers and diversity (based on January and March 1997 surveys) were correlated with the four site characteristics using Spearman rank-order correlations.

Results

One hundred fourteen bird species were recorded from all sites combined (Table 1). Despite differences in characteristics, an introduced species, the Javan Myna was the most abundant species at all sites.

Based on January and March 1997 surveys, the maximum mean number of bird species was recorded in Ulu Pandan Canal (29.50 ± 2.50) and the minimum at East Coast Park (10.50 ± 0.50). In the study of one of the established park connectors at the Ulu Pandan Canal 60 bird species were identified. Some of these bird species (Greater Racket-tailed Drongo and Banded Woodpecker) are usually found in native habitats such as the rainforest. In contrast the bird community in the more recently established connector, the Jurong Canal, was relatively depauperate with only 37 bird species recorded. The Ulu Pandan Canal connector is bordered by a diverse natural habitat. Three secondary woodlots (1-2 ha in area) were within 100 m of this connector (Sodhi and Briffett 1996). The bird community of Ulu Pandan was also similar to an established urban park, the Kent Ridge Park. The Duxton Plain Park bird community was different from all other surveyed areas because it had the highest abundance of human-associated species such as the Feral Pigeon, House Crow and Eurasian Tree Sparrow. This area is located in the Central Business District of Singapore and is the most intensely urbanized. The bird diversity was the highest in the Bishan Park (1.3) and lowest in West Coast Park (0.9). These data should be interpreted cautiously because of uneven sampling among sites.

Mean total bird species appeared to increase, although not significantly, with percent vegetation cover. Diversity was not significantly correlated ($P > 0.50$) with any of the site characteristics (coverage by built areas, open areas, vegetation and water). PCA and subsequent correlation revealed that as the amount of vegetation cover increased the abundance of both parkland bird species (Purple-backed Starling, Javan Myna and Pink-necked Pigeon) and forest bird species (Greater Racket-tailed Drongo, Olive-winged Bulbul, Short tailed Babbler and Greater Green Leafbird) increased.

Based on activity surveys conducted along five of the linear areas it was found that bird species forage and sing in linear areas, including the Ulu Pandan Canal connector (Briffett et al.1997:70). Therefore connectors can possibly serve as functional habitats for some bird species.

IMPLICATIONS FOR DESIGN AND MANAGEMENT

This study has important implications for the design and management of the park connector system in Singapore and possibly other similar urbanized tropical areas. Management and landscape planners should not only concentrate on planning within the connector, for example, planting of native vegetation, but also should plan to incorporate surrounding landscape features that will eventually enhance the biodiversity value of connectors. This was confirmed in other research conducted on metapopulations elsewhere (Janzen 1983). The study shows that human-made corridors or linear habitats are successful in attracting a large number of both migratory and resident bird species. It was noted that the bird species carried out a variety of activities within the corridors suggesting that these corridors serve as functional habitats for bird species.

CONCLUSIONS

This study demonstrated that the planning, design and management of the corridor system has a significant effect on how people use the corridors, what wildlife are attracted to them, and what maintenance practices are employed. It has also indicated that each of these levels of decision making affects the others. It is necessary to design a comprehensive strategy that covers planning, design, management and maintenance and establishes fundamental principles on which all of these should be based. There is also a need to account for how each of these corridors is related to the others. The implementation details of such a plan can be revised at regular intervals to ensure that planting and maintenance techniques and the introduction of new designs and landscapes accord with the overall vision established in the plan. Corridor strategies should ultimately be based not only on the "biotic, abiotic and cultural factors peculiar to each local landscape," but also, "on the basis of inhabitant's values and perceptions" (Ahern 1995). Corridors extend through many different environments, from predominately natural — such as woodlands, unspoiled coastal shores and wetlands — to predominately urban — such as city centers and industrial estates. Each length presents different challenges in terms of what can be achieved through planning and design, and what kind of management program to adopt. Equally important, without knowledge of public attitudes and commitment to public participation, many innovative corridor schemes have failed through abuse and lack of support. Many researchers advocate the involvement of local groups and communities in the management of corridors and case studies are presented to confirm this (Adams and Dove 1989, Barker 1986, Goode 1990).

If sustainability is the aim, ecology should be incorporated into the regional planning of urban landscapes. Ecological principles could be considered a framework comprising content, context, dynamics, heterogeneity and hierarchies (Flores et al. 1998), as applied in a case study of the New York Metropolitan area (Yaro and Hiss 1996). Heterogeneity, diversity and connectivity within and among the components of green spaces contribute powerfully to the features and processes for which they are valued (Flores et al.1998). These factors also contribute to the complexity of interactive effects and potential conflicts amongst the multiple uses of corridor systems.

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1 This refers to vegetation planted by humans and in a strict sense refers only to crops planted for harvest. Hill (1973:31), however, extends the meaning to include plant communities, which are deliberately planted and maintained for purposes such as, aesthetic enjoyment and recreation.

Table 1: The mean number (±standard error) of bird species recorded in ten linear areas of Singapore. BP=Bishan Park, DF=Dairy Farm Road, DUX=Duxton Plain, EC=East Coast Park, JC=Jurong Canal, KR=Kent Ridge Park, PRP=Pasir Ris Park, SIME=Sime Road, UP=Ulu Pandan Canal and WCP=West Coast Park.

Species (Common Name)	Scientific Name	BP	DF	DUX	EC	JC	KR	PRP	SIME	UP	WCP
Grey Heron	*Ardea cinerea*	0	0	0	0	0	0	0.10±0.21	0	0	0
Purple Heron	*Ardea purpurea*	0	0	0	0	0	0	0	0	0.17±0.07	0.05±0.16
Striated Heron	*Butorides striatus*	0.33±0.17	0	0	0.11±0.07	0.50±0.33	0.07±0.05	0.45±0.28	0	0.33±0.12	0.25±0.35
Chinese Pond-heron	*Ardeola bacchus*	0	0	0	0	0	0	0	0	0.19±0.11	0
Black-crowned Night Heron	*Nycticorax nycticorax*	0	0	0	0	0	0	0	0	0	0.10±0.32
Cattle Egret	*Bubulcus ibis*	0.28±0.28	0	0	0	2.40±3.80	0	0	0	1.86±0.70	0.20±0.48
Little Egret	*Egretta garzetta*	2.33±1.04	0	0	0	0	0	0.05±0.16	0	0	0
Yellow Bittern	*Ixobrychus sinensis*	0.11±0.07	0	0	0	0	0	0	0	0.03±0.03	0.05±0.16
Cinnamon Bittern	*Ixobrychus cinnamomeus*	0.06±0.06	0	0	0	0	0	0	0	0	0
Glossy Ibis	*Plegadis falcinellus*	0	0	0	0	0	0	0.30±0.95	0	0	0
Black Baza	*Aviceda leuphotes*	0	0	0	0	0	0.11±0.11	0	0.05±0.16	0	0
Oriental Honey-buzzard	*Pernis ptilorynchus*	0	0	0	0	0	0.07±0.05	0	0	0.03±0.03	0
Black-winged Kite	*Elanus caeruleus*	0	0	0	0	0.05±0.16	0	0	0	0	0
Brahminy Kite	*Haliastur indus*	0	0.11±0.07	0	0.06±0.06	0.05±0.16	0.07±0.07	0	0.10±0.21	0.14±0.06	0.05±0.16
White-bellied Fish-eagle	*Haliaeetus leucogaster*	0	0	0	0	0	0.04±0.04	0	0.20±0.35	0	0
Grey-headed Fish-eagle	*Ichthyophaga ichthyaetus*	0	0.06±0.06	0	0	0	0	0	0	0	0
Japanese Sparrowhawk	*Accipiter gularis*	0.06±0.06	0	0	0	0	0	0	0	0	0.05±0.16
Slaty-breasted Rail	*Gallirallus striatus*	0	0	0	0	0	0	0	0	0.06±0.06	0
Red-legged Crake	*Rallina fasciata*	0	0.06±0.06	0	0	0	0	0	0	0	0
White-breasted Waterhen	*Amaurornis phoenicurus*	0.56±0.18	0.22±0.15	0	0	0.10±0.21	0.44±0.11	1.55±0.93	0.05±0.16	0.28±0.08	3.55±1.17
Pintail Snipe	*Gallinago stenura*	0	0	0	0	0.15±0.47	0	0	0	0	0
Wood Sandpiper	*Tringa glareola*	0	0	0	0	0	0	0	0	0.06±0.04	0
Common Sandpiper	*Tringa hypoleucos*	1.00±0.34	0	0	0.11±0.11	1.00±0.88	0	0	0	0.44±0.16	0.05±0.16
Little Tern	*Sterna albifrons*	0	0	0	0	1.05±2.83	0	0	0	0.08±0.08	0
Pink-necked Green-pigeon	*Treron vernans*	0.94±0.35	1.00±0.51	1.10±1.97	1.50±0.78	0.15±0.34	3.81±0.83	1.55±1.01	2.05±1.23	1.33±0.35	1.90±2.42
Rock Pigeon	*Columba livia*	0.56±0.24	0	11.5±8.96	0	6.95±3.69	0	0	0.05±0.16	0.61±0.19	0.20±0.48
Turtle Dove	*Streptopelia orientalis*	0	0	0	0	0	0	0.15±0.47	0	0	0
Spotted Dove	*Streptopelia chinensis*	2.11±0.81	2.67±0.70	0.80±1.87	0.72±0.24	1.15±0.75	0.59±0.17	3.85±3.17	0.30±0.42	2.31±0.35	2.55±1.30
Peaceful Dove	*Geopelia striata*	0.33±0.56	0.06±0.06	0	0	0.20±0.42	0	0	0.65±0.67	0.97±0.21	0.10±0.32
Emerald Dove	*Chalcophaps indica*	0	0.06±0.06	0	0	0	0	0	0.20±0.35	0	0
Rose-winged Parakeet	*Psittacula krameri*	0	0	0	0	0	0	0.05±0.16	0	0	0
Red-breasted Parakeet	*Psittacula alexandri*	0	0	0	0	0	0	1.15±3.13	0	0	0
Long-tailed Parakeet	*Psittacula longicauda*	0.22±0.15	0.17±0.12	0	0	0.10±0.32	0.11±0.11	0.70±0.86	1.50±2.26	0.08±0.06	0
Lesser Sulphur-crested Cockatoo	*Cacatua sulphurea*	0	0	0	0	0	0	0	0	0.11±0.06	0.25±0.54
Blue-rumped Parrot	*Psittinus cyanurus*	0	0	0	0	0	0	0	0.05±0.16	0	0
Eclectus Parrot	*Eclectus roratus*	0	0	0	0	0	0.04±0.04	0	0	0	0
Indian Cuckoo	*Cuculus micropterus*	0	0	0	0	0	0.04±0.04	0	0	0.03±0.03	0
Banded Bay-cuckoo	*Cacomantis sonneratii*	0	0.11±0.07	0	0	0	0	0	0	0.03±0.03	0
Little Bronze Cuckoo	*Chrysococcyx minutillus*	0	0	0	0	0	0	0	0	0	0.05±0.16
Tanimbar Cockatoo	*Cacatua goffini*	0	0	0	0	0	0.04±0.04	0.40±1.10	0	0	0
Drongo Cuckoo	*Surniculus lugubris*	0	0.11±0.11	0	0	0	0	0	0	0	0
Asian Koel	*Eudynamis scolopacea*	0.67±0.28	0	1.80+2.25	0.61±0.22	0.20±0.35	0.63±0.21	4.60±2.40	0	0.39±0.08	1.95±1.12
Chestnut-bellied Malkoha	*Phaenicophaeus sumatranus*	0	0.28±0.22	0	0	0	0	0	0.05±0.16	0	0
Greater Coucal	*Centropus sinensis*	0	0.11±0.07	0	0	0	0.18±0.11	0	0.10±0.21	0.03±0.03	0.05±0.16
Lesser Coucal	*Centropus benalensis*	0	0	0	0	0	0	0	0	0.03±0.03	0
Swiftlet spp.	*Collocalia sp.*	0	0	0	0	0	0	0	0.50±1.08	0	1.05±2.29
Edible-nest Swiftlet	*Collocalia fuciohaga*	0.06±0.06	0.28±0.19	0	0	0	0.37±0.20	2.05±5.31	1.50±2.07	0.97±0.56	0
House Swift	*Apus nipalensis*	0.22±0.22	0.11±0.11	0	0	0	0.26±0.18	0.15±0.47	0	0.06±0.04	0
Brown Hawk Owl	*Ninox scutulata*	0	0	0	0	0	0	0	0.05±0.16	0	0
Common Kingfisher	*Alcedo atthis*	0.61±0.27	0	0	0.06±0.06	0.45±0.55	0.07±0.07	0	0	0.11±0.08	0
Blue-eared Kingfisher	*Alcedo meninting*	0	0	0	0	0	0	0	0.05±0.16	0	0
White-throated Kingfisher	*Halcyon smyrnensis*	1.39±0.29	0.89±0.18	0.30+0.67	0.11±0.07	0.35±0.41	0.52±0.13	0.65±0.53	0.10±0.32	1.14±0.15	0.25±0.26
Black-capped Kingfisher	*Halcyon pileata*	0	0	0	0	0.05±0.16	0	0.05±0.16	0	0.03±0.03	
Collared Kingfisher	*Todirhamphis chloris*	0.28±0.12	0.22±0.17	0.20+0.42	0.39±0.07	0.95±0.60	0.18±0.08	3.50±2.32	0.55±1.07	0.11±0.06	0.45±0.55
Blue-tailed Bee-eater	*Merops philippinus*	0	0	0	0	0	0	0	0	0.08±0.06	0
Blue-throated Bee-eater	*Merops viridis*	0	0.44±0.24	0.30±0.95	0	0	0.11±0.08	0.20±0.42	0.35±0.94	0.11±0.07	0.25±0.42
Dollarbird	*Eurystomus oreintalis*	0	0.06±0.06	0	0	0	0.22±0.12	0.05±0.16	0.30±0.42	0.19±0.08	0
Coppersmith Barbet	*Megalaima haemacephala*	0	0	0	0	0	0.04±0.04	0.05±0.16	0.05±0.16	0.06±0.06	0
Laced Woodpecker	*Picus vittatus*	0	0.11±0.07	0	0	0	0	0	0	0	0
Banded Woodpecker	*Picus mineaeceus*	0	1.22±0.34	0	0	0	0.15±0.06	0	0.75±0.35	0.06+0.04	0
Common Flameback	*Dinopium javanense*	0.06±0.06	0.11±0.11	0	0	0	0	0	0.05±0.16	0.03±0.03	0
Sunda Woodpecker	*Dendrocopus moluccensis*	0.11±0.07	0	0	0.06±0.06	0.05±0.16	0	0.65±0.88	0.15±0.34	0.08±0.04	0.05±0.16
Barn Swallow	*Hirundo rustica*	0	0.50+0.44	0	0	2.25±4.06	0.37±0.37	0.20±0.42	1.00±2.68	0.03±0.03	0.20±0.42
Pacific Swallow	*Hirundo tahitica*	1.50±0.37	0.44±0.21	0.10±0.32	1.44±0.39	3.10±3.11	0.15±0.10	1.00±1.20	0.30±0.63	1.64±0.34	0.65±1.13
Pied Triller	*Lalage nigra*	0.06±0.06	0.06±0.06	0	0	0.05±0.16	0.04±0.04	0	0.10±0.32	0.06±0.04	0