Journal of Environmental Sciences Vol.15, No.2, pp.241—248, 2003 ISSN 1001—0742 CN11—2629/X

Article ID: 1001-0742(2003)02-0241-08 **CLC number**: Q149 **Document code**: A

Landscape structure and bird's diversity in the rural areas of Taiwan

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Abstract: This study tries to discuss the relationship between landscape structure and organisms in the perspective of landscape architecture. The research hypotheses were then proposed as (1) there are relationships between landscape structure indexes and birds' diversity in the rural areas of Taiwan; (2) the relationships between landscape structure and birds' diversity will be different in different hierarchical levels.

In order to increase the bird species, landscape planners could tries to increase the density of water bodies, but decrease the farms and human planted woods. Decrease the density of constructed and human planted grasslands. Increase the area of un-worked acres, natural grasslands, and the area of water bodies and circular the water bodies and natural forest. In order to increase birds' diversity, landscape planners could decrease the concentration of paved areas. Concentrate the human planted trees to increase the core areas of woodlands. Increase the area of natural grassland circular. In order to increase the total number of birds in the planning areas, landscape planners could scattered the paved areas and lengthen the constructed areas. Decreases the core region of the constructed areas. Increase the area of un-worked acres and water bodies. Decrease the disturbance of both the interior area of natural and human planted woodlands and try to increase the density of water bodies.

The analysis results showed that the small grain size indexes are more suitable for the rural areas of Taiwan to capture the influential factors of bird communities. The high fragmentation of land usages in Taiwan lessens the influences of the regional landscape pattern.

Keywords: landscape structure; bird diversity; Taiwan

Introduction

What landscape structure should be considered when planning a park that will accommodate organisms? Are there landscape elements or combinations of elements that go hand-in-hand with a higher probability for the presence of organisms? This study tries to discuss the relationship between landscape structure and organisms in the perspective of landscape architecture. The practical landscape planning application is the main concern is emphasized in this study.

The purpose proposed in this study were to realize the effects of the landscape structures on the birds distribution conditions and to depict the influential grain size index of the rural areas of Taiwan by testing difference hierarchical land usages. The research hypotheses were then proposed as (1) There are relationships between landscape structure indexes and birds' diversity in the rural areas of Taiwan. (2) The relationships between landscape structure and birds' diversity will be different in different hierarchical levels.

1 Literature review

The relationship between landscape and species are emerging issues have been depicted in many articles. Landscape structure is helpful to model the distribution of birds and also useful on the land policy. Studies assert birds are particularly sensitive to the landscape patch size.

Birds are good subjects to test the relationship between species and landscape elements. Landscape scale is a suitable scale to test the relationship between species and land use.

1.1 Categories of landscape structure

Different studies have categories land uses into different types. The main categories include constructed areas, farms, man-made grassland, man-made woods, un-worked acres, acres grassland, natural woods, water bodies, and waterside areas(Table 1).

1.2 Categories in this study

Learn from previous studies and interview with experts of related fields to select the most representative landscape structure indexes. The landscape structures selected in this study include the vegetated lands, un-worked acres, woods, grasslands, and farms.

2 Methods

Eight categories of land usages were proposed to test the relationships between landscape structure and the birds' diversity. Shape index of patches, total area of patches, and density of patches are calculated as the indexes of the landscape structures. Further, three hierarchical levels were analyzed to realize the relationships between landscape structure and the birds' diversity separately.

Table 1 The main categories organized from previous studies

Categories of landscape structure	Studies	Study theme
Constructed areas	Nilon, 1995	Buildings, roads
	Whitcomb, 1981	Urban areas
	Ambuel, 1983	Urban areas
	Lynch, 1984	Urban areas
	Freemark, 1986	Urban areas
	Blake, 1987	Urban areas
	Van, 1987	Urban areas
	Lescourret, 1994	Urban areas
Farms	Nilon, 1995	Grassland, farm
	Whitcomb, 1981	Agriculture and pasturage lands
	Ambuel, 1983	Agriculture and pasturage lands
	Lynch, 1984	Agriculture and pasturage lands
	Freemark, 1986	Agriculture and pasturage lands
	Blake, 1987	Agriculture and pasturage lands
	Van, 1987	Agriculture and pasturage lands
	Lescourret, 1994	Agriculture and pasturage lands
Man-made grassland	Nilon, 1995	Grasslands
	Herkert, 1991	Grasslands
Man-made woods	Blake, 1991	Woods
	Freemark, 1980	Woods
Un-worked acres	Nilon, 1995	Open lands
	Whitcomb, 1981	Wetlands
	Ambuel, 1983	Wetlands
	Lynch, 1984	Wetlands
	Freemark, 1986	Wetlands
	Blake, 1987	Wetlands
	Van, 1987	Wetlands
	Lescourret, 1994	Wetlands
	Brown, 1986	Wetlands
	Gibbs, 1991	Wetlands
Natural grasslands	Nilon, 1995	Grasslands
	Herkert, 1991	Grasslands
Natural woods	Nilon, 1995	Forest lands
	Blake, 1991	Woods
	Freemark, 1980	Woods
	Whitcomb, 1981	Forest lands
	Ambuel, 1983	Forest lands
	Lynch, 1984	Forest lands
	Freemark, 1986	Forest lands
	Blake, 1987	Forest lands
	Van, 1987	Forest lands
	Lescourret, 1994	Forest lands
Water bodies	Nilon, 1995	Water bodies
Water side	Stauffer, 1980	

Most of the data of bird investigations in the rural areas of Taiwan are not in a set schedule and not in specific sites. This study requires the data have to be collected more than one year for the coverage of all four seasons. However, most of the data were reported in various kinds of format and only few data report its investigation route in a site. Further, the collected data have to match with the limited versions of the Photographic Maps for the analysis of the landscape structure of the investigation sites. Finally, forty-two matched data were selected from the 452 sites in the rural of Taiwan.

Before the statistically comparison of the collected data each investigation route were identified on the Aero-photography Map(Scale: 1/5000). Aero-photography Map was used to identify landscape structures within an area 500 meters on either side of the investigation route (Fig.1). The Pearson correlation was used to test the relationships between landscape and the birds' indexes.

3 Results and discussions

3.1 Research hypothesis I: there are relationships between landscape structure indexes and birds' diversity

3.1.1 Water bodies

For the land use of water bodies, the Pearson correlation analysis shows the significant highly positive relationships between area and species and total numbers. There is also negative relationship between

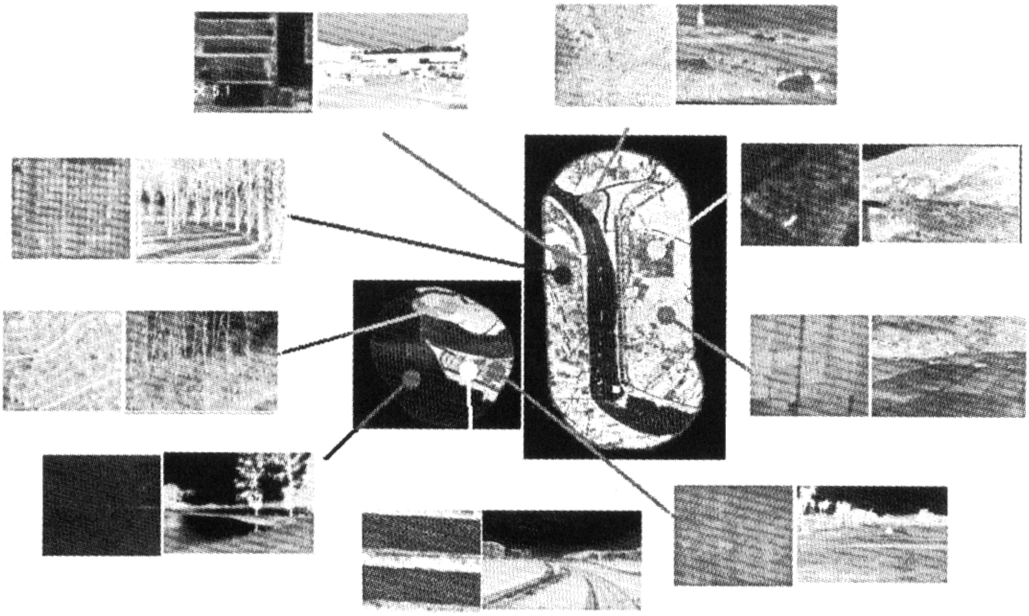

Fig.1 The identified land usages from the Aero-photography Map; note the study areas were 500 meters on either side of the investigation route

landscape shape indexes and there are still highly positive significant relationships between patch density and birds' species and total numbers (Table 2).

3.1.2 Natural woods

For natural woods patches, there are negative relationships between landscape patch shape index and birds' species and their total numbers (Table 3).

Table 2 The Pearson correlation analysis of the relationships between landscape indexes and birds' diversity indexes of water bodies

	Species	Diversity	Numbers
Area	0.7575	0.2453	0.6512
	0.0000***	0.1174	0.0000***
Shape index	-0.42	-0.003	-0.3116
	0.0292*	0.9883	0.1137
Density	0.6602	0.1433	0.7861
	0.0000***	0.3654	0.0000***

Table 3 The Pearson correlation analysis of the relationships between landscape indexes and birds' diversity indexes of natural woods

	Species	Diversity	Numbers
Area	-0.1867	0.0636	-0.1955
	0.2365	0.6892	0.2148
Shape index	-0.5813	-0.4297	-0.4362
	0.0057**	0.0519	0.0481*
Density	-0.1777	-0.1637	-0.1975
	0.2601	0.3003	0.2098

3.1.3 Natural grasslands

For natural grasslands, only the relationships between land use areas and birds' species and their diversity are positively significant, the relationships are not high(Table 4).

3.1.4 Un-work acres

For the relationships between land use and birds' indexes in the un-worked acres, the land use areas shows the significant relationships with birds' species and their total number(Table 5).

Table 4 The Pearson correlation analysis of the relationships between landscape indexes and birds' diversity indexes of natural grasslands

	Species	Diversity	Numbers
Area	0.4947	0.3201	0.2293
	0.0009***	0.0387*	0.1441
Shape index	0.1814	0.114	0.2526
	0.3122	0.5276	0.1561
Density	-0.1874	0.1407	-0.1897
	0.2347	0.3741	0.2289

Table 5 The Pearson correlation analysis of the relationships between landscape indexes and birds' diversity indexes of un-worked acres

	Species	Diversity	Numbers
Area	0.6493	0.1523	0.6611
	0.0000***	0.3356	0.0000***
Shape index	-0.0947	-0.1526	0.1135
	0.5885	0.3815	0.5163
Density	-0.1339	0.0549	-0.0929
	0.398	0.7297	0.5585

3.1.5 Man-made grasslands

For man-made grasslands, there are relationships between landscape patch shape index and total number of birds. There is also a relationship between land use density and birds' species (Table 6).

3.1.6 Man-made woods

For man-made woods, there are negative relationships between land use shape index and birds' diversity. The relationship between land use density and birds' species are also negative related(Table 7).

3.1.7 Farms

For land use of farms, there is only a negative relationship between landscape patch density and birds' species(Table 8).

3.1.8 Buildings

For buildings, the relationships between landscape shape index and birds' total number were significantly related. There are also significant relationships between building densities and birds' species and their diversity(Table 9) .

Based on the results of previous analysis, following are the charts of different purpose for the landscape planners on the practical perspective(Fig.2).

3.1.9 Findings of results of hypothesis I

In order to increase the bird species, landscape planners could tries to increase the density of water bodies, but decrease the farms and human planted woods. Decrease the density of constructed and human planted grasslands. Increase the area of un-worked acres, natural grasslands, and the area of water bodies. Circular the water bodies and natural forest.

Table 6 The Pearson correlation analysis of the relationships between landscape indexes and birds' diversity indexes of man-made grasslands

	Species	Diversity	Numbers
Area	-0.1533	-0.2531	-0.0995
	0.3325	0.1059	0.5307
Shape index	-0.4823	0.281	-0.5912
	0.0807	0.3305	0.0260*
Density	-0.3221	-0.1467	-0.1728
	0.0375*	0.3537	0.2739

Table 7 The Pearson correlation analysis of the relationships between landscape indexes and birds' diversity indexes of man-made woods

	Species	Diversity	Numbers
Area	-0.1559	0.1436	-0.1326
	0.3242	0.3643	0.4024
Shape index	-0.1506	-0.4054	-0.0025
	0.4108	0.0213*	0.9892
Density	-0.4884	-0.1088	-0.2811
	0.0010***	0.4929	0.0713

Table 8 The Pearson correlation analysis of the relationships between landscape indexes and birds' diversity indexes of farms

	Species	Diversity	Numbers
Area	0.202	0.1915	0.2344
	0.1995	0.2245	0.1351
Shape index	0.1094	0.0431	0.0778
	0.5578	0.8178	0.6772
Density	-0.3961	-0.0208	-0.2175
	0.0094**	0.8961	0.1666

Table 9 The Pearson correlation analysis of the relationships between landscape indexes and birds' diversity indexes of buildings

	Species	Diversity	Numbers
Area	0.1411	0.0608	-0.019
	0.3729	0.7022	0.905
Shape index	0.2125	-0.0145	0.3559
	0.1767	0.9275	0.0207*
Density	-0.421	-0.4129	-0.211
	0.0055**	0.0066**	0.1798

In order to increase birds' diversity, landscape planners could decrease the concentration of paved areas. Concentrate the human planted trees to increase the core areas of woodlands. Increase the area of natural grassland circular.

In order to increase the total number of birds in the planning areas, landscape planners could scattered the paved areas and lengthen the constructed areas. Decreases the core region of the constructed areas. Increase the area of un-worked acres and water bodies. Decrease the disturbance of both the interior area of natural and human planted woodlands and try to increase the density of water bodies

3.2 Research hypothesis II: the relationships between landscape structure and birds' diversity will be different in different hierarchical levels

The second hypothesis tested the relationships among different hierarchical levels of landscape structure. Different levels of the land usages were mapped with the GIS mapping system for further analysis (Fig.3).

The frequencies of the land use indexes of different hierarchical levels of landscape land use in the vegetated land uses(Table 10). It shows that the natural grassland has the highest score of shape index and the man-made vegetated land has the highest density score.

Influences on birds' species, diversity and total number of birds among different hierarchal levels were discussed. Their relationships are shown in the Tables 11—13.

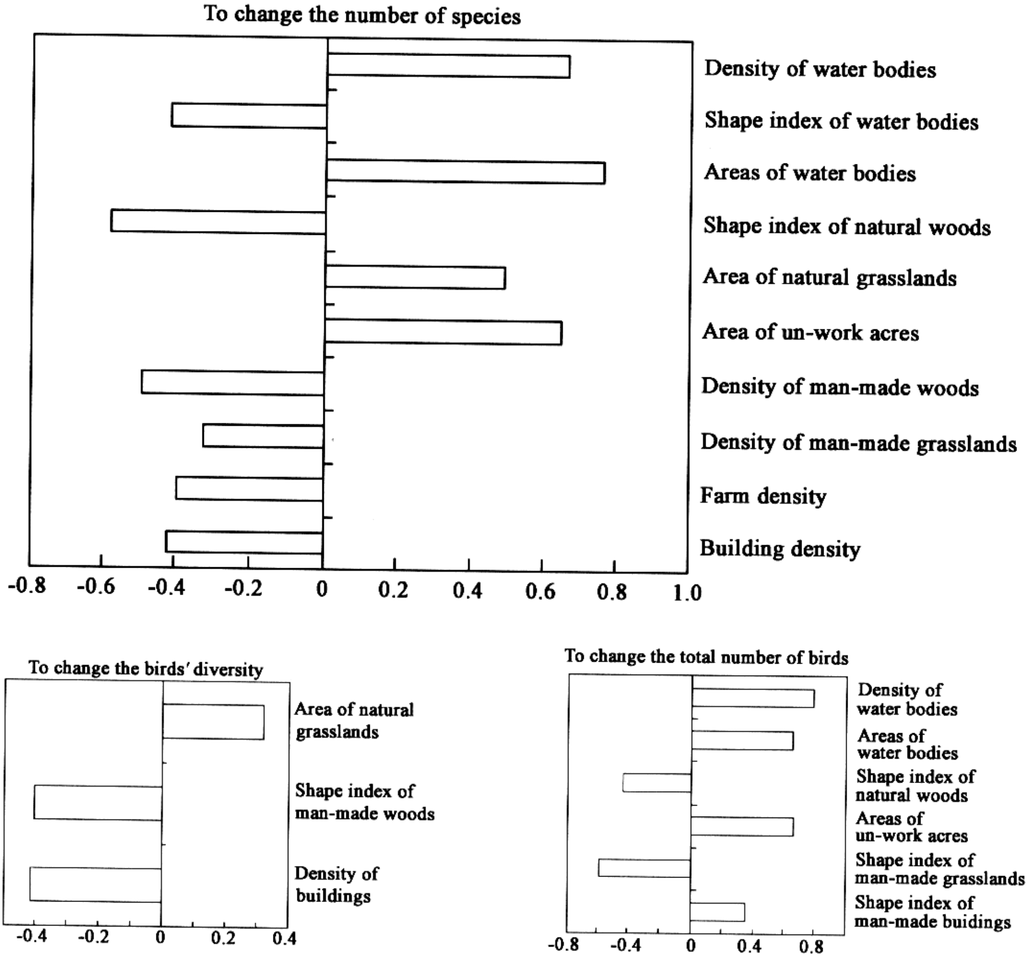

Fig.2 Suggestion modifications of land uses for landscape planners under different planning strategies

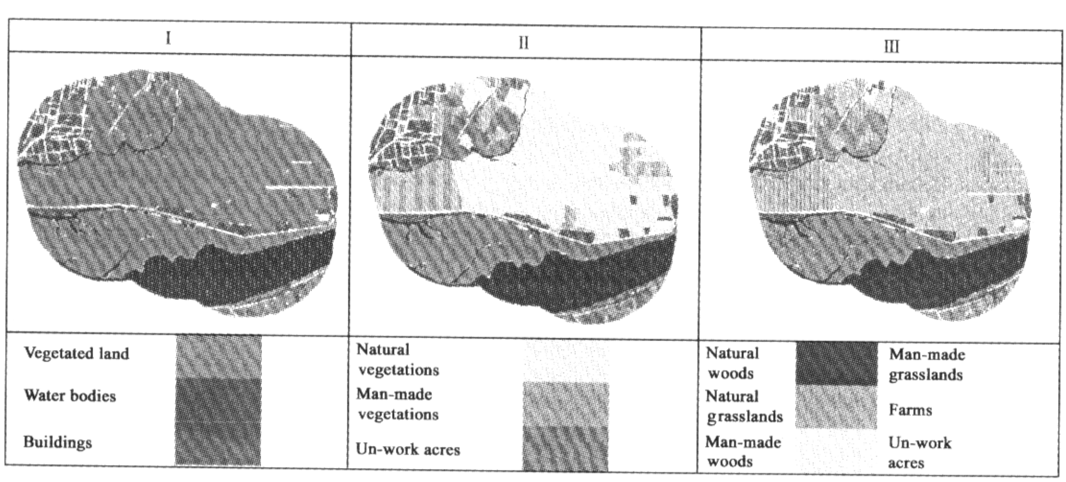

Fig.3 GIS mapped different hierarchical levels land usages

Table 10 The frequencies of the land use indexes of different hierarchical levels of landscape land use in the vegetated land uses

		Shape index		Area, m^2		Density, 100 acre	
		Mean	StDev	Mean	StDev	Mean	StDev
Ⅰ	Vegetated lands	1.469	0.064	55145.06	58945.45	19.535	13.448
Ⅱ	Natural vegetated lands	1.505	0.091	22838.53	32165.22	45.431	96.41
	Man-made vegetated lands	1.4835	0.251	20804.61	19718.83	86.571	175.995
	Un-worked acres	1.476	0.061	18563.47	31493.04	14.852	12.961
	Natural woods	1.429	0.036	38821.86	35008.46	30.73	13.985
	Natural grasslands	1.491	0.062	19153.66	31677.63	18.861	16.007
	Man-made woods	1.483	0.081	6728.08	12939.74	19.857	18.103
Ⅲ	Man-made grass land	1.471	0.072	6408.334	4150.305	11.5	10.132
	Un-worked acres	1.476	0.063	18563.47	31493.04	14.825	12.961
	Farm	1.406	0.061	32841.65	23838.99	24.5	28

Table 11 The Pearson correlation among birds' species and landscape indexes at different hierarchal levels

	Influential factors of birds' species		
	Ⅰ	Ⅱ	Ⅲ
Shape index	Vegetated lands	Natural grasslands	Natural woods
			Natural grasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres
Area	Vegetated lands	Natural grasslands	Natural woods
			Natural grasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres
Density	Vegetated lands	Natural grasslands	Natural woods
			Natural grasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres

Results of hypothesis II: The analysis results showed that the small grain size indexes are more suitable for the rural areas of Taiwan to capture the influential factors of bird communities. The high fragmentation of land usages in Taiwan lessens the influences of the regional landscape pattern.

For the future works in Taiwan, the concept of the Holistic Landscape Ecology should be promote to increase the combination of the culture concerns with the natural concerns in the landscape planning works. The damaged stream and the landscape structures by the 921 earthquake and the following typhoons will be the main issues of the landscape ecological planning projects. Finally the rural land planning strategies of Taiwan will face both the holistic concern and the damaged soil of Taiwan. The strategies of the rural planning works will put huge influences on the fractural land of Taiwan. How to use our land with wise and vision will be our own responsibility.

Table 12 The Pearson correlation among birds' diversity and landscape indexes at different hierarchal levels

	Influential factors of birds' diversity		
	Ⅰ	Ⅱ	Ⅲ
Shape index	Vegetated lands	Natural grasslands	Natural woods
			Natural grasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres
Area	Vegetated lands	Natural grasslands	Natural woods
			Natural grasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres
Density	Vegetated lands	Natural grasslands	Natural woods
			Natural arasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres

Table 13 The Pearson correlation among total number of birds and landscape indexes at different hierarchal levels

	influential factors of birds' Numbers		
	Ⅰ	Ⅱ	Ⅲ
Shape Index	Vegetated lands	Natural grasslands	Natural woods
			Natural grasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres
Area	Vegetated lands	Natural grasslands	Natural woods
			Natural grasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres
Density	Vegetated lands	Natural grasslands	Natural woods
			Natural grasslands
		Man-made grasslands	Man-made woods
			Man-made grasslands
			Farms
		Un-work acres	Un-work acres

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