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THE VALUE OF GREEN BELTS IN URBAN SPRAWL: A CASE STUDY OD TAICHUNG CITY, TAIWAN

Chih-Hao Chen, Walter Den

Department of Environmental Science and Engineering, Tunghai University, Taiwan

*Corresponding Author, Received: 7 June 2016, Revised: 20 Aug.2016, Accepted: 26 Jan. 2017

ABSTRACT: The role of green belts is not only to provide the recreation for human activities but also to improve environmental quality and to provide refuges for wildlife under intensified urban development. After the new demarcation of administrative areas, the influx and construction of industrial zones and commercial buildings has caused a major change of the original landscape in the Dadu hill area in Taichung City, Taiwan. The aims of this study are to provide recommendations pertaining the design of ecological corridors to improve the connectivity of the remaining green places, and the assessment of the health of habitat for the developed urban area. We compared the biodiversity (birds, mammals, plantation) and carbon flux in three different suburban areas including a campus, a metropolitan park and an undeveloped woodland in regular disturbance by human and fire. According to the results of habitat similarity, the metropolitan park and campus were grouped with the higher diversity of birds, but the woodland had the higher diversity of plantation and mammals. Seasonal change is the main factor which affects the carbon flux and vegetation growth situation, and the disturbance by human activities and canopy and coverage by plantation are the causes of fluctuations. The habitat assessment which integrated the biodiversity and carbon flux provided another angle to evaluate the greenbelt design comprehensively. However, the quantification of the whole ecosystem service value is a further direction of environment management, especially in green place conserving under the urban sprawl.

Keywords: Carbon flux, Urban Sprawl, Environmental Index, Urban Management

INTRODUCTION

With the industrial development and the transformation in Taiwan, urban renewal , re-zoning had changed the patterns of land using , as the agriculture and coastal area had reclaimed to industrial zones. However, the changing land using pattern had caused the direct impact to the original inhabit of human life, but also lead to the result about the habitat losing of wildlife.

The measurement and assessment are the basic work of the carrying capacity for an ideal sustainable and friendly urban environment. Despite the social and economic values, as the clean air, water, noise, and traffic, the ecosystem service value of the consideration of natural resource would make up for a complete environmental value[1, 2].

When the high-density population gathered in the urban, the accompanying high-intensity human activities and resource requirements, including the land development, had caused high pressure for itself, but also to force the surrounding resource supply and even further afield .

In recent year, the night calls of the Nightjars (Caprimulgus affinis) in Taiwan is a case of wildlife invasion in the urban because of the habitat losing by urban sprawl. Due to the urban expansion, the wildlife could not migrate to another suitable habitat , the nearby and similar habitat type would because their only selection..

The coexistence of wildlife and human could be the best solution at the present, but not the best treatment for both. When the construction could cause the direct environmental impact, as the habitat losing and fragment, the mitigation, and restoration[3] as the in-situ, ex-situ conservation, the design of the corridors between the small habitat[4, 5] , could provide the refuges for the wildlife and maintain the biodiversity. The habitats with linkability and buffer, play the essential role in the urban ecosystem for the vegetation, birds, mammals, amphibians, even the material flows, and also provide an excellent field of environmental education and observation[6-8].

This aim of this paper is to provide a design direction of the ecological corridors to save the green places under the pressure of construction and habitat fragment by integrating the biodiversity and carbon flux survey.

METHODS

Quadrat Setting and Species Census

The study area located on the Dadu hill area in Mid-Taiwan was classified by NDVI (Normalized Difference Vegetation Index) for habitat classification, and divided into three main quadrats

(13 sampling plots)(Fig1), Tunghai University campus, the southern of the Dadu hill, and the Northern part, including the Taichung Metropolitan Park, by vegetation condition, canopy(natural and human-made), landscape coverage, human disturbance and water area. The census of birds, small mammals and vegetation and the monitoring of carbon flux were carried out from March 2013 to November 2014.

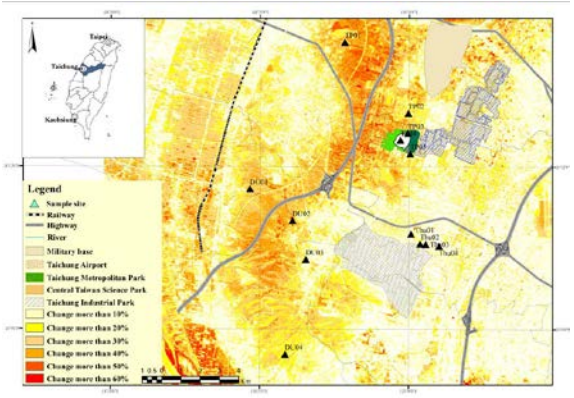

Fig 1 The satellite map of the study area by NDVI index.

The small mammal was trapped for species identification and released to original habitat after maker for population estimation. The line transect and point count method were used for bird census by binoculars and voice identification. In vegetation, 10 m x 10 m square sample area was settled in each plot for the investigation of woody plant and the herb. An Infrared gas analyzer (IRGA, LI-820, LI-COR Inc.))for carbon dioxide were used for carbon flux, and the light intensity was recorded at the same time by Li-Core 1400.

Habitat Similarity and Statistic Analysis

The difference of the community structure and species composition are quantified by Euclidean Distance Method. All data was handled by MS Office Excel 2011, StatPlus （AnalystSoft, StatPlus:mac - statistical analysis program for Mac OS. Version 5.）and the figures were performed using GraphPad Prism version 6.00 for Mac, GraphPad Software, La Jolla California USA, www.graphpad.com

RESULTS

Biological Census

Nine species of small mammals(Table1), 73 species of birds(Table2) and 188 species of flora(Table3) were detected and trapped on 13 plots where we conducted between March 2013 and November 2014. The distribution of the small mammal in Southern is better than other quadrats, and the percentage of conservation and endemic species of the birds in 3 quadrats are higher, especially in Tunghai University Campus. In the part of the flora, the species in the Northern, and the diversity and coverage in the Southern are higher.

Season effect and Carbon Flux

The carbon flux in Tunghai University Campus(371.60 ± 217.04 mg/m^2/s) is higher than the Southern (250.02 ± 94.98 mg/m^2/s)and Nothern(327.39 ± 215.15 mg/m^2/s)during the monitoring, and the difference between each plot are significantly($p<0.05$). The vegetation growth and the organic carbon would be affected by season, but also for the carbon flux(Fig2). The human disturbance, as the tread, traffic, even agriculture, would cause the significant difference(Fig3), the plot with lower disturbance would have higher flux($p<0.05$). In high vegetation coverage, the carbon flux would be higher than low ones significantly($p<0.05$), but the fluctuation in the different season is not significantly($p=0.053$)(Fig4).In this study, the definition of the canopy is not only the aboveground portion of the crop but also including the human buildings. The difference is not significant in the higher canopy(>25%), and the carbon flux is higher under the lower canopy(Fig 5). The season factor didn't affect the flux in the different canopy($p=0.053$).

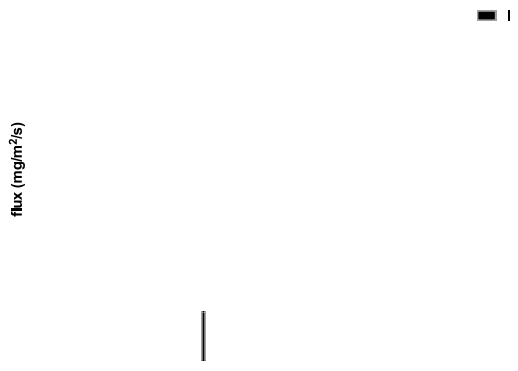

Fig 2 The carbon flux of each plot in different season

Fig3 The carbon flux in different disturbance degree

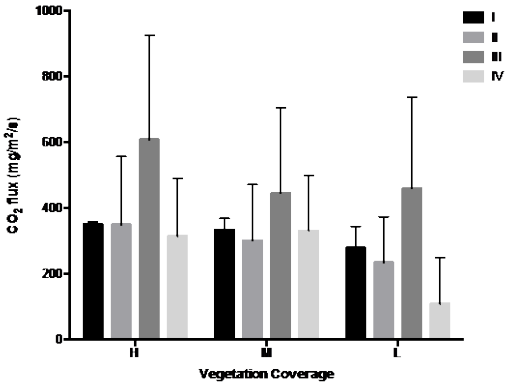

Fig 4 The carbon flux in different land coverage

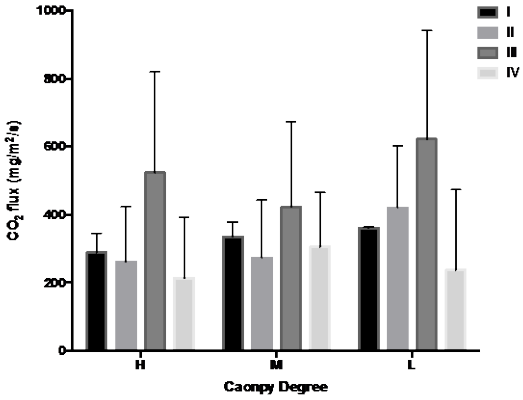

Fig5 The carbon flux in different canopy percentage

Note1: I : Jan-Mar ; II : Apr-Jun ; III : Jul-Sep ; IV : Oct-Dec

Note2: H: High degree; M: Medium degree; L: Low Degree

The relationship between the carbon flux and biological index

Table 4 shows the correlation about the mammals and plants in spring and winter are opposite, the season is the main factor. Otherwise, the correlation about the birds only exists in the winter as the migratory species, and lack of the food would result in the gathering situation.

CONCLUSION

Disturbance and Invasion species

Since the fire and construction had to be happened in the Dadu hill area usually, the Guinea Grass(Panicum maximum) from Africa had been the one of the dominant species and completed the habitat with the native species, Eulalia grass(Miscanthus sinensis). However, the grassland with the Guinea grass had become the main habitat type after the repeated fire and human disturbance. The similar situation had happened in Western American, the cheatgrass(Bromus tectorum) from Asia had completed with the native species, Sagebrush (Artmesia tridentata) and Sandberg bluegrass (Poa ampla), because of the high fire frequency and overgrazing. The invasion species not only change the habitat type but also result in the carbon sink to carbon source, the carbon emission had been 8 ±3 Tg C in Great Basin area[9].

In addition to the invasive species, due to the horticulture, agriculture and other needs of the cultivation in the metropolitan area and suburban area, the domestic species are cultivated widely, especially in the park, school or private gardens and other green places. It would not only affect the carbon flux, but also biodiversity.

Twenty(10%) domestic and 53(26%) naturalized species are found during the survey, and there are not significantly different between native species or not in carbon flux($p=0.2098$), but the naturalize and native species in the winter($p=0.0104<0.05$).

Therefore, although the non-native species did not significantly affect the circulation of carbon flux, however, the native species should have priority for plantation in the particular area, as a park, campus, and garden, to avoid and reduce the dispersal of invasionspecies[9, 10].

The planning of ecological corridors and area

According to the habitat similarity (Fig6,7,8,9), the habitat types of Tunghai University Campus and the Northern part are similar, and these two areas are under stable succession with better human management. In the southern part, the regular succession environment due to the repeated fire and agriculture, the influence of carbon flux by season was significantly than others.

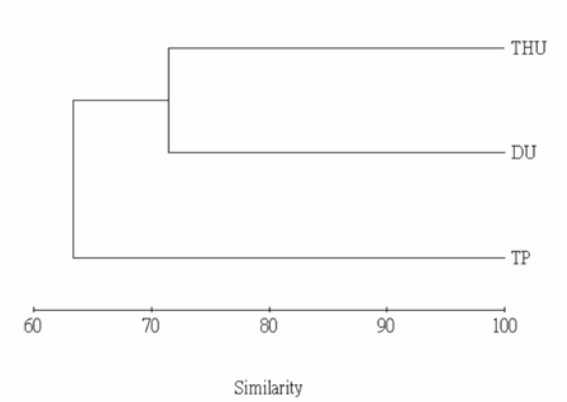

Fig 6 The similarity of small mammal in three quadrat

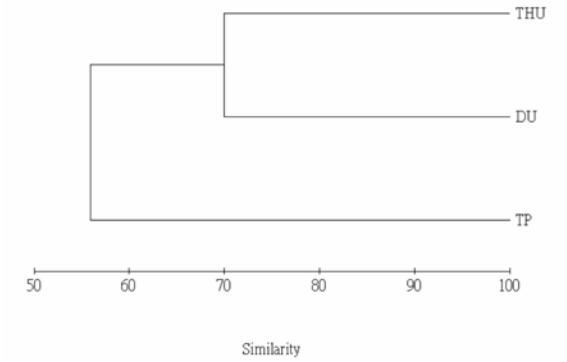

Fig 7 The similarity of birds in three quadrat

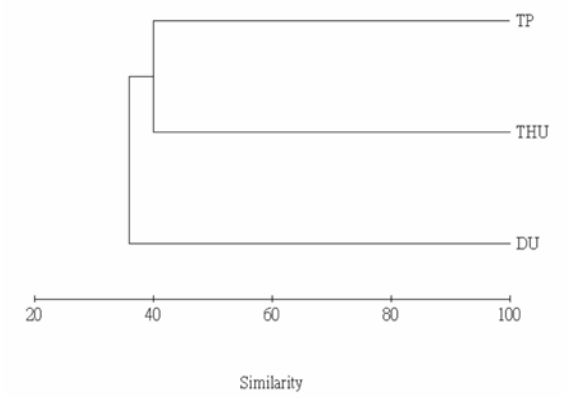

Fig 8 The similarity of plant in three quadrat

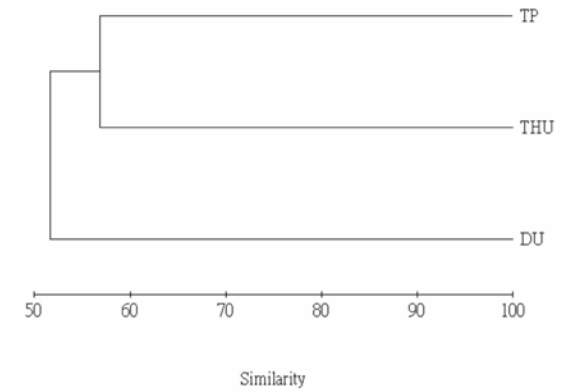

Fig 9 The similarity of habitat integrated indics in three quadrat

The whole area could be divided into two blocks for considerations, one is the Northern part and Tunghai Campus, and anther one is the Southern part, as a wildlife refuge. An industrial park and a business area are located on the connection between this two area, and could be suspended or cut off the possibility of species exchange. The human-made green belt, as the small park, and the replanting of the vegetation could improve the connectivity of the patches.

In conclusion, the season is the major impact on the carbon flux and biological distribution and dispersal. However, the influence of disturbance is greater than canopy and vegetation coverage. No matter for biodiversity conservation, human recreation, or improve the environmental quality, the green places in the urban and suburban area could seem as the refuge for wildlife and human. The monitoring of carbon flux could be an auxiliary tool for the traditional biological census to assess the habitat heterogeneity in Landscape ecology, and to reinforce the consideration in urban environment assessment.

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Table 1 The diversity and biological indices of the small mammal

	Southern				THU Campus				Northern				
	DU01	DU02	DU03	DU04	Thu01	Thu02	Thu03	Thu04	TP01	TP02	TP03	TP04	TP05
Species	2	5	6	4	2	5	2	2	0	2	2	1	1
Population	2	35	22	11	4	9	7	19	0	8	12	2	6
Richness	1.44	1.13	1.62	1.25	0.72	1.82	0.51	0.34	NA	0.48	0.40	0.00	0.00
Evenness	1.00	0.83	0.81	0.81	0.81	0.89	0.59	0.83	NA	0.54	0.41	NA	NA
Shannon-Weaver Index	0.69	1.33	1.45	1.12	0.56	1.43	0.41	0.58	0.00	0.38	0.29	0.00	0.00
% of Alien spceis	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% of Conservation spceies	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Integrated Index	5.13	5.00	5.65	4.85	3.59	5.50	2.80	3.16	0.00	2.65	2.27	1.00	1.00

Table 2 The diversity and biological indices of the birds

	Southern				THU Campus				Northern
	DU01	DU02	DU03	DU04	Thu01	Thu02	Thu03	Thu04	TP01	TP
Species	13	14	13	15	13	33	26	20	20	67
Population	200	116	116	257	212	745	833	534	224	2928
Richness	2.26	2.73	2.52	2.52	2.24	4.84	3.72	3.03	3.51	8.27
Evenness	0.79	0.78	0.89	0.69	0.74	0.73	0.71	0.74	0.74	0.77
Shannon-Weaver Index	2.04	2.06	2.29	1.87	1.90	2.56	2.32	2.22	2.22	3.23
% of Alien spceis	0%	4%	3%	1%	0%	1%	0%	5%	2%	4%
% of Conservation spceies	1%	3%	2%	1%	1%	1%	2%	1%	0%	7%
Integrated Index	6.32	6.80	7.11	6.27	6.02	9.36	7.93	6.98	7.54	13.76

Table 3The diversity and biological indices of the vegetation

		Southern				THU Campus				Northern				
		DU01	DU02	DU03	DU04	Thu01	Thu02	Thu03	Thu04	TP01	TP02	TP03	TP04	TP05
Woody	Species	5	2	4	3	4	5	4	2	1	1	1	1	3
	Shannon-Weaver Index	1.56	0.50	1.33	0.94	1.28	1.48	1.39	0.69	0.00	0.00	0.00	0.00	1.01
Herb	Species	2	8	3	4	6	2	7	2	2	3	4	6	8
	Shannon-Weaver Index	0.36	0.60	0.58	1.17	1.43	0.13	1.55	0.63	0.42	0.25	0.18	0.86	1.89
% of Coverage		97.50	91.00	93.00	5.50	40.50	103.00	21.00	125.00	107.00	101.00	96.50	112.00	8.50
Integrated Index		5.44	4.55	5.33	4.60	5.32	5.10	5.35	5.51	3.89	3.59	3.45	4.08	5.29

Table 4. The correlation between the carbon flux and biological index in spring and winter

Season	Group	Index	Pearson correlation coefficient	p-value
Winter	Mammals	Richness	-0.654	0.078
	Birds	Shannon-Weaver Index	0.802	0.017
	Plant	Shannon-Weaver Index	-0.768	0.026
Spring	Mammals	Richness	0.536	0.089
	Plant	Shannon-Weaver Index	0.505	0.087