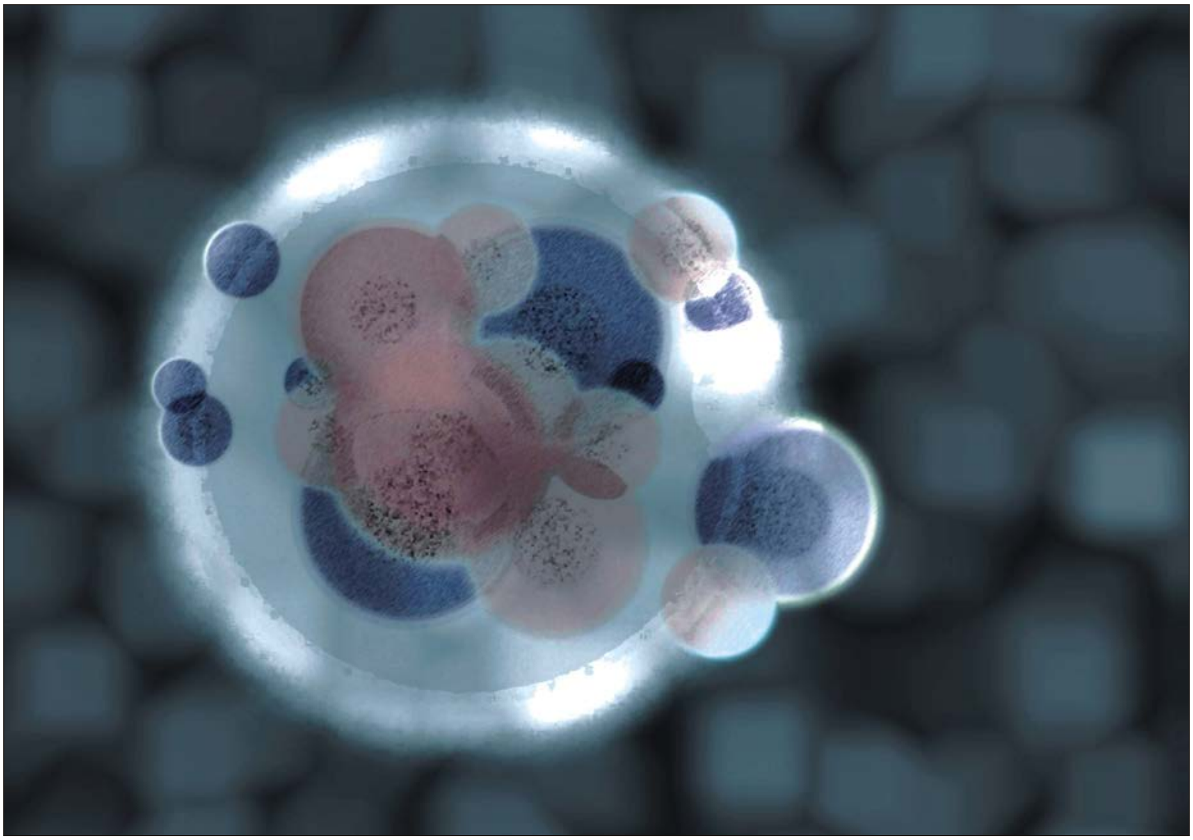

Journal of Biological Sciences

ISSN 1727-3048

Journal of Biological Sciences 9 (4): 345-350, 2009
ISSN 1727-3048

Role of Urban Environment on Conservation of Birds Diversity in Java, Indonesia

Satyawan Pudyatmoko, Kaharuddin and Sandy Nurvianto
Department of Forest Resources Conservation, Faculty of Forestry,
Gadjah Mada University, Indonesia

Abstract: This research investigated the effects of urbanization on bird communities, in which bird assemblages of different land use, namely urban and suburban, agroforestry and forest areas were compared. Point counts were applied to record all birds within a radius of 50 m and all birds detected visually and acoustically within 15 min were recorded. Although, the different of number of species among land use types was negligible, results showed that the diversity of bird communities were highly different. Bird diversity in urban environment was lower than those in forest but higher than in agroforestry. Urban environment with high landscape heterogeneity promoted by human supported a diverse bird species. The composition of bird communities was also very different among the land uses, because each species has different ranges of habitat optimal for them. Surprisingly, the value of conservation index of urban environment was the highest, because all of three endemic bird species can survive in urban environment. The evidence that urban area can have high conservation value must be considered by urban planner.

Key words: Yogyakarta, urbanization, heterogeneity, habitat

INTRODUCTION

The studies in the United States showed that among the leading causes of species endangerment the interactions of native with non-native species ranked highest, followed by urbanization and agriculture (Czech *et al.*, 2000). In many cases, introduction of exotic species can lead to rapid extinction of indigenous species. For example, introduction of exotic species by European have been the primary cause of extinction of many bird species in Australia (Primack, 1995). Urbanization threats wildlife directly by replacing natural habitat with infrastructure facilities and housing and by depleting resources necessary for wildlife to support urban development (Czech *et al.*, 2000). The world's urban population will grow substantially over the next 25 years (1.80% annually). In 2005, world's urban population was 3.15 billion people or 48.7% of the world's population and it is projected to increase to 4.9 billion people by 2030, roughly 60% of total human population (United Nations, 2006). Based on this prediction, the pressures of urbanization processes on the survival of wildlife is expected to increase. Extreme change of landscape composition and configuration of initially agriculture and natural land uses to urban environment will represent a major threat to regional and global biodiversity (Clergeau *et al.*, 2006).

The rapid process of urban development and change of human lifestyle, make deep understanding of the ecological processes operate in urban environment especially necessary for sustainable land-use planning (Palomino and Carrascal, 2006) and for conservation of biodiversity (Cornelis and Hermy, 2004). Urban areas are area excellent for ecological study (Whitten *et al.*, 1996). However, until recently little thought has been directed to conservation of urban habitate and wildlife (Bolen and Robinson, 2003). Especially in the southern hemisphere, urban ecosystem has been poorly studied when compared with those in northern hemisphere. Usually, urban environment is considered as area of low diversity with large populations of few species. However, there is mounting evidence that urban and suburban forests can contain relatively high level of biodiversity (Alvey, 2006). Urban forest and green space are a key means of preserving and promoting biodiversity in the urban ecosystem. Management of wildlife in urban area with the greatest human pressures and other resources in short supply is very challenging, because in this area the concept of multiple-use of land reaches to its maximum application (Bollen and Robinson, 2003).

Often, avian fauna was used to evaluate the impact of urbanization on wildlife or as an indicator of urban sustainability (Clergeau *et al.*, 2006; Donnelly and Marzluff, 2004; Fernándes-Juricis, 2000; Hostetler, 1999;

Corresponding Author: Dr. Satyawan Pudyatmoko, Department of Forest Resources Conservation, Faculty of Forestry, Gadjah Mada University, Jl. Agro1 Bulaksumur, Yogyakarta, Indonesia

Hostetler and Knowles-Yanez, 2003; Palomino and Carrascal, 2006; Melles, 2005; Sandström *et al*., 2006). Birds are sensitive indicators of environmental change because they are high in the food chain. Thus, they reflect changes to plants and animals that are their food. As birds are highly mobile they sum up changes over large areas and because birds have a short life spans, environmental changes will be quickly indicated by change of their populations. Furthermore, native bird species have proved a popular indicator of care for nature and effective nature conservation (London Sustainable Development Commission, 2004). To increase the quality of life in cities, the World Health Organization (WHO) has recommended a minimum of 9 m^2 of green space per person (Whitten *et al*., 1996). In the urban landscape the composition and species diversity of birds are mainly affected by local factors such as age of vegetation and the size of urban forest. Isolation from species gene pool does not appear to exert any significant influence on community assembly of birds (Fernándes-Juricis, 2000).

Urban areas can be divided into three zones (Van Druff, 1979). The metropolitan centre is the densely populated inner-city or down town area. This area has little room for vegetation and wildlife. The second zone is suburbia, which less densely developed than the inner city. More green area is available here and wildlife may present in remnants habitat of former natural communities interspersed among human habitations. The third zone is rural-urban interface, which is the least developed and opportunity to save important habitate is still available. To understand the role of urban environment on conservation of bird diversity, comparison of composition of bird community in the urban and in other land uses was conducted. The main goals of this research are to study the effects of urbanization on the bird communities by comparing their composition and diversity in urban and in natural environments.

MATERIALS AND METHODS

Study area: The study was conducted in Yogyakarta province in Java island, Indonesia. It is located in the central part of the island. Java is one the most densely populated island in the world with 114 millions inhabitants on an area of 132,000 km^2, or at average the human density is 864 people km^{-2}. Yogyakarta province covers an area of 3185.8 km^2 with an average human density of 1,011 people km^{-2}. The most densely area is the city of Yogyakarta with more than 12 thousands people km^{-2}, surrounded by sub urban areas with an average human density of 1,600 people km^{-2}. Hence, human pressures on the natural environment are very high leaving little space for natural and semi-natural habitats. In this province, state forests count for approximately 171 km^2, or only 5.4% of the total area. Further conversion of agriculture and green spaces and transformation from rural to urban are expected to continue, because annual population growth of suburban areas is still high (1.5% $year^{-1}$).

To study species composition of bird in different land use system ten locations were selected. They are consisted of eight metropolitan centres and suburbia areas (U1-8), one agriculture system (A1) and one forest environment (F1). The study area is in total 737 ha and composed of 137 ha urban, 300 ha agroforestry and 300 ha forest areas. Table 1 provide further details on each habitat type.

Bird survey: The survey of animal was conducted between July and September 2006. Point counts were used to record all birds within a radius of 50 m from the centre of point transect (Bibby *et al*., 1995). Points were visited between 06:00 and 09:00 h and all birds detected visually and acoustically within 15 min were recorded. The distance between points was 150 m. A rangefinder was used to measure and estimate distance and all observation beyond 50 m were excluded from the analysis. Field guide to bird species of Sumatra, Java, Bali and Kalimantan provided by MacKinnon *et al.* (2000) and the encyclopaedia of birds by Perrins (2003) were facilitated species identification.

Data analysis: Shannon-Wiener index (H') and the reciprocal form of Simpson index (1/D) was used to measure the diversity of bird species in each habitate types. It is calculated from the equation (Ludwig and Reynolds, 1988; Magurran, 1988):

Table 1: Description of study sites in Yogyakarta

Site code	Habitat type	Description
U1-8	Urban environment	The ground is covered predominantly by buildings, streets and parking lots. Remnants of former natural systems are very few. The number of inhabitant range between 4000 to 20000 peoples per km^{-2}.
A1	Agriculture system	Approximately 3 years mixed fruit tree plantation with a sparse cover of *Gliricidia sepium* and *Acacia mangium* (Leguminosae) up to 5 m, *Tectona grandis* (Verbenaceae) up to 10 m. Between the row of trees annual crop like maize, manioc and peanut were planted.
F1	Forest area	Mixed plantation composed of *Tectona grandis*, *Acacia mangium*, *Swietenia mahagony* (Meliacea) and *Schleicera oleosa* (Sapindaceae). Undergrowth layer mainly composed by grass species (Gramineae), *Lantana camara* (Verbenaceae) and *Chromolaena odorata* (Compositae).

$$H' = -\sum p_i \ln p_i \quad \text{and}$$

$$D = \sum \frac{n_i(n_i - 1)}{N(N-1)}$$

The significant different of species diversity between habitat types was calculated by using t-test provided by Hutcheson (1970) as follow:

$$t = \frac{H'_1 - H'_2}{\left(\text{var}\, H'_1 + \text{var}\, H'_2\right)^{\frac{1}{2}}}$$

The similarity of bird assemblage between land uses was quantified with percent of similarity (PS) introduced by Bray and Curtis (1957):

$$PS_{jk} = \left(\frac{2W}{A+B}\right) \times 100$$

The index of conservation important was calculated for each habitat type. This index allows the comparison of bird communities not only based on their species composition and abundance but also based on the species conservation status of observed species in each habitat types. The IUCN assessment system and endemic status was used to assign species value for each species. Species of no conservation concern will have a score (v) of 1, vulnerable species will have a score of 2, endangered species will have a score of 4 and critically endangered species will have a score of 16. Endemic but non threatened species will have a score of 4 and those that possess threatened status will have a score of 16. The index of conservation important was calculated for each habitat type as follow (Petit and dan Petit, 2003):

$$I_j = \sum_{i=1}^{n} v_i \, p_{ij}$$

where, I_j is the relative conservation important of habitat j, v_i is the vulnerable score of species i, n is the number of species in habitat j and p_{ij} is the relative preference by species i for the habitat j.

The habitat preference of a species for habitat j is calculated as the proportion of the total number of individuals of species i observed in habitat j. Consequently, for each species, the value of p_{ij} ranges from 0 to 1 within a land use type and sum to 1 across all land uses.

RESULTS

Results of this research showed that the number of bird species recorded in the study area was 55 species and 23 families with the value of pooled diversity index was H` = 2.85. Three species were listed as endemic to Java and Bali, namely *Orthotomus sepium* (Olive-backed Tailorbird), *Padda oryzivora* (Java Sparrow) and *Halcyon cyanoventris* (Javan Kingfisher). Olive-backed Tailorbird occurred in urban and agroforestry area and Java sparrow was found only in urban area, while Javan Kingfisher was present in all habitate types. Classification according to their guilds showed that 25 species were insectivore, nine omnivore, eight granivore, four carnivore, three frugivore and granivore, three insectivore and carnivore, two nectarivore and one insectivore and granivore. Most birds were generalist species with a broad habitat range from secondary forest, agriculture area to semi open and urban environment. No bird was known as forest dependent species. The list of species found in the study area was shown in Table 2.

In comparison with other habitat, agroforestry area has the highest number of species with 33 species and 18 families, followed by urban environment with 31 species and 17 families. Surprisingly, forest area has the lowest number species with only 30 species and 17 families. On the other hand, the highest density of individuals occurred in urban environment followed by forest and agroforestry. However, the calculation of diversity index with Shannon-Wiener Index, Simpson Index and Shannon-Evenness Index showed that forest consistently has the highest diversity. The t-test showed that the diversity of bird species between agroforestry and forest ($t = 7.32$; $p<0.01$; $df = 2375$), between agroforestry and urban ($t = 6.02$; $p<0.01$; $df = 1864$) and between urban area and forest ($t = 2.78$; $p<0.01$; $df = 2474$) differed highly significantly. Total number of individual per km^2 and the value of diversity index were shown in Table 3.

The composition of bird species among the habitat types was very different as shown by the calculation of community similarity. The similarity percentage between urban and agroforestry bird community was the lowest (27%), between agroforestry and forest was 34. 74% and the highest between urban and forest (35.17%). The conservation value of each habitat with bird species as determinant factors showed that urban environment possessed the highest value of conservation index (27.21) followed by agroforestry (18.46) and the lowest forest (18.33). According to BirdLife International (2008) Checklist version 1 published by Birdlife International all species recorded in the study area were classified as low concern of conservation priority. Therefore, the conservation value of each habitat types was determined mainly by the number of species and the number of individuals.

Table 2: List of observed bird species and their density in each habitat types

Species	Family	Density (individuals km^{-2}) Urban	Agroforestry	Forest	Guild
Halcyon cyanoventris	Alcedinidae	0.94	5.79	12.74	I, C
Todirhamphus chloris	Alcedinidae	32.00	37.64	5.79	I, C
Ardea cinerea	Ardeidae	44.96	0.00	0.00	C
Ardeola speciosa	Ardeidae	15.92	0.00	0.00	C
Bubulcus ibis	Ardeidae	65.29	0.00	0.00	I, C
Nycticorax nycticorax	Ardeidae	14.05	0.00	0.00	C
Artamus lencorhynchus	Artamidae	11.52	0.00	0.00	I
Tephrodornis gularis	Campephagidae	0.00	5.79	0.00	I
Lalage sueurii	Campephagidae	0.00	5.79	0.00	I
Pericrocotus miniatus	Campephagidae	12.21	2.90	0.00	I
Aegithina tiphia	Chloropseidae	69.35	2.90	25.48	O
Streptopelia chiueusis	Columbidae	52.45	0.00	25.48	G
Macropygia unchall	Columbidae	7.96	0.00	0.00	G
Streptopelia bitorquata	Columbidae	3.18	0.00	0.00	F, G
Macropygia emiliana	Columbidae	0.00	66.59	0.00	F, G
Columba livia	Columbidae	162.98	0.00	0.00	F, G
Corvus enca	Corvidae	0.00	2.90	0.00	C
Centropus bengaleusis	Cuculidae	0.00	0.00	6.37	I
(Centropus sineusis)	Cuculidae	0.00	2.90	19.11	I
Cocomantis merulinus	Cuculidae	5.53	2.90	0.00	I
Dicaeum concolor	Dicaeidae	0.00	17.37	12.74	O
Dicaeum trochileum	Dicaeidae	237.12	14.48	19.11	O
Dicrurus macrocercus	Dicruridae	0.00	0.00	19.11	I
Lanius cristatus	Laniidae	0.00	11.58	0.00	I
Lanius schach	Laniidae	3.28	23.16	31.85	I
Gallus gallus	Megapodiidae	0.00	5.79	0.00	I, G
Cyornis banyumas	Muscicapidae	0.00	17.37	0.00	I
Ficedula mugimaki	Muscicapidae	0.00	2.90	0.00	I
Rhinomyias olivacea	Muscicapidae	0.00	0.00	6.37	I
Nectarinia jugularis	Nectariniidae	162.63	55.01	203.82	N
Anthreptes singaleusis	Nectariniidae	0.00	0.00	12.74	N
Oriolus chiueusis	Oriolidae	2.34	0.00	19.11	O
Parus major	Paridae	2.34	8.69	6.37	O
Picoides molncceusis	Picidae	0.00	2.90	0.00	I
Dendrocopos macei	Picidae	0.00	2.90	0.00	I
Lonchura lencogastroides	Ploceidae	1072.09	37.64	299.36	G
Lonchura punctulata	Ploceidae	58.67	0.00	19.11	G
Lonchura maja	Ploceidae	89.45	0.00	12.74	G
Passer montanus	Ploceidae	531.44	0.00	0.00	G
Padda oryzivora	Ploceidae	15.92	0.00	0.00	G
Pycnonotus aurigaster	Pycnonotidae	254.76	518.24	159.24	O
Pycnonotus goiavier	Pycnonotidae	124.63	0.00	12.74	O
Abroscopus superciliaris	Silviidae	0.00	20.27	0.00	I
Cisticola exilis	Silviidae	0.00	0.00	6.37	I
Locustella certhiola	Silviidae	0.00	26.06	76.43	I
Orthotomus atrogularis	Silviidae	0.00	2.90	0.00	I
Orthotomus sepium	Silviidae	157.14	5.79	0.00	I
Orthotomus sutorius	Silviidae	80.15	52.11	76.43	I
Prinia familiaris	Silviidae	151.41	240.30	8.69	I
Prinia inornata	Silviidae	0.00	5.79	31.85	I
Prinia polychroa	Silviidae	0.00	34.74	210.19	I
Saxicola torquata	Turdidae	0.00	0.00	6.37	I
Copsychus malabaricus	Turdidae	0.00	0.00	6.37	O
Turnix suscitator	Turnicidae	8.24	2.90	12.74	G
Zosterops palpebrosus	Zosteropidae	44.46	11.58	12.74	O

*C: Carnivore, F: Frugivore, G: Granivore, I: Insectivore, N: Nectarivore, O: Omnivore

Table 3: Value of index diversity of bird community fore forest, urban and agroforestry area

Index	Forest	Urban	Agroforestry
No. of individuals (km^{-2})	1378.00	3494.00	1257.00
Diversity Simpson (1/D)	8.71	7.17	4.61
Diversity Shannon (H')	2.60	2.50	2.21
Shannon evenness (H'/ln S)	0.76	0.73	0.63

DISCUSSION

The finding of this study showed that although, the difference of the number of bird species among the habitats was negligible, the composition of bird communities was significantly different showed by low value of percentage of community similarity among the habitats. Among 55 species, only thirteen species occurred in all habitat type. The only family that occurred only in urban environment was Ardeidae (Heron family). Member of this family recorded in this research included *Ardea cinerea* (Grey Heron), *Ardeola speciosa* (Javan Pond-Heron), *Nycticorax nycticorax* (Black-Crowned Night-Heron) and *Bubulcus ibis* (Cattle Egret). Herons and egrets were mobile birds. Most individuals moved significant distances, not only from day to day but also hour to hour (Perrins, 2003). As roosting trees they selected big and tall tree, where the presence of predators and disturbances were at a minimum level. In urban environment they preferred arboretums to build nesting colony. The birds spent much of the non feeding portion of the days at roost. They typically formed a mixed segregation of species at the same tree.

The similarity between forest and agroforestry was, not as expected, lower than those between urban and forest. It was because the urban green areas have more big trees than agroforestry area, which was dominated by crops and small tree. Therefore, the environmental condition between forest and green area in urban area was more similar. In addition, although the number of recorded bird species in forests was the lowest, the value of diversity index was the highest, because in the calculation of diversity index not only the number of species was considered but also the evenness that is how equally abundant the species are (Magurran, 1988). The higher value of diversity index for forest bird community was evidence that the abundance of bird was more equal in forest than in urban environment and in agroforestry area. In general, the value of diversity index for urban, agroforestry and forest indicated the moderate status of ecological diversity (Jørgensen *et al.*, 2005). This research did not support finding that urban environment are generally less diverse than forest and agroforestry (Palomino and Carrascal, 2006). However, this finding was not unique. Kühn *et al.* (2004) reported that in Germany city grids were more divers in plant species than non-city grids. The same results were also reported by Araújo (2003) that in Europe urban areas had a higher level of biodiversity in comparison to unpopulated area. There was also evidence of positive association between human population density and species richness of bird, mammal, snake and amphibians in Africa (Balmford *et al.*, 2001). Urban and suburban areas can maintain high species richness, if they are composed by different semi-natural habitats (Cornelis and Hermy, 2004). Some possible explanation about the positive relationships between species richness and human population were proposed by Araújo (2003). First explanation was that the areas suitable for human were also generally suitable for other species. Second, human activities might increase the diversity of area through introduced species and promoted landscape heterogeneity.

The results of the research showed that the density of bird species in the urban area was higher than in any natural habitat in the surrounding area was supported by other research (Palomino and Carrascal, 2006). It was because in urban environment resources required by bird such as, foods and shelters were more abundant than in natural habitat. Moreover, several species are well adapted to urban habitat. The research showed that urban environment had higher conservation value than forest and agroforestry area, because all recorded endemic species were present. On the other hand, no forest-dependent species were recorded in forest as well as in the agroforestry area, which would increase the conservation value of these areas. The results of this study was an evidence that urban environment can maintain high level of diversity of non forest dependent species. The city and forest planner must maintain urban forests and green areas as well as street vegetation in adequate size to preserve diversity of bird species as high as possible.

ACKNOWLEDGMENTS

This study was funded with research grant provided by the Faculty of Forestry and Department of Forest Resource Conservation, Gadjah Mada University through PHK-A2 grant 2006. We thank all members of Bird Watcher Club at the Faculty of Forestry for helping with data collection. Also, many thanks for the manager of Wanagama Teaching Forest and Local Governments of Sleman and Saptosari, Yogyakarta, who permitted the authors to conduct this study in their territories.

REFERENCES

Alvey, A.A., 2006. Promoting and preserving biodiversity in the urban forest. Urban For. Urban Green, 5: 195-201.

Araújo, M.B., 2003. The coincidence of people and biodiversity in Europe. Global Ecol. Biogeogr., 12: 5-12.

Balmford, A., J.L. Moore, T. Brooks, N. Burgess, L.A. Hansen, P. Williams and C. Rahbek, 2001. Conservation conflicts across Africa. Science, 291: 2616-2629.

Bibby, C.J., N.D. Burgess and D.A. Hill, 1995. Methoden der Feldornithologie. 1st Edn., Neumann Verlag GmbH, Germany, ISBN: 3-7402-0159-2.

Bird Life International, 2008. The Bird Life checklist of the birds of the world, with conservation status and taxonomic sources. http://www.birdlife.org/datazone/species/downloads/BirdLife_Checklist_Version_1.zip.

Bollen, E.G. and W.L. Robinson, 2003. Wildlife Ecology and Management. 5th Edn., Prentice Hall, New Jersey, ISBN: 0-13-066250-X.

Bray, J.R. and J.T. Curtis, 1957. An ordination of the upland forest communities of southern Wisconsin. Ecol. Monography, 27: 325-349.

Clergeau, P., S. Croci, J. Jokimäki, M.L.K. Jokimäki and M. Dinetti, 2006. Avianfauna homogenization by urbanisation: Analysis at different European latitudes. Biol. Conservat., 127: 336-344.

Cornelis, J. and M. Hermy, 2004. Biodiversity relationships in urban and suburban parks in Flanders. Landscape Urban Plan, 6: 385-401.

Czech, B., P.R. Krausmann and P.K. Devers, 2000. Economic associations among causes of species endangerment in the United States. BioScience, 50: 593-601.

Donnelly, R. and J.M. Marzluff, 2004. Importance of reserve size and landscape context to urban bird conservation. Conservat. Biol., 8: 733-745.

Fernándes-Juricis, E., 2000. Bird community composition in urban parks of Madrid: The role of age, size and isolation. Ecol. Res., 15: 373-383.

Hostetler, M., 1999. Scale, birds and human decisions: A potential for integrative research in urban ecosystems. Landscape Urban Plan, 45: 15-19.

Hostetler, M. and K. Knowles-Yanez, 2003. Land use, scale and bird distributions in the Phoenix metropolitan area. Landscape Urban Plan, 62: 55-68.

Hutcheson, K., 1970. A test for comparing diversities based on the Shannon formula. J. Theor. Biol., 29: 151-154.

Jørgensen, S.E., F.L. Xu, F. Salas and J.C. Marques, 2005. Application of Indicators for the Assessment of Ecosystem Health. In: Handbook of Ecological Indicators for Assessment of Ecosystem Health, Jørgensen, S.E., R. Constanza and F.L. Xu (Eds.). CRC Press, USA, ISBN: 1-56670-665-3.

Kühn, I., R. Brandl and S. Klotz, 2004. The flora of German cities is naturally species rich. Evol. Ecol. Res., 6: 749-764.

London Sustainable Development Commission, 2004. Report on London's Quality of Life Indicators. Greater London Authority, London.

Ludwig, J.A. and J.F. Reynolds, 1988. Statistical Ecology: A Primer on Methods and Computing. 1st Edn., John Wiley and Sons, Wiley, ISBN: 0-471-83235-9.

MacKinnon, M., K. Phillips and B.V. Ballen, 2000. Burung-burung di Sumatera, Jawa, Bali dan Kalimantan (English: Field guide of bird in Sumatra, Java, Bali and Kalimantan). 1st Edn., Puslitbang Biologi, Bogor, ISBN: 9795790137.

Magurran, A.E., 1988. Ecological Diversity and its Measurement. 1st Edn., Princeton University Press, Princeton, ISBN: 0691084858.

Melles, J., 2005. Urban birds diversity as an indicator of human social diversity and economic inequality in Vancouver, British Columbia. Urban Habitats, 3: 25-48.

Palomino, D. and L.M. Carrascal, 2006. Urban influence on birds at a regional scale: A case study with the avifauna of northern Madrid province. Landscape Urban Plan, 77: 276-290.

Perrins, C., 2003. The New Encyclopedia of Birds. 1st Edn., Oxford University Press Oxford, ISBN: 0198525060

Petit, L.J. and D.R. dan Petit, 2003. Evaluating the importance of human-modified lands for neotropical bird conservation. Conservat. Biol., 17: 687-694.

Primack, R.B., 1995. Naturschutzbiologie (English: Conservation Biology). Spektrum Akademische Verlag, Heidelberg, ISBN: 3-86025-281-X.

Sandström, U.G., P. Angelstam and G. Mikusiñski, 2006. Ecological diversity of birds in relation to the structure of urban green space. Landscape Urban Plan, 77: 39-53.

United Nation, 2006. World Urbanization Prospects: The 2005 Revision. http://www.un.org/esa/population/publications/WUP2005/2005WUPHighlights_Final_Report.pdf.

Van Druff, L.W., 1979. Urban Wildlife-Neglected Resource. In: Wildlife Conservation: Principles and Practices, Teague, R. and E. Deckers (Eds.). The Wildl. Society, Washington DC., ISBN: 0933564066.

Whitten, W., R.A. Soeriaatmadja and S.A. Afiff, 1996. The Ecology of Java and Bali. 1st Edn., Periplus Editions (HK) Ltd., Bejing, ISBN: 962-593-072-8.