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Dynamic Informatics of Avian Biodiversity on an Urban and Regional Scale

Wei-Ta Fang

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1. Introduction

Birds often constitute the most diverse and abundant species in a large-scale range (Rutschke, 1987; Virkkala, 2004). As such, and because their specific richness is relatively high in winter seasons, they may provide a useful raw material to evaluate predictive methods in wintering groups migrating through over an enormous range of environments (Bradley & Bradley, 1983). In the avian ecology, because they are highly mobile, and often yet ordinarily forage, breed, and stop in very specific habitats, birds indicate their specific behaviors of habitat selection (Jokimäki & Suhonen, 1998; Paillisson et al., 2004; Silva et al., 2004). Thus, they are also an ideal subject for habitat studies.

Indeed, the lives of migrants and residents are replete with habitat biological choices: where to stop to replenish depleted fat stores, or where to build a rest site to molt feathers during migration, etc. (Erni et al., 2002; Glimcher, 2002; Wiltschko & Wiltschko, 2003). Since birds' mobility may lead them to exploit different habitats depending on whether they are anchoring or shortly stopping, the relative importance of habitat characteristics may therefore be selected by birds spatially and temporally. Therefore, birds are likely to be candidates for habitat condition assessments for their specific bio-choices where to select for approximate stopover sites.

In order to understand their choices, avian community studies both in microhabitat-scale and landscape-scale are required (Buckley & Forbes, 1979; Palmer & White, 1994). Specifically, assessing which habitat elements are associated with bird communities during the non-breeding season (i.e., winter) may require a larger spatial scale than in the breeding season. During non-breeding and migrating seasons, individual birds spread and forage over larger spatial scales (Williams et al., 2003). At the larger scale, landscape configuration becomes crucial factors accounting for the variation in wintering bird species richness and diversity. However, there are many controversial issues to form avian refuges on larger

scales. In the following section, concept of avian refuges for area and habitat issues is described.

2. Concept of diversity and habitat

Species respond to the size of patches when one considers designing avian refuges. Given the variable situation in a fragmented area perplexed by urbanization, it is not surprisingly that there is no best size to fit carrying capacities for avian habitats. Similarly, the increase in bird species individuals with area of habitat islands is attributed to minimum area requirements as interacting effects of competition or food demanding. Therefore, "how big is big" became issues to bring debates for the requirement to build such refuges. Many debates relate to use the island biogeographic concept to generate optimal refuge designs (Diamond, 1975; Gilpin & Diamond, 1980; Higgs & Usher, 1980). Several "principles" were provided by island biogeographic hypothesis (MacArthur & Wilson, 1967). First, refuges should be designed as large as possible, or a single large reserve is better than several small ones. Second, refuges should be close together as possible. Third, refuges should be as circular as possible to avoid "peninsula effect", in which species individuals reduces in an elongate areas compared with the circular areas in the same size (Forman, 1995, pp.108). However, there are many debates of this concept to design refuges related to the "species-area relationship" and "species-habitat relationship" (Simberloff & Abele, 1976; Forman et al., 1976; Forman, 1995; Pelletier, 1999; Oertli et al., 2002). In this chapter, I have reviewed several issues to document as below:

2.1. Species-area relationships

The concept of species-area relationship idea dates back to Arrhenius who studied data from a number of quadrat samples in plant associations (Arrhenius, 1921). Gleason (1922; 1925) came to the conclusion that a straight-line relationship was obtained. However, his theory was developed empirically to find a graph to fit certain observed results, and this rule was not based on mathematical reasoning. Later, Preston (1948; 1962) studied large amounts of empirical data to fit this model. He created an equation named Arrhenius equation as follows:

$$S = cA^z \tag{1}$$

Species area curves were then calculated for each plot using the equation, such as:

$$\log S = z \log A + \log c \tag{2}$$

Where S is species richness, z is the slope, A is the area, and c is the constant. Such a general pattern is important not only for fundamental aspects of ecological concept but also for ecological designs for refuges. Preston concluded that if the number of species (S) are recorded in different areas (A), there are almost an increase in S with increasing A. However, there were so many debates to regard this model as merely a computationally convenient method to fit observed data, despite some undesirable properties.

Forest pattern is the first patch to study the relationships between avian communities and areas (Forman et al., 1976). Martin (1988) declared that species numbers are related to forest foliage cover. He confirmed that foliage provides the substrate to protect the nests from predators. In addition, it also can influence the thermal environment to warm bird bodies in cold winter. Other studies have found birds responded to woody cover, shrub cover, grass cover, and litter cover.

There were many critiques for this hypothesis (Simberloff & Abele, 1976; Sismondo, 2000). In nature, area-per-se hypothesis was expected to be observed only within a certain intermediate range of areas, not at all spatial scales. At small spatial scales, the species-area relationship is not governed by equation (1) but is curvilinear on a log-log plot; and at landscape scales, the species-area relationship bends upward toward a limiting slope of unity (Durrett and Levin 1996). Second, species differ ecologically, thus not all units of species (S) are equal. Since some habitat generalists are widespread, most species in small patches associated with surrounding matrix are generalists which choose between major habitats and edge habitats, whereas in large patches are specialists only which finitely choose at interior habitats. These studies indicated that spatially and taxonomically different species differ from one another in their responses to area. Different avian communities are likely to yield different land-use patches.

2.2. Species-habitat relationships

Debates between field domains of the area-per-se hypothesis and species-habitat hypothesis have lasted for almost forty years. However, there were still no conclusion to generalize principles in ecological designs and no final upshot on which hypothesis was better (MacArthur & Wilson, 1967; Forman & Godron, 1986). Birds respond to both food and rest sites in habitat selection as above-mentioned. Species individuals are correlated with the need of lawn, mudflat, open shore, and canopy or water surface for horizontal heterogeneity. Bird-habitat relationships, thus, are the results of responses that bird use habitats for different activities, such as foraging, molting, and resting in winters.

There are many habitats for bird to select in pondscape configuration, majoring as water regimes. Recently on pond-core studies, Lane & Fujioka (1998) found species-habitat hypothesis works. They declared that watercourses, connecting by ditches around rice fields, affect shorebirds in shallow ponds. Elphick & Oring (2003) suggested that water depth significantly affected bird communities in flooding mudflats. The experiment explained this phenomenon and confirmed that if pond's water level was too deep, often causing respiration to slow down in bottoms due to a lack of oxygen exchange. They found that the species in constructed wetland was worse than those of natural wetland in comparison of the ecological integrities. Therefore, constructed wetland required to regulate water level from an ecological view, according to the demands for the principles of ecological designs. Taking into consideration of design criteria, reducing water level to promote shorebird's habitat quality could also increase in other avian diversity (Johnsgard 1956; Tamisier & Grillas, 1994; Bird et al., 2000; Fujioka et al., 2001; Quan et al., 2002; Ravenscroft & Beardall, 2003). Hattori & Mai (2001) declared that high water levels (equal to

deep at 1 m or at more), reducing ecological diversity, only attracted water-edge's species (i.e., families Ardeidae, etc; such as egrets) in often. As Green et al. (2002) said, constructed wetland could not replace the value of natural wetland because the water level in constructed wetland was too deep, causing avian community worse than that of natural wetland. They suggested that water level in constructed wetland had been regulated so well about 10- 15 cm as to attract shorebirds (families Charadrii and Scolopaci) more. If water level reduction caused an increase of shorebirds, then, how many influences are running counter to interior waterbird individuals, like ducks (i.e., family Anatidae)? Taft et al. (2002) recommended that, if drained continuously, reducing water level would drop waterfowl individuals (i.e., family Anatidae). So, how to control water level, adjust mudflat area in order to observe changes of avian diversity, became the major subject of farm-pond management in habitat-scale studies.

2.3. Anthropogenic disturbances

As mentioned in the previous section, there were many studies focused on avian community with microhabitats as well as anthropogenic disturbance, such as drawdown, etc. Anthropogenic disturbances may be of beneficial or harmful to avian communities (Mustachio and Cousin, 2001). Focused on disturbed and undisturbed habitat, authors claimed the species that located in undisturbed habitats were much higher than in the sites from the highly disturbed habitat (Bolder et al., 1997; Chamberlain & Fuller, 2000). Most cases insisted that intensive anthropogenic influences caused avian decline due to negative edge effects (e.g., habitats adjacent to road paving, traffic flows, and urban development), and habitat fragmentation effects (e.g., habitat loss or segmentation). Edge effect, defined as the "juxtaposition of natural habitat and human modified habitat", may cause habitat less favorable and species likely to become locally extinct. For example, farm-pond roadside hedges were distinguished from non-roadside hedges in several analyses. The rationale for this distinction is that proximity of traffic may be a factor reducing habitat quality for some landbirds in roadside habitats. Roadside hedges may be poorer in species and less preferred by several bird species than non-roadside hedges. Other direct and indirect influences from anthropogenic disturbances are indicated as following tables, such as: (1) habitat loss or fragmentation; (2) introduced exotic species; (3) pollution (air, water, or soils); (4) population loss of specialists; (5) over population of generalists. Regarding to the impact of anthropogenic disturbance on habitats, the characteristics of birds categorized as roughly "specialist" or "generalist" as well as grouped as detailed "guilds" to illustrate habitat relationships are described in the following section.

3. Concept of diversity in a regional scale

Regional ecosystem is the number of avian species it contains. Therefore, avian community turns to indices of a habitat examination in a given area. Different levels of edge disturbance have different effects on avian communities. If the goals were to preserve biodiversity in microhabitats as well as in a landscape scale, to understand how diversity was impacted by different management strategies is required. Because diversity indices provide more

information than simply the number of species present (i.e., they accounted for some species being rare and others being common), they serve as valuable tools that enable to quantify diversity in avian communities and describe their numerical structure. However, many debates between taxonomic diversity were around the entire groups and taxonomic diversity in specific guilds. Since Howell (1971) started to use five functional groups to examine avian residency in forests, many avian ecologists used "guilds" to avoid errors from large amount of species counts involved. They critiqued that the taxonomic approach of avian studies could not be commensurate with landscape scales. Alternatively, studies using aggregate species richness or diversity indices were over-simplified, too (Karr 1971; Emlen, 1972). In the following section, some approaches to calculate species diversity in all species and in specific functional groups are described and compared, therefore, a suitable approach to fit for avian community in farm-ponds would be carefully selected.

3.1. Species diversity

Population ecology was generally defined as "the scientific study of the abundance and distribution of species" (Fisher et al., 1943; Brown, 1984). With the two topics of relative abundance of species (diversity) and distribution along gradient zonation (guilds), one should start to find with effects (avian community), and then move on to causes (landform changes in gradient zonation) (Terborgh, 1977). Species diversity in the entire groups focuses attention upon the first topic. Then, the next guild topic is to dissect the environmental factors that affect that avian distribution in microhabitats and in a region.

Diversity provides information about rarity and commonness of species in an avian community (May, 1975; Karr, 1976). The ability to quantify diversity was an analytical tool for biologists trying to understand environmental quality, such as anthropogenic disturbance and environmental change (Rosenzweig, 1995). After the term "biodiversity" defined at the Rio Convention in 1992, there was a sudden shift in the literature towards the search for indicators of biodiversity itself (Duelli & Obrist, 2003). Since then, however, the term biodiversity has sometimes been used to indicate some aspect of environmental quality by diversity indices.

A diversity index is a mathematical measure of species in a community (Buckley & Forbes 1979; Magurran, 1988). It provides more information about community composition than simply species richness (i.e., the number of species present); and more, it also provides mixed counts of the relative abundances as well as species richness. There are several equations to calculate the indices of diversity. For example, Shannon-Wiener diversity index (also named for Shannon index or Shannon-Weaver index) is one of many diversity indices used by biologists (Shannon & Weaver, 1949). Others include the Simpson diversity, and so on. Each of these indices has strengths and weaknesses. An ideal index would discriminate clearly and accurately between samples, not be greatly affected by differences in sample size, and be relatively simple to calculate. In the avian survey project, well-designed indices should be considered to take advantages of the strengths of each and developed a more complete understanding of avian community structure. In this section, the above-mentioned indices of species diversity were discussed.

3.1.1 Shannon-Wiener diversity index (H'): is an index that is commonly used to characterize species diversity in an avian community. This index accounts for both abundance and evenness of the species present. The proportion of species (*i*) relative to the total number of species (P_i) is calculated, and then multiplied by the logarithm of this proportion ($\log_2 P_i$). The resulting product is summed across species, and multiplied by -1, such as:

$$H' = -\sum_{i=1}^{S} P_i \log_2 P_i \tag{3}$$

S: avian species richness
Pi: The percentage of the *i* species in avian community

3.1.2 Shannon-Wiener evenness index (J): is a measure of the relative abundance of the different species making up the richness of an area (Hill, 1973). The Shannon-Wiener evenness index for a given number of species can be calculated as:

$$\text{Shannon} - \text{Wiener} \ (J) = H' / H_{max} = H' / \ln S \tag{4}$$

3.1.3 Simpson's dominance index (C): if the greater the *C* value, the more dominant species among avian community.

$$C = \sum_{i=1}^{n} \left(\frac{Ni}{N} \right)^2 \tag{5}$$

Ni: individual numbers of the *i* species
N: individual numbers of avian community

3.1.4 Simpson' diversity index (D):

$$D = 1 - C \tag{6}$$

C: Simpson's dominance index

3.2. Species guilds

All avian species have their specific bio-choices to select a suitable habitat for diet for food or water, shelter from weather and predators, and a place to raise offsprings. In addition, each species has its own special requirement. Muller's Barbet (*Megalaima oorti*), for example, nests in tree cavities; while Chinese Bamboo-partridge *(Bambusicola thoracica)* finds bush covers to be underneath forest layers for their chicks. The species are jointed in such a manner so that every group should consist of similar characteristics such as "generalists" and "specialists". Named for generalist species, some avian species select what they need in a variety of habitats in farm ponds. They can cope with a large range of water and vegetation types, and sooner adapt to different diets and environmental conditions. Examples of such species are Tree Sparrow (*Passer montanus*), Chinese Bulbul (*Pycnonotus*

sinensis), and Japanese White-eye (*Zosterops japonica*), etc. Duelli and Obrist (2003) suggested that generalists may not good indicators to illustrate biodiversity for the full visions of entire species. It is fundamentally an environmental indicator for broad range including habitat edges rather than a biodiversity indicator as the interior species in pond cores.

However, "real" biodiversity indicators may be needed to measure the impact of anthropogenic influences. Such an assessment is different from measuring the impact of lead on a selected taxonomic group from habitat specialists, which had been chosen because it is especially sensitive to lead rare and threatened. Specialists are less common than generalist and can thrive only in a narrow range of habitat quality. These animals have limited microhabitat ranges and hardly adapt well to new diets or environmental conditions. These species include many types of birds, such as waterfowl (families Anatidae and Podicipedidae) and shorebirds (families Charadrii and Scolopaci), etc. In conclusion, specialists rather than generalists are most likely to be those that are poisoning.

The concept of "*guild*" provides a beneficial approach of divided avian habitat selection into groups with environmental quality according to landscape configuration. Root (1967), the first avian scientist to form guild concept, defined a guild was as "a group of species that exploit the same class of environmental resources in a similar way". He focused the Blue-gray Gnatcatcher *(Polioptila caerulea)* associated with other species in California oak woodlands. Recognizing that the traditional taxonomic approaches was failed to categorize avian communities, he described a "foliage-gleaning guild" that feeds from foliage and occasionally from branches. This group included five species having similar diet, foraging location, and feeding behavior.

Since Root defined functional groups based on the traditional guilds: diets and foraging strategies, some authors followed his approaches (Emlen, 1972; Terborgh, 1977; Karr, 1980; May, 1982; Blake, 1983) to study avian behavior and foraging strategies; other authors studied nesting, resting, singing, or residential locations (Howell, 1971; Karr, 1971; Karr, 1976; Emlen, 1977; Riffell et al., 1996; Canterbury et al., 2000; Skowno & Bond, 2003); or they studied both, such as foraging strategies and singing location (Recher et al., 1983). However, most studies using functional groups have tended to: (1) group species by subjective criteria, or by a single behavior; (2) focus on just one or some groups; and (3) apply only at a single, or at a small spatial scale. Indeed, bio-choices based on entire species studies produced an objective result in a regional scale. Rather, microhabitat selection due to bio-choices reflects partitioning of spatial variation in a heterogeneous landscape. Clearly explained landscape configuration patterns, "*guilds*" based on bio-choices would be likely formed as indicators to monitor microhabitat quality. The "*guilds*", used to judge environmental conditions, were examined within heterogeneous landscape. Not assumed as the same definition as the first "*guild*" defined by Root (1967), habitat preference was to use to define functional groups later (Recher & Holmes, 1985; French et al., 2002). French et al. (2002) declared that wintering birds were related to land uses by grouping to generalists and specialists. In order to avoid the problems of landscape complexity, avian grouping was a useful approach to decide avian diversity in the microhabitat perspectives. Due to a lack of prior information

about the necessary environmental factors that affected avian guilds, cluster analysis was applied in avian studies. It was used to study for grouping avian community of similar kind into respective functional groups. As a set of methods for building groups (clusters) from multivariate data, their aim was to identify groups with habitat preferences for microhabitats. Then, groups were made as homogenous as possible to reduce the differences between them as large as possible. This obtained a result for existing data correlation hierarchy and expected numbers of functional groups

4. Materials and methods

4.1. Dynamic informatics

I selected ecologically significant Taoyuan Tableland associated irrigation ponds as my study area because one fifth of all the bird species find home on these ponds in Taiwan (Chen, 2000; Fang, 2004a, b; Fang & Chang, 2004; Fang et al., 2009; Fang & Huang, 2011; Fang et al., 2011). This tableland, at an area of 757 km² in size, comprises an area of 2,898 ha of irrigation ponds on the northwestern portion of Taiwan. Located approximately 30 km from the capital city of Taipei, this rural area was easily converted to urban lands due to the aggregated effects of urbanization and commercialization. Socioeconomic benefits are driving public opinion which is urging the government to approve land-use conversion from farmlands into urban uses. The Taoyuan Tableland lies between the northern border of the Linkou Tableland (23°05'N, 121°17'E) and the southern border of the Hukou Tableland (22°55'N, 121°05'E); it borders the town of Yinge in the east (22°56'N, 121°20'E) and the Taiwan Strait in the west (22°75'N, 120°99'E) (Department of Land Administration, Ministry of the Interior, 2002)(see Fig. 1.). It sits at elevations from sea level to 400 m and is composed of tableland up to 303 m and hills with sloping gradients from 303 to 400 m. It runs in a southeast-to-northwest trend, abutting mountains in the southeastern corner and the shore of the Taiwan Strait at the far end. With a high average humidity of 89%, the tableland is located in a subtropical monsoon region with humid winters and warm summers. January temperatures average 13 °C, and July temperatures average 28 °C. Annual average precipitation ranges from 1,500 to 2,000 mm.

The tableland gradually rose approximately 180,000 years ago. At that time, the Tanshui River had not yet captured the flow from the ancient Shihmen Creek, which directly poured out of the northwestern coast forming alluvial fans. Eventually, foothill faults caused by earthquakes during the same era, resulted in the northern region of Taiwan abruptly dropping by 200 m, and thus, the Taipei basin was born. Since the Taipei area had subsided, the ancient Shihmen Creek which meandered across the Taoyuan Tableland was captured by northward-flowing rivers some 30,000 years ago. The middle streams changed their courses because of the subsidence in the Taipei basin. The resulting Tahan Creek, became the upstream portion of the Tanshui River in the Taipei Basin. Due to blockage of water sources, downstream areas on the Taoyuan Tableland were deficient in water. This caused high flushing and drops in water yields. Historically, it was difficult to withdraw and supply irrigated surface water from rivers due to the tableland's unique topography, thus,

forming an obstacle for the development of agriculture (Agricultural and Forestry Aerial Survey Institute, 2010) .

This area has a population density of 2,331 persons/km^2 and its population is increasing at a rate of 2,000~3,000/month. Population pressures have contributed to reductions in historical areas of farmlands and irrigation ponds (Fang, 2001). Losses of farm-pond and farmland habitats have had series effects on a range of avian communities as well as other fauna and flora. On the Taoyuan Tableland, agricultural practices are intensifying, which is reducing the heterogeneity of the existing landform, and adding pollutants, also resulting from industrial practices (Fang et al., 2011).
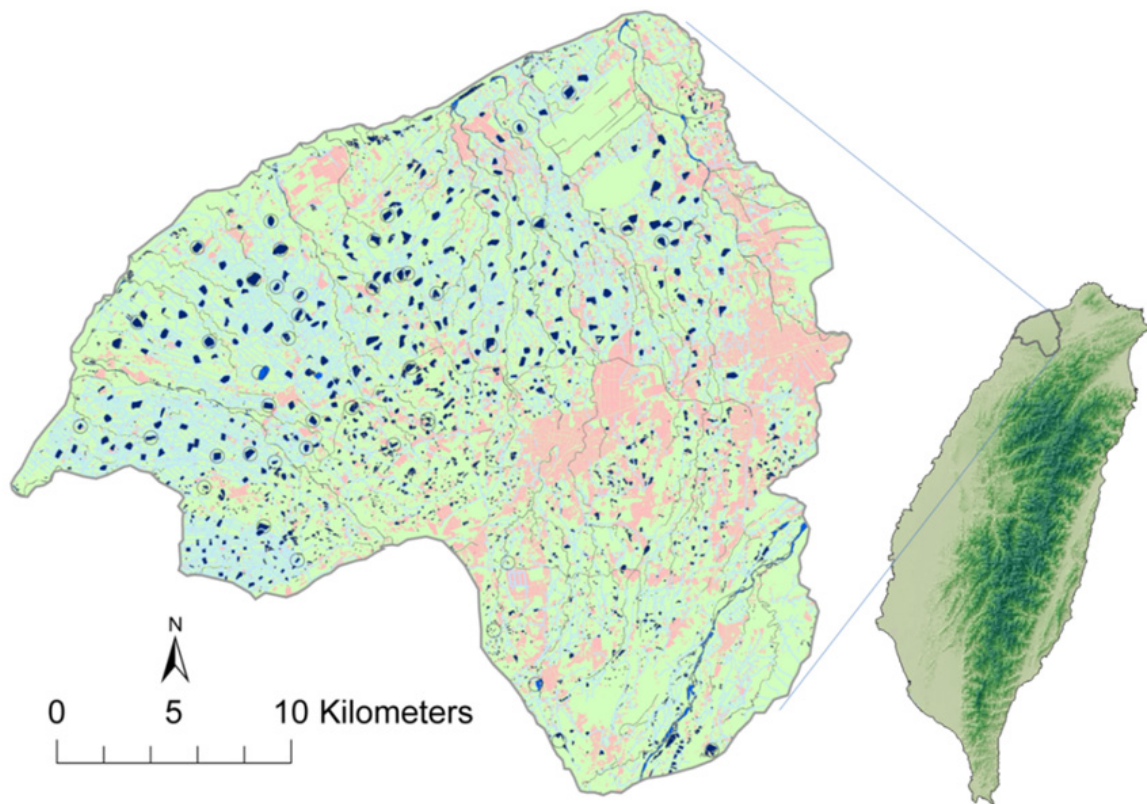

Figure 1. Location away the city limits more than 2 km of forty-five study ponds in the range of the tableland (see also as Fang et al., 2011).

4.2. Waterbirds sampled

Avian observers recorded all bird species seen within a 100-ha radius at 564.19-m basal radius of the bird census point at pond edge associated with line transects along pond-edge trails during 30-minute periods (one case of irrigation ponds see Fig. 2.). Sites were visited four times in the winter seasons between November and February. To reduce the effects of bird-observer bias, three to four observers were grouped and rotated between ponds. The observers counted birds that were in any habitats. All counts were conducted between 7:00 a.m. and 10:00 a.m. on days without rainy days when visibility was good (Bookhout, 1996).

Figure 2. Avian observers recorded all bird species seen within a 100-ha radius at 564.19-m basal radius of the bird census point at pond edge (photo by Wei-Ta Fang).

Foliage-loving species was also recorded followed the point-count method. Avian presence/absence on foliage strata was recorded in each pond at each of the following height intervals: edge ground, wetland grasses (< 0.5 m in height), bushes (> 0.5- 2.5 m in height), trees (> 2.5 m in height). Points were sampled at 10-m internals along edge trails established down each side of each pond. Waterbirds were grouped into microhabitat guilds based on actual observations on the sites. Foliage-loving species were initially classified into four height categories: pond-edge ground, low foliage (< 0.5 m in height), middle foliage (> 0.5- 2.5 m in height), and high foliage (> 2.5 m in height). Species were subsequently classified into two groups: understory (ground and low foliage groups) and canopy (middle and high foliage groups).

I calculated the number of individuals detected of each species at each pond for each month. Then, we calculated mean values of these variables for each study microhabitat across all study ponds in a wintering season (Fang et al., 2011).

4.3. Waterbird diversity

There are two traditional bird analyses for entire avian communities and specific avian groups, richness, and diversity. Differences in the characteristics of avian groups and

pondscape configuration may vary according to species-area relationships among regions. Therefore, to find differences in the response of species to habitat area and isolation, studies must include multiple analytical approaches to detect which analysis was better based on an entire community, or on a specific group.

Descriptive statistics for entire communities were used as the first stage of statistical avian data processing. The main aim was initial analysis of the distribution of avian communities sooner, such as an average individual value and; or a guild value was described for specific groups later. Afterwards, avian diversity was described in the result of diversity indices for all communities or a single group. To detect species evenness and abundance, we used Shannon-Wiener diversity index (H') (also named for Shannon index or Shannon-Weaver index), which is given a measure of the richness and relative density of a species to calculate diversity (Shannon and Weaver, 1949). This diversity measure conducted by Shannon and Weaver which originally came from information theory and measures the order observed within a particular system. Regarding to my studies, this order was characterized by the number of avian individuals observed for each species in the sampling ponds. The first step was to calculate P_i for each category (i.e., avian species), and then we multiplied this number by the log of the number. The index was computed from the negative sum of these numbers. In short, the Shannon-Wiener index (H') is defined as (7):

$$H' = -\sum_{i=1}^{S} P_i \log^2 P_i \tag{7}$$

S: avian species richness
Pi: The percentage of the i species in avian community

This index reflected bird richness in species and evenness amongst the avian community. The benefits of H' was sensitive by the change in threatened birds by avian study than that of Simpson's diversity index (D)(Dean et al., 2002). If the value of H' is higher, it means that species is abundant, or species distribution is even. However, species diversity is sometimes difficult to see relationships with spatial heterogeneity by limited survey data. Grouping and classification are required as well as for spatial heterogeneity reduction from the analyzed variables. It is the main procedure in this methodology for invoking avian groups with similar attributes of spatial behavior. The main approach in cluster analysis application is based on the idea to represent the grouping structure by avian data classification, based on the similarity in guilds between the species.

4.4. Simulation for dynamic informatics

Studies of variation in species individuals with relative abundances have been conducted by using species diversity. Although diversity may be measured most directly as the individual numbers, but it has been expressed the interplay of species richness and abundance into a single value (Shannon & Weaver, 1949; MacArthur & MacArthur, 1961; Dean et al., 2002). In this study, diversity was considered over a wide spectrum of spatial scales, from variation across a single pond scale to a regional scale, where temporal patterns were consequences of

individual habitat selection. The diversity was measured all species. Four regional diversity variations were mapped from experimental semivariogram for avian communities in contour maps. On these maps a successional gradient was indicated to document concentric rings in bird diversity for spatial-temporal analysis (see Equation 8):

$$\gamma(h) = \frac{1}{2N(h)} \left\{ \sum_{i=1}^{N(h)} [z(x_i + h) - z(x_i)]^2 \right\} \tag{8}$$

The best linear unbiased estimator (BLUE) will be achieved to (9)：

$$\hat{z}(x_0) = \sum_{i=1}^{n} \lambda_i z(x_j) \tag{9}$$

while λ_i: weighting of detections; and $\sum_{i=1}^{n} \lambda_i = 1$

The estimation value is equal to the true value, such as:

$$E[\hat{z}(x_0)] = E[z(x_0)] \tag{10}$$

I introduced μ (Lagrange multiplier), then

$$L = Var[\hat{z}(x_0) - z(x_0)] - 2\mu(\sum_{i=1}^{n} \lambda_i - 1) \Rightarrow min[L] \tag{11}$$

$$\begin{cases} \dfrac{\partial L}{\partial \lambda_i} = 0, & (i = 1,2,\ldots,n) \\[2mm] \dfrac{\partial L}{\partial \mu} = 0 \end{cases} \tag{12}$$

$$\begin{cases} \sum_{j=1}^{n} \lambda_j \gamma(\left| x_i - x_j \right|) + \mu = \gamma(\left| x_0 - x_i \right|) \\[2mm] \sum_{j=1}^{n} \lambda_j = 1 \end{cases} \quad (i = 1,2,\ldots,n) \tag{13}$$

5. Results and discussion

5.1. Dynamic informatics for individual frequencies

The avian survey detected ninety-four species in 45 point-count locations associated with line transect of this investigation as a 2003-2004 example (see also Fang et al., 2011). In Taoyuan, forty-five species (48%) species were wintering migrants; forty species (43%) were permanent residents. Five short-transit species (5%) were encountered on the farm-pond sites, one species (1%) was not present at the site previously, defined "missing"; and three

species (3%) were escaped from captivity. The total number of species in the winter seasons in the study area varied. I found greater species richness in wintering migrants (48%) compared with permanent residents (45%). In the microhabitat scale, the species in water regime (vertical structure from water table to aerial space) and waterfront edge were encountered most frequently.

Avian individual frequencies of occurrence were surveyed (see Table 1). I found significantly higher abundances of ten species, accounted for 74% of the entire species abundance, such as: Black-crowned Night-Heron (*Nycticorax nycticorax*) (occurrence frequency 2,363, occurrence rate of 15.7%, resident species), Little Egret (*Egretta garzetta*)(occurrence frequency 1,883, occurrence rate of 12.5%, resident species), Grey Heron (*Ardea cinerea*) (occurrence frequency 1,829, occurrence rate of 12.2%, wintering migrant species), Light-vented Bulbul (*Pycnonotus sinensis*) (occurrence frequency 1,575, occurrence rate of 10.5%, resident species), Eurasian Tree Sparrow (*Passer montanus*)(occurrence frequency 1,125, occurrence rate of 7.7%, resident species), Great Egret (*Casmerodius alba*)(occurrence frequency 726, occurrence rate of 4.8%, wintering migrant species), Red Collared-dove (*Streptopelia tranquebarica*)(occurrence frequency 509, occurrence rate of 3.4%, resident species), Japanese White-eye (*Zosterops japonica*)(occurrence frequency 504, occurrence rate of 3.3%, resident species), Little Ringed Plover (*Charadrius dubius*)(occurrence frequency 316, occurrence rate of 2.1%,wintering migrant species), and Little Grebe (*Tachybaptus ruficollis*)(occurrence frequency 304, occurrence rate of 2%, resident species), respectively. Other kinds of avian abundance, 84 species, were accounted for the total abundance of 36%. There were 23 species of which above 100 individuals were detected in the entire survey records, fewer than 10 individuals of 40 species were detected throughout the survey (see also the detection of 2003-2004 in Fang et al., 2009).

Place	Common Name	Scientific Name	Individual Frequency	Ratio of Frequency
1	Black-crowned Night-heron	*Nycticorax nycticorax*	2,363	15.7%
2	Little Egret	*Egretta garzetta*	1,883	12.5%
3	Grey Heron	*Ardea cinerea*	1,829	12.2%
4	Light-vented Bulbul	*Pycnonotus sinensis*	1,575	10.5%
5	Eurasian Tree Sparrow	*Passer montanus*	1,125	7.7%
6	Great Egret	*Casmerodius alba*	726	4.8%
7	Red Collared-dove	*Streptopelia tranquebarica*	509	3.4%
8	Japanese White-eye	*Zosterops japonica*	504	3.4%
9	Little Ringed Plover	*Charadrius dubius*	316	2.1%
10	Little Grebe	*Tachybaptus ruficollis*	304	2.0%
Totals			11,134	74.1%

Table 1. The individual frequency and their frequency of ten abundant species.

5.2. Dynamic informatics for biodiversity

Based on the point-count locations used random samplings in Taoyuan Tableland, the Shannon-Wiener index (H') by the data of ornithology have been caculated from December 2008, January 2009, and Febuary 2009 in migrating winters. This list with only 7 point-count locations within the entire points of the value of $H' > 2$ can be detected during December 2008, such as: No. 2 (2.522), No. 5 (2.152), No. 15 (2.128), No. 24 (2.127), No. 44 (2.062), No. 33 (2.057), No. 39 (2.022), respectively. This is also 7 point-count locations within the entire points of the value of H' > 2 can be detected during January 2009, such as: No. 32 (2.351), No. 27 (2.267), No. 7 (2.259), No. 40 (2.205), No. 19 (2.134) No. 2 (2.123), No. 5 (2.038), respectively. During the February 2009, a total of 14 point-count locations that the value of $H' > 2$ can be detected at the list, such as the numbers of No. 23 (2.575), No. 44 (2.528) No. 40 (2.516), No. 15 (2.360) No. 1 (2.357), No. 20 (2.320), No. 24 (2.312) No. 2 (2.282), No. 36 (2.281), No. 5 (2.219), No. 37 (2.145), No. 30 (2.046), No. 23 (2.042), No. 34 (2.007), respectively. The average value from three months was calculated at a lower value of 1.603 ± 0.494. This represents some seasonal dynamic informatics currently at a relative peak of H' in the month of Febuary on an urban and regional scale from anthropogenic influences during migratory seasons.

5.3. Modelling by biodiversity

Studies of variation in species individuals with relative abundances have been conducted under the calculation of species diversity. Although diversity may be measured most directly as the individual numbers, but it has been expressed the interplay of species richness and abundance into a single value (Shannon & Weaver, 1949; MacArthur & MacArthur, 1961; Dean et al., 2002). In this study, diversity was considered over a wide spectrum of spatial scales, from variation across a single pond scale to a regional scale, where temporal patterns were consequences of individual habitat selection. The spatial scale on diversity was measured, depended on the pondscape mosaic upon the moment of all species considered from December 2008, January 2009, and Febuary 2009. Three regional diversity variations were mapped for avian communities in contour maps (Figs. 3, 4, & 5). These maps were indicated a successional gradient to document concentric rings in bird diversity for spatial-temporal analysis.

Based on the experimental semivariogram for avian communities in contour maps. Diversities (H'), markly indicate from this anthropogenic influenced trends decreased with increasing dysfunctional pondscapes (monthly variations, see Figs. 2, 3, & 4). This is to say that pondscape configuration is so important in this situation. Indeed, three-month surveys demonstrated monthly diversity oscillations that horizontal heterogeneity might still occur at microhabitats. Species were able to select their proper habitats and then either over-wintered or undertook long migrations by different groups as well as by local generalists in huge assembleges. I, thus, hypothesized that diversities, at meso-scale, varied among different guilds of species from habitat selection. The occurrence rates detected by observers on avian communities were intriguing this hypothesis in different microhabitats, and they were largely examined and classified into groups in the section that follows.
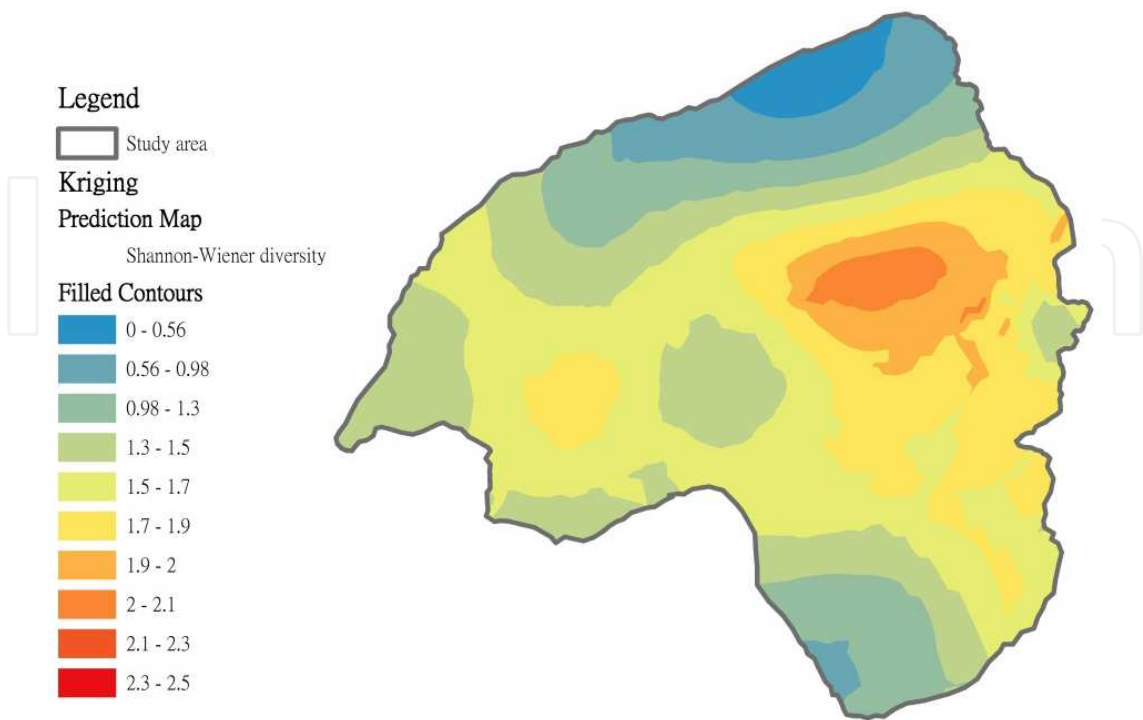
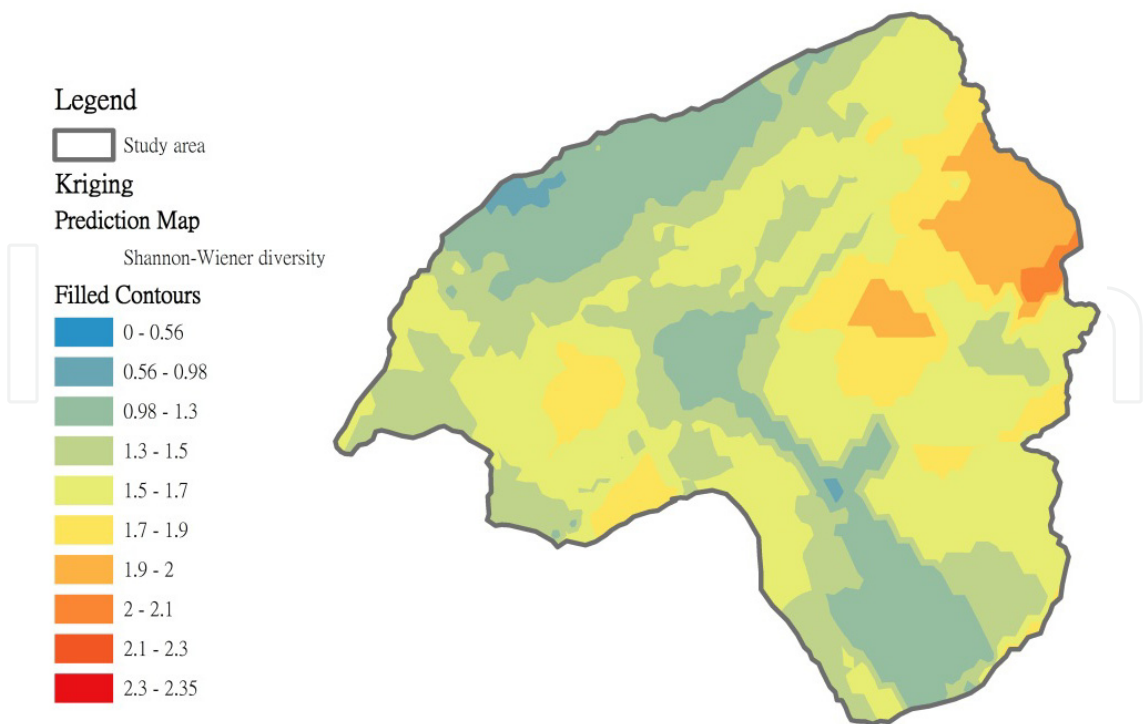**Figure 3.** Scenario Model in Shannon-Wiener Diversity by Kriging Approach (December 2008).

Figure 4. Scenario Model in Shannon-Wiener Diversity by Kriging Approach (January 2009).
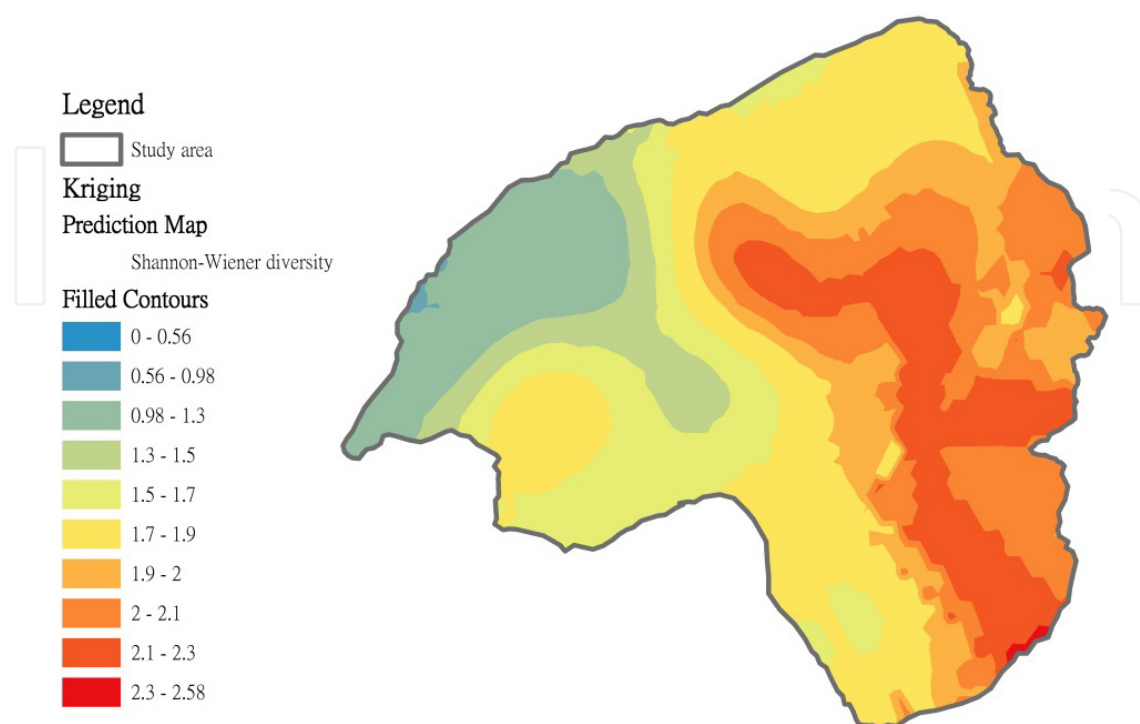
Figure 5. Scenario Model in Shannon-Wiener Diversity by Kriging Approach (Febuary 2009).

5.4. Finding

Despite their agribusiness value, farm ponds appear to have great influences on the make-up of avian communities in urbanized areas, especially for water-edge avian community (See Figs. 6, 7, & 8). I compared the following community characteristics against the corresponding ratio of constructed area value associated with pond configuration of each site for all functional groups: cumulative waterfowl, cumulative shorebirds, cumulative landbirds, cumulative air feeders, and cumulative water-edge species. Pondscape was a strong and/or moderate correlate in any birds of the ordinations (i.e., water-edge birds, shorebirds, and waterfowl) beyond landbirds and air feeders. The presence of adjoining natural and/or urbanized habitats was probably the most important determinant of wetland avifauna in these areas. Regarding to this detailed study, there may be a number of reasons why some farm ponds do not become a refuge for the more sensitive species. First, the ornamental vegetation covers used for surrounding areas are often too few, and they may support a small insect population. Second, anthropogenic structure is subjected to concrete construction without native trees, and this may make it unattractive to water-edge species that require an intact shrub layer, dead wood, or generally undisturbed microhabitats. Third, small pond size associated with curvilinear shape is not optimum to support for preserving and attracting water-edge birds and other avifauna.
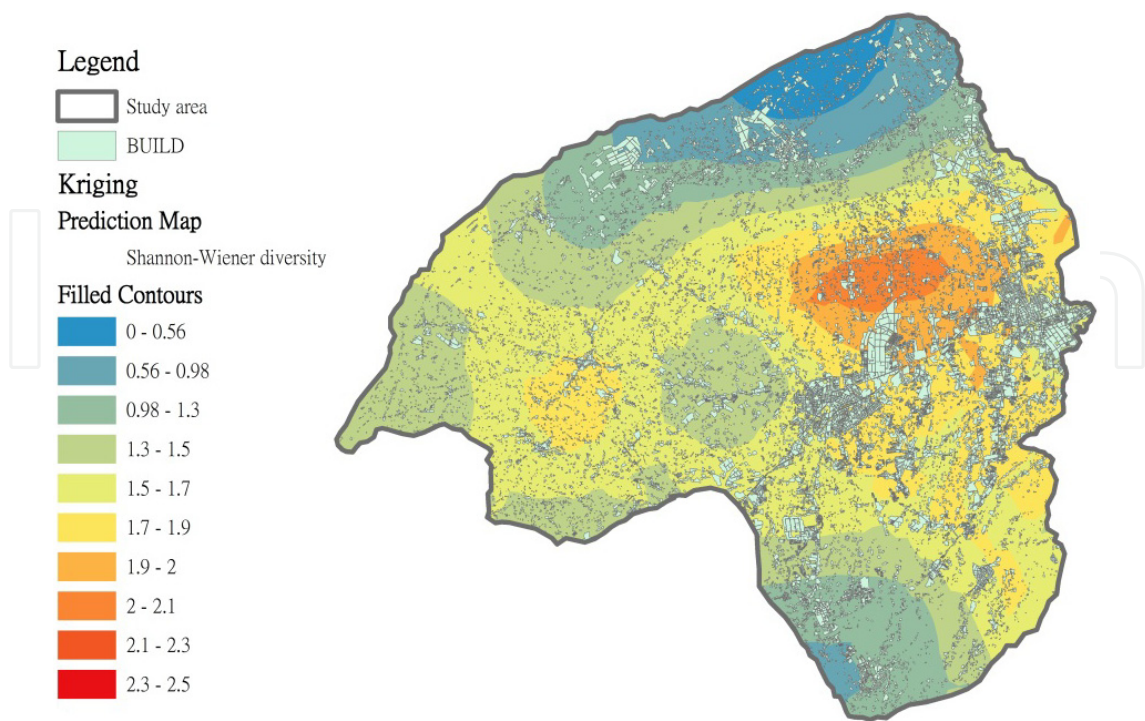
Figure 6. Scenario Model in Shannon-Wiener Diversity by Kriging Approach within building areas (December 2008). Based on the experimental semivariogram for avian communities in contour maps, the same overlapped map layers as Fig. 7 & Fig. 8.
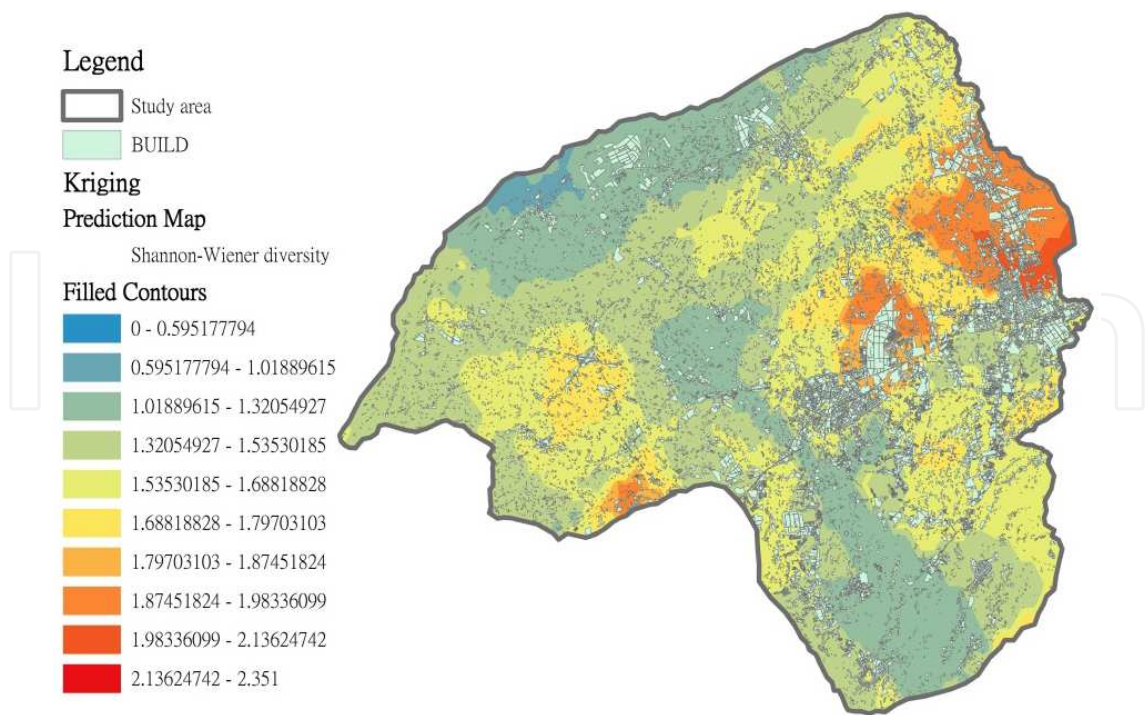

Figure 7. Scenario Model in Shannon-Wiener Diversity by Kriging Approach withing building areas (January 2009).
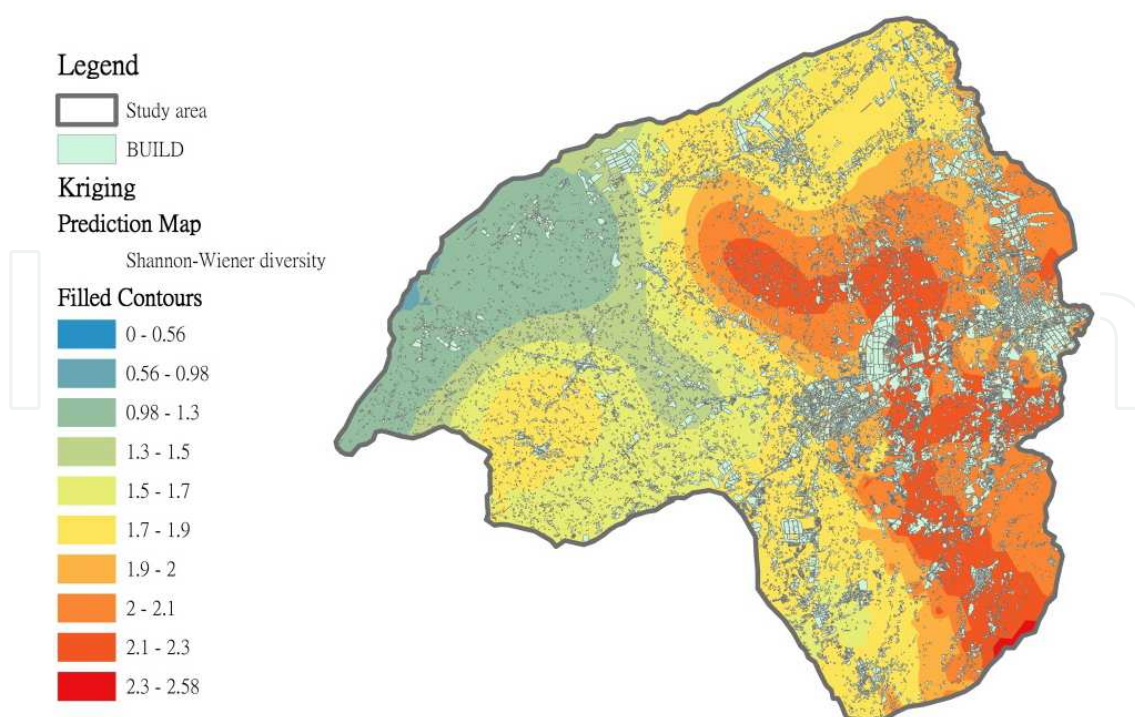
Figure 8. Scenario Model in Shannon-Wiener Diversity by Kriging Approach within building areas (February 2009).

6. Conclusion

Farm ponds generally represent a habitat condition between natural and urban environments, and have great potential for supporting quite varied bird communities (Fang et al.,2009; Fang, 2011; Fang & Huang, 2011; Fang et al., 2011). This chapter characterizes species richness and community structure over a habitat size gradient to a landscape gradient of a farm-pond complex. In my study, forty-five ponds were surveyed ranging in area from 0.2 to 20.47 ha within a landscape complex in the Taoyuan Tableland. An avian survey, detected ninety-four species and individuals, was conducted on three occasions. Contrasting responses to pond configurations at the functional group level, the relationship between the landscape and birds were calculated the effects of pond size and shape within the complex on species richness and community composition. Seven types of avian functional groups, representing locally major species, were identified over urbanized characteristics. Some generalists, like Chinese Light-vented Bulbul (*Pycnonotus sinensis*) and Japanese White-eye (*Zosterops japonica*), have been detected in the urbanized areas. The presence of adjoining natural and/or constructed habitats from anthropogenic influences was probably the most important determinant of avifauna in study areas. This study was used a simulation of diversity of birds with kringing methods beyond a lower mean *H'* value of 1.603 ± 0.494 during migratory seasons for three occasions from 2008 to 2009 in Taoyuan, Taiwan. Studies of variation in species individuals with relative abundances have been conducted by using species diversity for further results and findings in several months. This study will be conducted for decade for more advanced findings in urbanized rural areas.

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