Urban Park Design for Bird Diversity: Theory and Application in Landscape and Site Scales

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Abstract. There has been a new approach of creating urban park not solely for plants, but also for birds. This paper provides recommendations for urban park as bird habitat based on ecological theories, i.e. theory of island biogeography, theory of succession, intermediate disturbance hypothesis (IDH), and competitive exclusion principles. Empirical data from previous field research and literature study were used to come up with recommendations. Urban areas still able to provide good habitat for birds, although its diversity is lower than in natural areas. In a landscape scale, to get a high diversity of bird, urban parks should be large, close to each other, preferably connected to each other, and compact in shape. As for successional stages, various mid-stages will promote bird richness, except for early and climax stages. This is also supported by IDH, which stated that mid-disturbance habitat will harbor a maximum bird number. As for planted species in site scales, various plants should be provided to diversify food for birds, including those that producing nectars, seeds/grain, and small-size fruits. Aquatic freshwater habitat (ponds, rivers, marshes) also will invite birds that feed on small fishes, macro-zoobenthos, and water-related insects. In Indonesia, anthropogenic disturbance might also reduce bird diversity.

Keywords: bird habitat, ecological theory, intermediate disturbance hypothesis, theory of island biogeography, urban birds

1. Introduction

With the fast development of a city, people begin to find out how to create convenient cities, where people and nature can blend together and creating high quality livable cities. Providing green open spaces through creation of urban parks is one of the attempts to get this objective.

In the initial development of urban parks, urban planners might think on the creation of green open spaces, planted with ornamental plants. As the requirement for higher quality increases, green open spaces has been developed for multi-function areas. In addition, currently city planner worldwide also thinking about creating urban park for wildlife, along with the increase awareness of biodiversity. Among the wildlife that can be managed in urban areas, birds have gain the most popularity compare to other taxa [1]. The birds’ high diversity, coupled with relatively easy adaptation of many bird species has made birds as urban park attraction for people who visited the parks. Birdwatching activity –that has been spreading all over the world [2]- also might trigger urban planner to create and design more bird-friendly parks.

Designing urban parks for birds (and other wildlife) requires a strong theoretical background in order to get a diverse and abundant birds. High diversity of birds in urban area is an indication of a healthy and high quality environment. Some previous study, for example [3] and [4] linked urban birds and ecological theories. This objective of this paper was to
provide theoretical background and its practical application in designing urban parks in order to get a diversity and abundance of birds and provide necessary practical recommendations.

2. Methods
Selection of existing theories were based on personal accumulation of knowledge for about three decades of lecturing in ecology and biodiversity conservation. These theories were developed and derived from the temperate countries in the US and Europe, which might not directly applicable for the tropical Indonesian situation. Therefore, for the application of the theory, literature studies on published literatures regarding empirical data from previous field research on bird ecology in Indonesia was conducted.

The primary literatures selected were related to urban park in Indonesia, mainly in the Jakarta Greater Area, including Bogor city and its vicinity. If not available, examples for non-urban parks also will be used as long as they are relevant. Based on the theories and examples in Indonesian urban parks, recommendations were formulated.

3. Results and Discussion
3.1. MacArthur and Wilson’s theory of island biogeography
Ecological theories have been developed fast during the past few decades, including those that related to biodiversity conservation. One of the most important theory is the theory of island biogeography [5] which predict the effect of distance and island size on the number of species inhabiting on an island.

Originally developed for true island, this theory lately has been revived along with the intensive habitat fragmentation on land, creating habitat fragments (patches) and can be treated as habitat island. Patches can be seen as ‘islands’, and non-habitat (matrix) can serve as the ‘sea’.

The island biogeography theory provides ways to design better urban parks as bird habitat in a landscape scale (Figure 1). Due to the constraints in the urban environment, all of the ‘better ways’ may not be fulfilled. Basically, the best urban parks for birds should be large and compact in size. When large parks are not available, smaller parks also good, as long as connected to each other (for example by green belt along roads). Although there is no specific minimum size for the urban park, the size of 0.25 ha for the minimum size for urban forest can be applied as well. As for the green belt, rows of trees with continuous canopy would be excellent for birds. On site scale, diversity of micro-habitat within a particular urban park is also can increase bird diversity.

This theory has been tested for birds in urban area in many temperate countries, including in Canada [6], USA [3] and in various other countries [7]. In Indonesia, a study in urban area showed that island biogeography theory fitted the situation for birds in the city of Bogor and its vicinity [8]. Size, fragmentation, edges, and isolation did affect bird diversity in urban areas of Bogor.
3.2. Theory of succession
Succession is the process of gradual change in the plant species within an ecological community or an ecosystem. Although there are two different schools of thought (i.e. Gleasonian and Clementian), the messages of this theory is clear – that an ecosystem is changing through time, including urban parks. As an individual, newly planted seedlings will grow to be saplings, poles, and eventually become mature trees. As a community, open areas will grow into shrubs, low-height tree stands, and eventually creates an urban forest as a climax stage.

Previous research has demonstrated that succession indeed very important as a basis for bird management [10, 11]. Studies in urban parks in the residential areas of Bogor showed that bird community does changes with the change of urban park successional stages [12]. Bird composition in the early successional stage, for example, was differed with the climax stage. Thus, in a landscape scale, by arranging several urban parks in various successional stages will greatly increase the bird diversity. This can be done through systematically replace old trees with new ones when trees in urban park reach maturity.

3.3. Intermediate disturbance hypothesis
The intermediate disturbance hypothesis (IDH) was revived by [13] and stated that the species diversity would reach maximum at an intermediate level of disturbance. Linking the IDH and the previous theory of succession, in term of the number of species, this means that the maximum number of birds are actually not in the climax stages -which categorized as
undisturbed or less disturbed in the IDH. According to the IDH, the highest number of birds are in the mid-successional stages.

In the urban areas of Bogor, the IDH has been tested and confirmed by [12]. In the old and mature urban forest, bird diversity was decreased, compare to the area where successional was still rapid. Another research on bird diversity in the natural areas in Southeast Sulawesi [14] also confirmed this hypothesis. Bird species in the secondary natural forest with medium disturbance had more species compared to the primary species with less disturbance. Further, in Central Sulawesi, bird diversity in forest garden and logged forest was higher than areas with no disturbance in the natural forest [15].

3.4. Competitive exclusion principle
The competitive exclusion principle [16] serves as the basic theory for species competition. This theory was developed by Henri Gause, and thus also known as the Gause Principle. Basically, this theory says that two species (of birds, in this case) with identical habitat requirement cannot coexist together indefinitely. When two seemingly similar species - usually belong to the same genus (congeneric) – able to coexist in the same urban park or in other habitat types, there must be something that differentiate those two species. That ‘something’ usually can be discovered through keen observations.

The competitive exclusion principle will lead to niche segregation. By segregating resources into fine ways, a certain habitat can be utilized by more bird species. Therefore, an urban planner’s task would be to provide habitat that can be segregated by many bird species. This theory is very useful theory for designing urban park on a site level, mainly through the provision of food and nest/roost area for birds, as recommended by [12]. Even for one type of food that will be consumed by various bird species, for example insect, the birds will differentiate themselves based on space (aerial heights, height of trees, parts of trees, parts of urban park floor, etc.) and time (diurnal, nocturnal, crepuscular). Examples of tree species that attract many urban birds are *Antidesma bunius*, *Syzygium polyanthum*, *Muntingia calabura*, *Erythrina crista-galli*, *Callistemon viminalis*, and *Spathodea campanulate*.

3.5. Recommendations for urban park design
Based on the analysis of related theories, recommendations for the design and habitat management/manipulation for urban park, particularly related to increasing or maintaining bird diversity, can be formulated (Table 1). The theory of island biogeography was mostly related to the design in the landscape scale, intermediate disturbance hypothesis and theory of succession could be applied for design in both landscape and site scales, while the competitive exclusion principle was most appropriate at the site scales. In the site scales, habitat manipulation are mostly related to management of plants and micro-habitat.

Besides recommendations on design, anthropogenic disturbances also need to be managed properly. Some actions needed including regulation to prohibit hunting, trapping or destroying nests by the local authority. In locations where bird experience less disturbance, birds would be much more varied, abundant, and easy to find. Birds on Bali Island is a good example. Compare to Java Island, birds in Bali can be easily spotted in urban parks, temples, home garden, hotel’s garden, golf courses, and along roadsides because the Balinese do not disturb or hunt the birds due their belief.

In conclusion, urban parks can be designed and managed in such a way in order to get a high wildlife diversity. By using certain ecological theories, general design in landscape scales, coupled with specific habitat manipulation on site scales can greatly enhance the diversity of birds and other wildlife, including as insects (mainly butterflies), herpetofauna, and small mammals.
| Scale (among/between urban parks) | Parameter | Recommendations | Related Theory* |
|---------------------------------|-----------|----------------|-----------------|
| Landscape                       | Size      | As big as possible, either in the center of a city (e.g. Bogor Botanical Garden) or at the peri-urban area (e.g. Dramaga Campus in Bogor) | TIB |
|                                 | Number    | As many as possible; total urban park is expected to be 10% of the total area, based on Government Regulation 22/2012 | TIB |
|                                 | Distance to each other | As close as possible, or urban parks can be connected to each other by greenbelt or tree rows along roadsides/boulevard, or connected by a smaller park(s) as stepping stone(s) (e.g. Manggala Wanabakti’s park is connected by trees to the larger Gelora Bung Karno park in Jakarta) | TIB |
|                                 | Shape     | Compact, more rounded, non-elongated (if possible); interior area for compact parks are larger that elongated parks, because birds need to have some kind of refuge in the interior area | TIB |
|                                 | Habitat types | Varies for each urban park; it will be best if there are some aquatic-type habitat and some terrestrial-type habitat (e.g. mangroves of Muara Angke, mixed tree plantation in National Monument – Jakarta) | TIB, IDH, Succession |
| Site (within an urban park)      | Species planted | Various species, not monoculture; in urban parks there some non-indigenous (i.e. alien) species might also planted, but indigenous species are preferred | CEP, Succession |
|                                 | Age of trees | Varies; as the tree stands get older setting back the succession al stages by replanting might be necessary; some mature old trees, however, need to be maintained as they are important for cavity nesting birds | CEP, Succession |
|                                 | Phenology  | In urban areas, the amount of flowering plants and fruit-producing trees are sometimes limited, and thus plant species need to be selected in such a way so the nectar and small-sized fruit are available all year long | CEP |
|                                 | Canopy structure | The more complete canopy structures (i.e. ground-cover, bushes, small trees, mature trees, emergent trees), the better for bird diversity; some nature-like areas need to be set aside as in many urban parks, the parks receive very intensive cutting, pruning, and weeding | CEP |
|                                 | Micro-habitat | Varies, it will be best if the urban park contains terrestrial micro-habitat and aquatic micro-habitat, for example arboretum, old growth of rubber plantation, shrub, abandoned land, home garden, pond/lake, stream | CEP |

TIB - Theory of Island Biogeography; IDH – Intermediate Disturbance Hypothesis; Succession – Theory of Succession; CEP – Competitive Exclusion Principles
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