

## Research paper

# Do Biotope Area Factor values reflect ecological effectiveness of urban landscapes? A case study on university campuses in central Taiwan



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## HIGHLIGHTS

- Biotope Area Factor (BAF) used to estimate ecological effectiveness is evaluated.
- BAF values of university homogenous units were compared with biodiversity data.
- BAF values were incongruent with in situ diversity of flora and fauna.
- Future system should consider factors affecting biodiversity and operation scale.

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## ABSTRACT

In recent years, applying ecological concepts into landscape designs to enhance biodiversity within urban areas has become an important strategy worldwide. A commonly adopted strategy for the development of systems is to estimate the ecological effectiveness of relative landscape mosaics. Biotope Area Factor (BAF) is a general methodology that is used, however it only considers the land use surface types of the landscape mosaic unit using aerial photos and expert questionnaire method. It is not clear whether the ecological effectiveness of areas estimated by BAF system is congruent with the actual ecological characteristics and diversity of inhabiting organisms. The practicality of the BAF systems are evaluated in this study by comparing the BAF values of homogenous units amongst eight urban university campuses in central Taiwan with vegetation density/structure and arthropod/plant diversity collected in situ. We used linear models to evaluate the relationship between BAF values and in situ arthropod/plant diversities and vegetation structures. The results showed that BAF values of various homogenous units were partially correlated with vegetation structure, but were incongruent with in situ diversity of plants and arthropod. Our findings indicated that the current urban area ecological effectiveness quantifying BAF system may not be appropriate. For future studies, we suggest that the operation scale should be adjusted and factors influencing biodiversity should be considered in the weighting system to realistically and precisely designate the ecological effectiveness of landscape mosaic units.

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## 1. Introduction

The recent increase in human population has caused rapid depletion of natural resources and natural habitats, and therefore integrated collaborative approaches aiming to achieve environmental protection and sustainability are inevitable and urgent. Applying ecological concepts and green environment

managements to develop and maintain a sustainable landscape are ways of achieving a sustainable development. As the area of artificial environments continuously expands, how to make good use of green and blue infrastructure networks (such as forests, parks, water bodies, school campuses, etc.) as essential elements to enhance various levels of diversity has become an issue worldwide (Kareiva, Watts, McDonald, & Boucher, 2007). Researchers believe that landscape design will play an important role in the protection of ecological and biological diversity (Barnett, 2008; Handel, Saito, & Takeuchi, 2013; Hobbs, 1997; Müller, Werner, & Kelcey, 2013). Recently, applying ecological concepts in landscape designs to achieve environmental protection and biodiversity enhancement has become a common strategy (GBO3, 2010; Millennium

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Ecosystem Assessment, 2003; Strategic Plan, 2010). Although the area of natural habitats continues to decrease globally, we can still achieve environment protection and biodiversity enhancement to a certain degree if appropriate management policies created from well-designed ecological experiments are adopted during the planning and design of green space in urban environments (Barnett, 2008; Handel et al., 2013; Müller et al., 2013; Niemelä & Kotze, 2009; Scholes et al., 2012; Seto et al., 2012).

A commonly used strategy to enhance ecological and biological diversity in artificial or urban areas is the development of systems to measure the ecological effectiveness of various types of landscape spaces (Butchar et al., 2010; CBI, 2012; Kohsaka, 2010; Mori & Christodoulou, 2012). Biotope Area Factor (BAF) or Green Factor (GF) are procedures applied in specific European countries and the United States as a guideline to sustainably manage landscapes of urban areas (Farrugia, Hudson, & McCulloch, 2013; Finlay, 2010; Kruuse, 2011). These indices represent the ratio of the ecologically effective area (i.e., area covered by green vegetation and/or permeable to rainwater) to the total landscape area under consideration (Farrugia et al., 2013; Finlay, 2010; Kruuse, 2011). The ecologically effective areas is defined as an area exhibiting a positive effect on the ecosystem or an effect on the development of the biotope of a site (Becker, 1990; Hirst, Morley, & Ban, 2008). The higher the plant coverage, the more the permeability to rainwater and suitable for the organisms, the higher the ecological effectiveness of an area. The types of surface areas are weighted differently according to the following attributes: permeability to water, rain water storing ability, relationship to soil functioning, pureness of the environment and stipulations of suitable habitats for plants and animals (Kenworthy, 2006; Kruuse, 2011). Developers must consider the previously stated attributes and maintain a specific level of overall ecological effectiveness in their landscape design in order to obtain construction permits from local authorities (Finlay, 2010; Hirst et al., 2008; Kruuse, 2011). Currently, indexing systems are achieved by professional experts that rank the relative ecological effectiveness of various homogenous land elements by utilizing aerial photos and satellite images of the landscape space under consideration to generate a weighting system. Systems such as BAF or GF have been applied in landscape designs in various temperate cities for more than 30 years (Gómez-Baggethun & Gren, 2013). However, it is not clear whether the current expert questionnaire method of determining the weighting values of various homogenous land types can actually reflect the ecological condition, composition and abundance of organisms inhabiting these areas. For that reason, there is an urgent need to evaluate the validity of existing weighting systems to determine if they can reflect the ecological effectiveness of various landscape types.

Construction of green infrastructure networks in urban areas can create an ecologically functional environment to help reduce the impacts generated from urban developments and activities (McPhearson, Maddox, Gunther, & Bragdon, 2013). In addition, the green spaces in urban areas are important locations for city residents to conduct recreational activities (Schaffler & Swilling, 2013). In many East Asian countries, a substantial percentage of green space in urban areas is located in school campuses. Among the various types of school campuses, universities are considered the largest (Colding, 2007; Kulkarni et al., 2001). Therefore, university campuses represent substantial green space and ecological habitats, which are potentially significant elements for enhancing the ecological effectiveness of the urban areas in East Asia (Varghese, 2006). In this study, we focus on university campuses located in urban areas to evaluate whether the original BAF system of designating ecological effectiveness of expert questionnaire method can realistically reflect the ecological condition and biodiversity of these areas. We chose eight universities in central Taiwan and for each campus we identified typical landscape types according

to the land-use intensity. We classified homogenous units within each landscape type and determined their ecological effectiveness by the expert questionnaire method. In addition, systematic ecological data collection and biodiversity surveys were conducted in these units and such information was used to assess the suitability and validity of the BAF indexing system.

## 2. Materials and methods

### 2.1. The study area

In this study, the university campuses surveyed were all located in Taichung City, Taiwan. These universities have been established from 13 to nearly 100 years and their campus area ranges from 9 to 145 ha. Despite the small area of some campuses, the student populations of these universities were all greater than 10,000 (Table 1).

### 2.2. Classification of land use surface types and homogenous units

Digital satellite aerial photos of the university campuses studied were purchased from The Aerial Survey Office, Bureau of Forestry, Taiwan to perform subsequent processing and analyses. According to the land use type identified from the photos and results of in situ surveys, we were able to determine seven homogenous units from the eight university campuses studied. From these seven homogenous units a total of eight land use surface types were classified. We established the ecological effectiveness weighting values of these eight land use surface types using the expert questionnaire method (Becker, 1990). Photos ( $n = 35$ ) of these land use surface types taken from eight campuses were sent to landscape architecture, architecture, ecology, water conservation, urban planning, environmental engineering, forestry and horticulture professionals ( $n = 20$ ). For each surface type, the ecological effectiveness weighting value was derived from the mean of scores (ranging from 0 to 10) given by 20 experts of the aforementioned academic fields. The area of each homogenous unit and the area of each surface type in each homogenous unit for all the campuses were determined by ArcGIS program (ESRI, 2011). This information was used to calculate the relative area for every surface type. The ecological effectiveness weighting value and relative area of land use surface types were used to estimate the Biotope Area Factor for each homogenous unit (Becker, 1990). The BAF values and relative area of homogenous units were used to estimate the overall BAF values of each university campus.

### 2.3. Ecological data collection and biodiversity survey

Ecological data collection and biodiversity survey were conducted between April and June, 2013. Initially, we used the satellite aerial photos and ArcGIS program to determine the area of green space in each campus homogenous unit. In the green space one sampling plot (area  $10\text{ m} \times 10\text{ m}$ ) was designated per hectare and the distance between any two plots was at least 60–70 m. Within the eight university campuses a total of 180  $10\text{ m} \times 10\text{ m}$  sampling plots were established. Each of the sampling plots were divided into four  $5\text{ m} \times 5\text{ m}$  subplots. In the center of each subplot we investigated the coverage of herb plants in a  $1\text{ m} \times 1\text{ m}$  area. For each species of herb plant the percentage covered in the  $1\text{ m}^2$  was determined by eye. In each  $100\text{ m}^2$  sampling plot, each woody plant species with a diameter greater than 1 cm was identified and its DBH was measured. To measure the understory vegetation structural complexity (UVD) we used a red cloth ( $1\text{ m} \times 1\text{ m}$ ) as the background and estimated the density of vegetation in front of it. The red cloth was held by one person whom stood at each of the four cardinal edges of the sampling plot, while one person stood in the center of the plot and took pictures with a digital camera

**Table 1**

Basic data of the eight urban university campuses located in Taichung City, Taiwan surveyed in this study.

University	Total area (ha)	Green space area (ha)	Building area (ha)	Population
Central Taiwan Univ.	8.7	2.59	6.11	10,708
Chao Yang Univ.	13.48	3.67	9.81	16,722
Feng Chia Univ.	16.15	4.65	11.5	21,402
Asia Univ.	22.8	9.47	1.33	12,497
Ling Tung Univ.	23.56	14.27	9.29	10,244
Providence Univ.	30.4	13.54	16.86	12,698
Chung Hsing Univ.	62.27	17.53	44.74	17,216
Tunghai Univ.	145.27	91.04	54.23	18,057

of the red cloth and the vegetation in front of it. To represent the vertical stratification of the understory vegetation, the cloth was placed at two different heights (from ground to 100 cm and from 100 to 200 cm). These photographs were transformed into black-and-white using Photoshop and the data from the four cardinal directions and two heights were averaged and used as the UVD of the plot. To estimate leaf area index (LAI) we used Li-Cor LAI-2000 Plant Canopy Analyzer (LI-COR® Biosciences, Nebraska, USA) for each sampling plot. During the data collection two sets of LAI-2000 were used simultaneously; one was placed in the center of each 25 m<sup>2</sup> subplot while the other was placed in a neighboring open area. Readings from four subplots and the open area were used to calculate the LAI value of each 100 m<sup>2</sup> sampling plot.

#### 2.4. Survey of arthropod diversity

Pitfall traps were established in each sampling plot to collect ground arthropods. Each set of pitfall traps consisted of five 50 ml centrifuge tubes placed in the center of the 100 m<sup>2</sup> sampling plot and the centers of four 25 m<sup>2</sup> subplots. Each tube was filled with 30 ml 70% alcohol and was open consecutively for 3 days. The invertebrate specimens collected were first classified into insects, spiders and other arthropods. Insect specimens were identified to taxonomic orders. Spiders were first separated into adults and juveniles, and adult spiders were sorted into morphospecies and then identified into species by palpal organ or epigynum.

#### 2.5. Statistical analyses

To estimate the Biotope Area Factor of each homogenous unit we used the ecological effectiveness weighting value determined by the expert questionnaire method and relative area of land use surface types. The BAF values of a given homogenous unit in different universities were different because the relative area of land use surface types in a given homogenous unit varied from campus to campus. The BAF value of a given sampling plot was that of the homogenous unit in which it was situated.

We performed a principle component analysis on understory vegetation density, leaf area factor, tree height and DBH and the scores of PC1 axis were used to represent the vegetation structure of a given sampling plot. The diversity of woody and herb plants in the sampling plots were estimated by Shannon–Wiener index while that of spiders were estimated by the Margalef species richness (Krebs, 1989). For insect specimens, the Margalef species richness was calculated by using abundance of taxonomic orders rather than individual species. Margalef species richness is among the simplest ways of species diversity quantification, which considers measure for the total number of the species in a community as well as the abundance for each species (Krebs, 1989). We used linear mixed-effects models (LMM) implemented in the package lme4 (version 1.1-6) (Bates, Maechler, Bolker, & Walker, 2014) to evaluate the relationship between BAF values and in situ animal/plant diversities and vegetation structures. All estimates were to optimize the restricted maximum likelihood criterion. In each model,

we set a random intercept and slope for each “university campus” as the two correlated random factors. The degree of freedom for the *T* distribution of each coefficient is determined by Satterthwaite’s approximations to test its significance with the package lmerTest (version 2.0-6) (Kuznetsova, Brockhoff, & Christensen, 2014). We also estimated the bootstrapped 95% percentile confidence interval of each variable with the package lme4 (version 1.1-6) (Bates et al., 2014). In each model, 500,000 simulations for parametric bootstrap intervals were performed.

### 3. Results

#### 3.1. Classification of land use surface types and homogenous units

The land use surface types of the eight university campuses surveyed were (1) sealed areas, (2) partially sealed areas, (3) semi-enclosed areas, (4) vegetation on beams, (5) vegetation on ground, (6) vegetation on ground but with grass only, (7) buildings and (8) man-made water bodies. Descriptions of the characteristics for each surface type and the BAF weighting values generated by expert questionnaire method are shown in Table 2. The homogenous units of the eight university campuses surveyed included (1) green space, (2) sport area, (3) parking lot, (4) high density construction area, (5) intermediate density construction area, (6) low density construction area and (7) pasture area. The BAF values of various homogenous units in eight university campuses are shown in Table 3.

#### 3.2. Relationship between BAF, vegetation structure and biodiversity

There was a positive relationship between vegetation structures measured and designated BAF value of the sampling plots. Plots located in homogenous units with higher designated BAF values tended to exhibit higher UVD and LAI (Fig. 1) however, in LAI the relationship was not statistically significant (Table 4). The PC1 values generated from a PCA with various vegetation structure measurements of sampling plots also showed a positive relationship with BAF but the relationship was not significant (Table 4). Although the relationship between BAF values and UVD of sampling plots were significantly positive, those between biodiversity and BAF values were not as apparent. The Shannon indices of woody and herb plants and designated BAF values of sampling plots did not correlate significantly (Fig. 2, Table 4). Neither spider species richness (Fig. 3a) nor insect taxonomic order richness (Fig. 3b) displayed a significant correlation with designated BAF values of the sampling plots (Table 4). The general pattern was such that sampling plots having similar BAF values tended to exhibit a wide range of vegetation structure or diversity estimate values.

### 4. Discussion

Results of our study reveal that with university campuses located in urban areas in central Taiwan, BAF values of various

**Table 2**  
Characteristics of land use surface types in the university campuses and BAF weighting values determined by expert questionnaire method.

Surface type	Characteristics	BAF value
Building	RC-Structure	0
Sealed areas	Impermeable to air and water and has no plant growth	0.2
Man-made pool	Impermeable to water	2.5
Partially sealed areas	Permeable to water and air, but no plant	2.9
Vegetation on beams	On cellar covers or underground garages with less than 80 cm of soil covering	4.4
Semi-enclosed areas	Permeable to water and air, some plant growth from the crack	5.2
Vegetation on ground with grass only	Vegetation connected to soil below, with grass only	6.8
Vegetation on ground	Vegetation connected to soil below, available for development of flora and fauna	8.7

**Table 3**  
BAF values of various homogenous units in the eight university campuses in central Taiwan. (I: green space; II: sports area; III: parking lots; IV: high density construction area; V: intermediate density construction area; VI: low density construction area; VII: pasture area).

University	BAF of homogenous units(% area)							Overall BAF
	I	II	III	IV	V	VI	VII	
Central Taiwan Univ.	–	4.9 (43%)	0.9 (23%)	2.0 (34%)	–	–	–	2.6
Chao Yang Univ.	–	3.2 (32%)	2.6 (23%)	1.8 (8%)	2.1 (37%)	–	–	2.4
Feng Chia Univ.	–	1.9 (27%)	1.4 (49%)	–	2.2 (24%)	–	–	1.8
Asia Univ.	6.2 (9%)	3.5 (15%)	–	1.3 (21%)	2.2 (37%)	5.2 (18%)	–	3.7
Ling Tung Univ.	8.0 (21%)	4.0 (31%)	–	1.3 (16%)	–	5.9 (31%)	–	4.8
Providence Univ.	7.1 (13%)	3.0 (17%)	1.0 (5%)	2.4 (27%)	3.0 (16%)	4.7 (21%)	–	3.5
Chung Hsing Univ.	6.5 (11%)	2.8 (14%)	–	2.4 (42%)	–	4.0 (34%)	–	4.3
Tunghai Univ.	8.7 (3%)	3.1 (6%)	–	–	4.0 (22%)	5.7 (52%)	5.5 (18%)	5.3

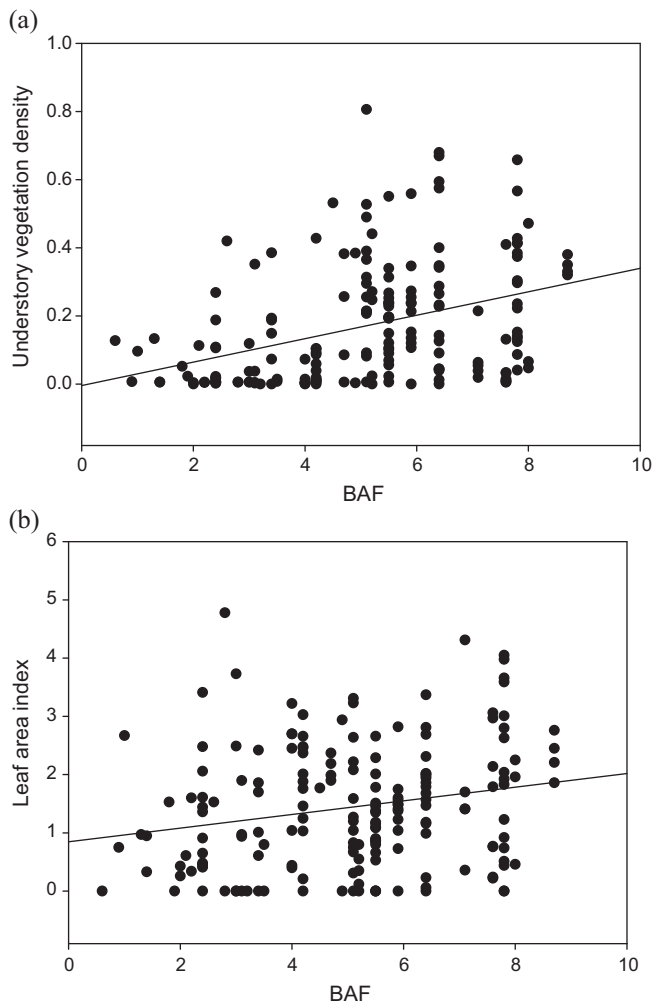
homogenous units generated from expert questionnaire method are significantly incongruent with in situ plant and animal diversities. For homogenous units of similar level of BAF values, the diversity of various flora and fauna varied considerably. The lack of congruency between biodiversity and ecological effectiveness weighting values occurs in homogenous units exhibiting various levels of BAF values. The cause of the incongruence between arthropod diversity and BAF may be that the organisms surveyed in our study (such as insects and spiders) have good mobility and are vulnerable to small-scale microenvironment fluctuations (Checa, Rodriguez, Willmott, & Liger, 2014; Stefanescu, Peñuelas, & Filella, 2003). Even though the plant communities in some homogenous units are suitable for certain communities of arthropods, any chance event such as microclimatic changes or microenvironment disturbances may significantly alter the composition as well as the abundance of arthropods inhabiting these habitats (Checa et al., 2014; Huang, Tso, Lin, & Lin, 2011; Stefanescu et al., 2003). In this study, we surveyed about 180 100 m<sup>2</sup> sampling plots and collected arthropod specimens systematically. Given such large sample size and standardized sampling effort, it was unlikely that the observed diversities failed to represent the typical arthropod fauna of plant

communities in various homogenous units. On the other hand, for sessile organisms such as woody plants, which are less vulnerable to environmental fluctuations, their diversities also deviated considerably from designated BAF values of the sampling plots. Therefore, in urban university campuses located in central Taiwan, the ecological effectiveness weighting values of homogenous units estimated by the current landscape architectural techniques follow BAF system are not congruent with the diversity of organisms inhabiting these areas. Homogenous units designated with higher ecological effectiveness weighting values do not necessarily contain higher plant or animal diversities, and vice versa.

While the similarities between designated ecological effectiveness weighting values and in situ biodiversity are small, the congruency between BAF and certain vegetation structures are more evident and significant. In this study we quantified canopy and understory level structures by measuring leaf area index and understory vegetation densities. However, only the latter is significantly correlated with designated ecological effectiveness weighting values. Sampling plots located in homogenous units with higher BAF values tend to have more complicated understory vegetation. Such result are not surprising because when experts

**Table 4**  
Results of the analyses using linear mixed effects models to examine the relationship between designated BAF values and vegetation structure data, as well as the diversity estimates of various organisms of sampling plots in eight university campuses.

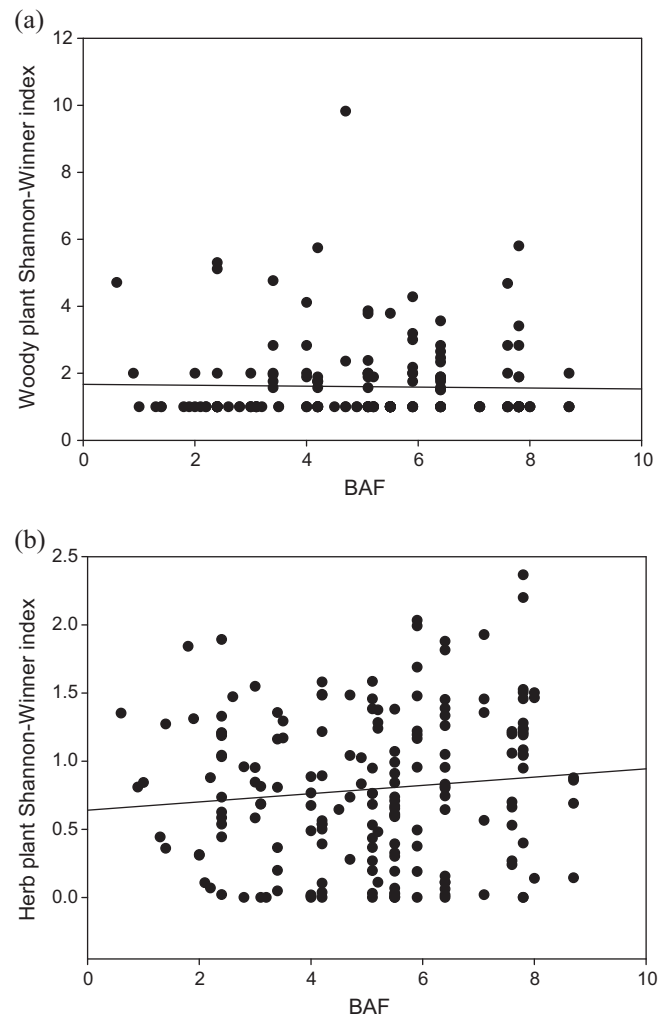
Variables	Estimate	SE	DF	T	P
<b>(a) Intercept</b>					
PC1	–22.6	5.88	10.7	–3.85	0.003
UVD	0.0064	0.0347	36.9	0.185	0.854
LAI	0.877	0.311	6.48	2.82	0.028
Wood Shannon	0.303	0.133	6.66	2.27	0.060
Herb Shannon	0.920	0.165	5.34	5.59	0.002
Spider richness	1.180	0.238	6.60	4.93	0.002
Insect richness	1.12	0.0557	23.6	20.1	<0.001
<b>(b) BAF (slope)</b>					
PC1	4.40	1.99	5.75	2.21	0.071
UVD	0.0296	0.0110	5.75	2.70	0.037
LAI	0.123	0.0712	5.24	1.72	0.143
Wood Shannon	–0.00119	0.0217	10.9	–0.0550	0.957
Herb Shannon	–0.0147	0.0247	9.65	–0.595	0.566
Spider richness	0.0781	0.0444	3.84	1.76	0.156
Insect richness	–0.0112	0.0117	9.08	–0.962	0.361



**Fig. 1.** Linear regressions between designated Biotope Area Factor values and (a) understory vegetation density (UVD) and (b) leaf area index (LAI) of the sampling plots.

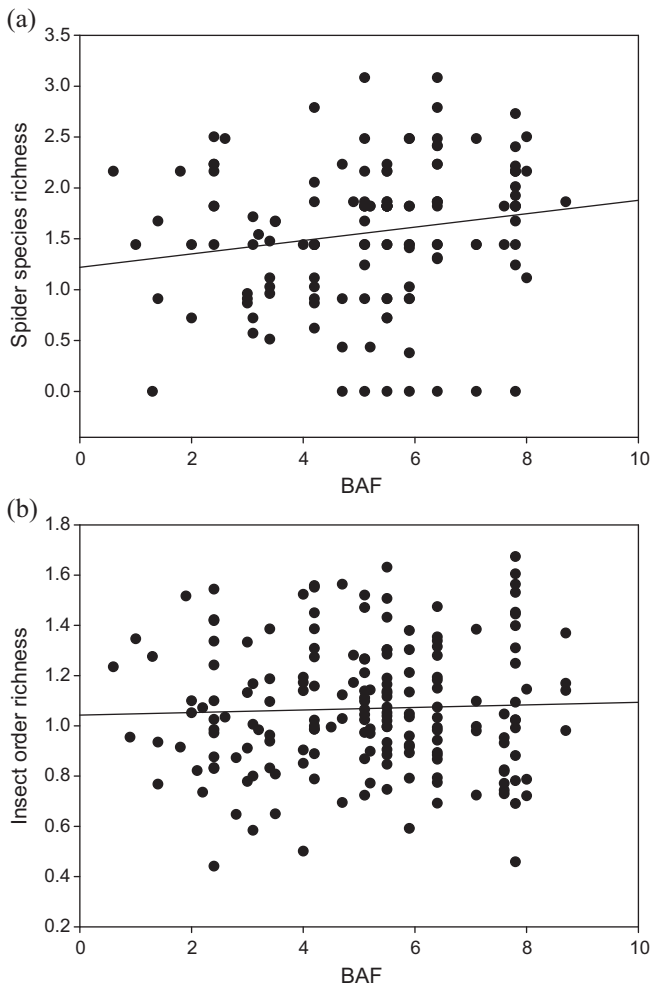
quantify the ecological effectiveness of an area the key considerations are the vegetation structure and water permeability of land use surface types (Farrugia et al., 2013; Finlay, 2010; Kruuse, 2011). According to the principles of the BAF system, a land that contains a larger area of plants and is permeable to rainwater is considered more ecologically effective and can potentially be more suitable for organisms to inhabit (Kenworthy, 2006; Kruuse, 2011). Therefore, homogenous units with a higher relative area of meadow, shrubs and woods will be designated with higher BAF values. Results of our vegetation structure survey show that in university campuses in central Taiwan homogenous units with a higher designated BAF value tend to have more complicated vegetation structures in terms of higher understory vegetation density. Although environmental weighting systems such as BAF have been used for many decades (Gómez-Baggethun & Gren, 2013), results of our study show for the first time that areas being designated as more ecologically effective do exhibit more complicated vegetation structures.

Environmental weighting systems such as BAF propose that areas that are more ecologically effective are more suitable for organisms to inhabit and should potentially have a higher biodiversity (Kenworthy, 2006; Kruuse, 2011). However, results from our survey conducted in university campuses in central Taiwan show that while homogenous units with higher BAF values exhibited a more complicated understory vegetation structure, they did not have a higher plant and animal diversity. Many studies have



**Fig. 2.** Linear regressions between designated Biotope Area Factor values and (a) woody plant Shannon-Winner index and (b) herb plant Shannon-Winner index of the sampling plots.

shown a positive relationship between arthropod diversity and vegetation complexity and also how arthropods such as spiders and insects are sensitive to vegetation structures (Bultman & Uetz, 1982; Hatley and Macmahon, 1980; Nyffeler, 2000; Oxibrough, Gittings, O'Halloran, Giller, & Smith, 2005; Uetz, 1975; Wise, 1993). In our study, the sampling plots exhibiting higher BAF values in general had a higher understory vegetation structure complexity, but they did not have a higher arthropod diversity. Such incongruence may have possibly resulted from the way the BAF weighting values of homogenous units were determined. Currently, the ecological effectiveness values of landscape mosaics are determined by the analytic hierarchy process. Landscape architecture professionals will first determine the ecological effective weight values of the various land use surface types in a landscape mosaic. Then, the BAF value of a homogenous unit is calculated by the weighting values and the relative area of various land use surface types it has. Urban planning and management conducts are mostly operated in the homogenous unit scale of the landscape mosaic. After we established the sampling plots in homogenous units, we used an expert questionnaire method to designate their ecological effectiveness values and found that such values were not congruent with the actual diversity of organisms that inhabited these plots. These results indicate that the current way of using homogenous unit scale in planning and managing urban



**Fig. 3.** Linear regressions between designated Biotope Area Factor values and (a) spider species richness index and (b) insect taxonomic order richness index of the sampling plots.

areas may not be appropriate. A homogenous unit in a landscape mosaic is usually composed of a diverse array of land use surface types. Compared to the homogenous unit operational scale, the land use surface type operational scale can directly reflect the diversity of organisms inhabiting these areas (Huang et al., 2011; Hunter, 2002; Tschardt, Klein, Kruss, Steffan-Dewenter, & Thies, 2005). However, if urban planning and managing are operated on the land use surface type scale, the entire task will be considered too complicated to achieve. Therefore, an operational scale between homogenous unit and land use surface types might be needed to more realistically reflect the ecological characteristics and biodiversity of landscape mosaic units. We suggest that within the homogenous units another operational scale should be used to better reflect the characteristic and diversity of land use surface types within these units.

Many factors influencing composition and abundance of organisms are not considered in the operation of BAF system and this reason might be the main cause for the incongruence of BAF weight values and the biodiversity in situ. For example, landscape mosaic units of similar land use surface type compositions that are surrounded by different landscape types will differ greatly in biodiversity due to the variations in sources of colonizing organisms (Jokimäki, 1999). Even units with similar land use surface type compositions are embedded in identical landscape type, their size difference will generate varying level of edge effects and consequently lead to biodiversity variation (Fahrig, 2003). In addition,

whether the landscape mosaic units of interest are isolated or are connected by corridors (and therefore becomes a component of habitat networks) will have a considerable impact on biodiversity (Angold et al., 2006; Dunning, Borgella, Clements, & Meffe, 1995). Another vital determining factor is the arrangement pattern of land use surface types in a certain homogenous unit. For landscape mosaic units with similar BAF values that are located in similar landscape settings whether the land use surface types are arranged in a cluster (clustered landscape pattern) or a network pattern (network landscape pattern) the abundance and diversity of inhabiting organisms will differ considerably (Bengtsson et al., 2003; Huang et al., 2011; Hunter, 2002; Tschardt et al., 2005).

## 5. Conclusion

In this study, we quantitatively evaluated whether the ecological effectiveness of landscape mosaics estimated by BAF system through expert questionnaire method was congruent with the actual condition. Our finding indicated that current BAF system cannot realistically reflect the ecological condition of landscape mosaics and diversity of inhabiting organisms, at least in university campuses in central Taiwan. We suggest that in future studies, the ecological and biodiversity data of various land use surface types in homogenous units should be systematically determined and such information be used to determine an appropriate operation scale. In addition, intrinsic factors (area and land use surface type arrangement patterns) and extrinsic factors (surrounding landscape settings and their connection with other landscape mosaic units) should also be incorporated in the weighting system in order to accurately estimate the ecological effectiveness of landscape mosaic units.

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