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以環境變項類神經方法預測桃園台地冬季埤塘鳥類多樣性及觀鳥遊憩資源規劃之應用

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計 畫 主 持 人 ： 方偉達

計畫參與人員 ： 碩士班研究生-兼任助理人員：莊維吉
碩士班研究生-兼任助理人員：林怡均

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Modelling waterbird diversity in irrigation ponds of Taoyuan, Taiwan using an artificial neural network approach

Abstract: The study develops an approach adopted by Artificial Neural Networks (ANN) to model the relationship between pondscape and waterbird diversity. Study areas with thousands of irrigation ponds are unique geographic features from the original functions of irrigation converted to waterbird refuges. The model considers pond shape and size, neighboring farmlands, and constructed areas in calculating parameters pertaining to the interactive influences on avian diversity, among them the Shannon-Wiener diversity index. Results indicate that irrigation ponds adjacent to farmland benefited waterbird diversity. On the other hand, urban development leads the reduction of pond numbers, which reduces waterbird diversity. By running the ANN model, the resulting index shows a good-fit prediction of bird diversity against pond size, shape, neighboring farmlands, and neighboring developed areas with a correlation coefficient (*r)* of 0.72, in contrast to the results from a linear regression model ($r < 0.28$).

Key words: Artificial Neural Network (ANN), Irrigation Pond, Waterbird, Landscape ecology, Taiwan

Introduction

Waterbird refuges represent one of the multifunctional perspectives in the restoration of agro-ecosystems. Previous studies inferred that causes of species diversity are affected by habitat heterogeneity (Forman and Godron 1986; Forman 1995; Begon et al. 1996; Francl and Schnell 2002). Distributions of avian species within such land mosaics are correspondingly discontinuous, depending on the locations of preferred habitats, density-dependent processes, and the quality of individual patches. Thousand of farm ponds are unique landscape features of the Taoyuan Tableland in Taiwan. Farm-pond areas are dominated by fields separated by hedgerows and windbreaks. Beyond area, all parameters in pond configuration can be condensed to fall into the categories that address eco-physical identities, such as shape, depth, edge, clustering, and connectivity in a landscape scale (Forman 1995; Linton and Boulder 2000;

Froneman et al. 2001; Leitão and Ahern 2002; Oertli et al. 2002). Many studies on pondscape have focused on the aforementioned spatial configurations, such as biodiversity, pond size, pond depth, pond shape, and pond sustainability (Boothby, 1997; Weyrauch and Grubb, 2004; Denoel and Lehmann, 2006). Pondscape parameters including pond size (PS), mean shape index (MSI), mean pond fractal dimension (MPFD) etc. can be considered. To some extent, descriptive statistics were used for statistical data processing to combine parameters in spatial analysis (Halsey et al. 1986; Evertsz et al. 1992; Gustafson and Parker 1992; Cheng and Agterberg 1995; Kronert et al. 2001; McGarigal et al. 2002). The study determines whether there is a relationship between the pond sizes and numbers of species and individuals, the richness, and diversity determined by standardized sampling units.

This study assesses a non-linear relationship using neural network models instead of linear regression. Artificial Neural Network (ANN), which originated about several decades (McCulloch and Pitts 1943), was inspired by a desire to emulate human learning. ANN is highly effective for modeling nonlinear problems. The practical implication is that an ANN can accurately predict nest occurrence and breeding success of red-winged blackbird in response to ecological applications (Ozesmi et al. 2006). They developed ANN model from data in two regions and years apart for a marsh-nesting bird, the red-winged blackbird *Agelaius phoeniceus*. The first model was developed to predict occurrence of nests in two wetlands on Lake Erie, Ohio in 1995 and 1996. The second model was developed to predict breeding success in two marshes in Connecticut, USA in 1969 and 1970. Independent variables were vegetation durability, stem density, stem/nest height, distance to open water, distance to edge, and water depth. Results showed that the ANN model improved predictive performance over the generalized linear models. This study attempts to investigate bird diversity and its relationship to pond attributes using ANN approach. The results will be useful in ecological planning to solve these aforementioned problems created by anthropogenic driving forces. Hence, the study objective aims at characterizing the diversity of bird species associated with these ponds. Such characterization helps establish decision criteria needed for designating certain ponds for habitat preservation and developing their protection strategies.

Materials and methods

Study areas

Taoyuan Tableland irrigation ponds are ecologically significant because one fifth of all the bird species find home on these ponds (Chen 2000; Fang 2004a). This tableland, at an area of 757 km^2 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 2002)(Figure 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 1500 to 2000 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 (Huang 1999; Chen 2000).

This area has a population density of 2331 persons/km^2 and its population is increasing at a rate of 2000~3000/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 (Fang and Chang 2004). 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.

Survey method

This survey was based on an intensive 4-month bird survey in which simultaneous censuses were carried out at 45 ponds four times from November 2003 to February 2004 (pond plots see Figure 1). All surveys were conducted by 45 experienced bird observers starting at the same time before sunrise and ending at 10:00 am on the same day. Each pond was surveyed and coded for numbers of bird species and individuals within 30 minutes with a point-count approach (Bookhout 1996). Figure 1 also shows the land-use patterns including farm ponds, built-up areas, and roads. The surrounding area at a 564.19-m basal radius from the pond geometric center (comprising a 100-ha circle) was surveyed by line-transect methodology, as shown in Figure 2. Since the land-use ratio of basal areas (e.g., %FARM, %BUILD) within the 100-ha circle were calculated, the area with structures was used to infer attributes unsuitable for wetland birds (i.e., waterfowl, shorebirds, birds of the water's edge, etc.) To reduce the effects of bird-observer identified bias, three to four observers were grouped and rotated between ponds. The observers counted birds that were in any habitats. Birds belonging to the families Apodidae (swifts) and Hirundinidae (swallows) were also included from counts in flight. The Shannon-Wiener diversity index (*H'*) was calculated to determine bird diversity, and results are discussed in the following sections. The proportion of avian species (*i)* relative to the total number of species (P_i) was calculated, and then multiplied by the logarithm of this proportion ($\log_2 P_i$). The resulting product was summed across species, and multiplied by -1:

$$H' = -\sum_{i=1}^{S} P_i \log_2 P_i \qquad (1)$$

where *S* is avian species richness and *Pi* is the percentage of species *i* in the avian community.

The habitat variables such as pond size, pond shape, proportion of farmland area in peripheral areas, and proportion of areas with structures in peripheral areas were identified based on field surveys and Taiwan's Geographic Aerial Map at a 1:5000 scale (Department of Land Administration, Ministry of the Interior 2002) and Aerial Photographs at a 1:5000 scale of 2003 (Agricultural and Forestry Aerial Survey Institute 2003).

Modeling formation

ANN model was applied to the avian assemblage of the Taoyuan Tableland, Taiwan (Fang, 2005). One biological variable was selected to describe its structure: Shannon-Wiener's diversity index (*H*') of the waterbirds. Four habitat variables were selected as explanatory parameters: pond size (PS), mean pond fractal dimension (MPFD), proportion of farmland area in peripheral areas (%FARM), and proportion of areas with structures in peripheral areas (%BUILD). Table 1 summarizes the descriptive statistics of habitat variables such as mean, standard deviation (SD), median (Med) and etc. The comparison reveals that pond size varies sharply and MPFD varies between 1.22 and 1.51. Ponds have the high values of fractal dimension which shows that the edge is more complex. When the patch's fractal increases, movements of biological species along the margin increases on the contrary, when the fractal on the margin decreases, biological species might cross the margin. Moreover, the land uses in the areas are approximately 72.5% and 11.4% for farmland and built-up land. These areas have a large percentage of the farmland associated with green space that is strongly correlated with waterside bird abundance.

It shows the back-propagation (BP) neural network architecture which consists of four layers of neurons connected by weightings (Fang, 2005). The ANN models are developed from 35 of the 45 sampled irrigation ponds chosen at random and were validated using the 10 remaining sampled irrigation ponds. The role of each parameter was evaluated by inputting fictitious configurations of independent parameters and by checking the response of the model. The information was captured by the network when input data passed through the hidden layer of neurons to the output layer. The weightings connecting from neuron *i* to neuron *j* were denoted as w_{ji}. The output of each neuron was calculated based on the amount of stimulation it received from the given input vector, x_i, where x_i was the input of neuron *i*. The net input of a neuron was calculated as the weights of its inputs, and the output of the neuron was based on some sigmoid function which indicated the magnitude of this net input. So the net output, y_j, from a neuron can be indicated as (Fang, 2005):

$$u_j = \sum_{i=1}^{P} (w_{ji}x_i - \theta_j) \quad (2)$$

And

$$y_j = \varphi(u_j) \quad (3)$$

where

w_{ji} is the weighting from x_i to u_j

x_i is the *ith* input i.e. the habitat variable,

y_j is the output of *jth* neuron i.e. waterbird diversity

u_j is the *jth* neuron from an outgoing signal to the magnitude of all observations

θ_j is a threshold to be passed through by the non-linear activation function, $\varphi(\cdot)$

$\varphi(u_j)$ is the activation function of u_j, such as the sigmoid function.

p is the number of inputs

For this research, we chose the continuous sigmoid as the basic function (Fang, 2005):

$$\varphi(u_j) = \frac{1}{1+\exp(-u_j)} \tag{4}$$

Results and Discussion

Avian grouping

According to the recordings for 94 species, 15,053 individuals were detected in four months, microhabitats were categorized into seven guilds: air feeders (ten species), waterfowl (nine species), shorebirds (14 species), waterside birds (22 species), woodland birds (20 species), scrubland birds (13 species), and grassland birds (six species). The value of dissimilarities was divided in accordance with distance (marked at a distance of 0.25) into seven guilds. If this classification was adopted, the low similarities (marked at a distance of 0.75) could be divided into four guilds: waterfowl (nine species), shorebirds (14 species), waterside birds (22 species), and land birds (49 species), respectively. The likelihood of species occurrence was surveyed and categorized into a concentric pattern, such that the gradients run from the pond's core to its edge: (1) interior pond species comprised of waterfowl (families Anatidae and Podicipedidae) and shorebirds (families Charadriidae and Scolopacidae); (2) waterside species (families Ardeidae et al.); and (3) external pond species of land birds (i.e., species detected in such microhabitats as grasslands, scrublands, and woodlands; of families Corvidae, Frigillidae, Laniidae, Passeridae, Pycnonodidae, Sylviidae, and Zosteropidae, et al.) which were dominant in their respective microhabitats.

We then proposed that waterfowl, shorebirds, and waterside birds (families Anatidae, Charadriidae, Scolopacidae, and Ardeidae) in microhabitats were associated with distribution patterns of "interior species-edge species". Therefore, pond areas mainly provide shelter and foraging for wintering migrants and residents. Microhabitat structural influences on bird distribution patterns can be classified into pond core, edge, and surrounding land uses (Fang 2004b; Fang et al. 2004). On irrigation ponds, we detected more than half of the species richness of land birds, and species of land birds did not change much among the four months (Table 2). To relate the richness, abundance, and diversity of guilds to habitat variables, correlation analyses were carried out. The species-pondscape relationships were investigated between ecological groups and areas surrounding the ponds. Such analyses restricted to pooled guild data to reduce confounding area effects. Parameters found to be important as local determinants of community structures are the amount of farmland and amount of urban environment. Specific land uses found to be important were low-rise residential houses and high-density apartments.

Modeling application & Discussion

The resulting habitat profiles depict the complex influence of each habitat variables on the biological variables of the assemblage, and the non-linear relationships. The four habitat variables were selected as the inputs: pond size (PS), mean pond fractal dimension (MPFD), proportion of farmland area (%FARM), and proportion of areas with structures (%BUILD) in peripheral areas. The diversity of waterbirds (*H*') was predicted throughout the exercise using the back-propagation (BP) algorithm with a three-layered neural network. The first layer, called the input layer, was comprised of four cells representing each of the habitat variables. The second layer, or hidden layer, was composed of a further set of neurons whose number depends on the best-calculated unbiased results. Since the BP algorithm was trained by the least mean square method, the least mean square training could reduce the error or distance between the actual output and the desired output, by adjusting the weightings. Training cases are presented sequentially, and the weightings were adjusted. We determined the number of second-layer neurons through a series of interactions which varied from two and four to eight neurons. We calculated the correlation coefficients between true values of *H*' and the predicted value of *H*' from the ANN. We determined the uses of non-linear models by ANN, of the number in the hidden layer for four neurons, without choosing two or eight neurons. Correlations between observed values and values estimated by ANN models of the four dependent parameters were moderately significant. The correlation coefficient (*r*) for four neurons was detected to differ between the training set ($r = 0.726$, $n = 35$) and the validation set ($r = 0.723$, $n = 10$) in contrast to a lower information status from a linear regression model ($r < 0.28$). Results showed that the ANN model is effective for predictive performance over the linear regression.

In this study, ANN predicts the diversity in the sampling sites and then inverse distance weighting interpolations are performed based on the ANN results. Figure 4 shows the resulting map of waterbird diversity in the winter of 2003. The black represents the irrigation ponds. The ponds are important landscape features that provide habitat for both breeding and migrating birds (Paracuellos and Telleria 2004; Paracuellos 2006; Hanowski et al. 2006). These ponds may be important as local food sources for both breeding and migrating individuals due to the presence of emerging insects from the ponds. Results also show that the diversity of waterbirds in western Taoyuan is higher than that of the east part, especially in the southwest part on the map (Figure 3). Science Eastern Taoyuan is more urbanized than the southwest area (Figure 1), the habitat in southwest of Taoyuan is better than that of the east part. Accordingly, the species of waterbirds are few in the vicinity of the built-up land. Thus, the waterbird diversity is low in the eastern Taoyuan. The presence of adjoining natural and farmland habitats was probably the most important determinant of the avifauna in farm-pond areas. We compared the following the characteristics against the corresponding ratio of constructed area values associated with pond configurations at each site (Figure 1). Evidence for an effect of human disturbance on birds is generally assumed that the presence of human infrastructures affects the distribution negatively. Due to the transportation, and urban development in Taoyuan County, farm ponds and farmland have continued to decrease. The increase of constructed areas decreases the species of birds (Marzluff and Ewing 2001). The further allocation to the current inappropriate land uses for urban development in the surrounding farm-pond areas might pose a threat to waterside bird group (Marzluff and Ewing 2001; Osborne et al. 2001). Moreover, the pond areas help wintering bird refuges and the diversity of waterbirds correlates with the pond parameters such as the number of ponds and pond sizes. Previous studies have shown that the farmlands associated with green space, which might translate to greater insect abundance, was strongly correlated with waterbird abundance (Fang, 2005). Results from the same study also imply that the waterbirds are affected by the pond pattern at large spatial scales. As the ponds cluster together, the likelihood of discovering new creatures increase, thereby increase its species diversity.

Regarding this detailed study, there may be a number of reasons why few irrigation ponds do not become refuges for waterbird species. First, there is too little of the ornamental vegetation cover found on the surrounding areas, and it may support only a small insect population. Second, the small pond size associated with a curvilinear shape is not optimal to support, preserve, and attract waterbirds and other avifauna because of lacking of the management practices to support food chains. Third, anthropogenic structures are usually made of concrete with no native trees, and this may make such areas unattractive to waterbird species that require an intact shrub layer, dead wood, or generally undisturbed microhabitats.

Conclusion

The study applied ANN to investigate the relationship between the habitat variables and the waterbird diversity. The results indicate that the predictive performance of the model is better than the output of the regression model, confirming the non-linearity of the relationship among the variables. The habitat variables such as the pond size, mean pond fractal dimension, proportion of farmland area, and proportion of areas with build-up in peripheral areas are good predictors of waterbird diversity. This analysis can help the agencies responsible for planning pondscape management to better promote use of ecological simulation skills and, thereby, to assess bird diversity in farm-pond areas.

In addition, integrated pondscape research must be a long-term project. It is necessary to increase a time frame of ten to twenty years. For example, to undertake evaluations of pondscape change requires avian data of long-term losses or increases of richness and abundance from year to year. This consideration would help make the simulation and evaluation model more precise in continuing this work over the long run.

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References

Agricultural and Forestry Aerial Survey Institute. (2003) Aerial Photographs, 1:5,000 of scale in digital debase forms, Taipei, Taiwan, ROC.

Begon M, Harper JL, Townsend C.R. (1996) Ecology: Individuals, Populations and Community, Third Edition, Blackwell Science, Oxford Press.

Bookhout TA (1996) Research and Management Techniques for Wildlife and Habitats. The Wildlife Society, Bethesda, Massachusetts, USA.

Boothby J (1997) Pond conservation: towards a delineation of pondscape, Aquatic Conservation-Marine and Freshwater Ecosystems, 7 (2): 127-132.

Chen CJ (2000) The Change about Culture Landscape of Irrigation Reservoir and Pond in the Taoyuan Terrace, and the Establishment of Sustainable Environment Waterways, National Science Council, Taipei, Taiwan, ROC. (in Chinese)

Cheng Q, Agterberg FP (1995) Multifractal modeling and spatial point processes. Mathematical Geology 27: 831-845.

Denoel M, Lehmann A (2006) Multi-scale effect of landscape processes and habitat quality on newt abundance: Implications for conservation, Biological Conservation, 130 (4): 495-504.

Department of Land Administration, Ministry of the Interior. (2002) Taiwan's Geographic Aerial Map, 1:5,000 of scale in digital database forms, Taipei, Taiwan, ROC. (in Chinese)

Evertsz CJG, Mandelbrot BB (1992) Multifractal measures. In: Peitgen, HO, Jurgens H, and Saupe D (ed.) Chaos and Fractals: New Frontiers of Science. Springer Press, New York, New York, USA, pp. 921-953.

Fang TY (2001) The Study of the Spatial Structure Change of Water Land in Taoyuan Terrace, Master Thesis, Department of Bioenvironmental Systems Engineering, National Taiwan University, Taiwan, ROC. (in Chinese)

Fang WH (2004) Threaten Birds of Taiwan, Second Edition. Wild Bird Federation Taiwan, Taipei, Taiwan, ROC. (in Chinese)

Fang WT (2004) The ecological drawdown assessment for avian communities in Taoyuan's constructed wetlands. In: Yeh SC (ed.) The Proceeding of 2004 Annual Symposium of Environmental Education. Chinese Society for Environmental Education, Kaohsiung, Taiwan, ROC, pp. 861-869. (in Chinese)

Fang WT, Chang TK (2004) The scientific exploring of Ecoscape-design on constructed wetlands in Taoyuan, In: Lee CJ (ed.) The Proceeding of Water Source Management of Taoyuan Main Canal. Taoyuan Irrigation Association, Taoyuan, Taiwan, ROC, pp. 345-369. (in Chinese)

Fang WT, Loh D, Chang TK (2004) Spatial analysis of wintering bird habitats on constructed wetlands, Taoyuan Tableland, In: Tsai MH (ed.) The Proceeding of 2004 Annual Symposium of Agricultural Engineerings. Chinese Society of Agricultural Engineerings, Taipei, Taiwan, ROC, pp. 1179-1190. (in Chinese)

Fang WT (2005) A Landscape Approach to Reserving farm ponds for wintering bird Refuges in Taoyuan, Taiwan. Dissertation, Texas A&M University.

Forman RTT (1995) Landscape Mosaic: The Ecology of Landscape and Regions, The University of Cambridge, Cambridge, UK.

Forman RTT, Godron M (1986) Landscape Ecology John Wiley & Sons, New York, USA.

Francl KE, Schnell GD (2002) Relationships of human disturbance, bird communities, and plant communities along the land-water interface of a large reservoir. Environmental Monitoring and Assessment 73: 67-93.

Froneman A, Mangnall MJ, Little RM, Crowe TM (2001) Waterbird assemblages and associated habitat characteristics of farm ponds in the Western Cape, South Africa. Biodiversity and Conservation 10: 251-270.

Gustafson EJ, Parker GR (1992) Relationships between landcover proportion and indices of landscape spatial pattern. Landscape Ecology 7: 101-110.

Halsey TC, Jensen MH, Kadanoff LP, Procaccia I, Shraiman BI (1986) Fractal measures and their singularities: the characterization of strange sets. Physical Review A 33: 1141-1151.

Hanowski J, Danz N, Lind J (2006) Response of breeding bird communities to forest harvest around seasonal ponds in northern forests, USA, Forest Ecology and Management. 229 (1-3): 63-72.

Huang BJ (1999) Assessment and Application of Groundwater Resource in Taoyuan Area, Master Thesis, Department of Bioenvironmental Systems Engineering, National Taiwan University, Taipei, Taiwan, ROC. (in Chinese)

Kronert R, Volk M, Steinhardt U (2001) Landscape Balance and Landscape Assessment, Springer-Verlag Press, Berlin, Germany.

Leitão AB, Ahern J (2002) Applying landscape ecological concepts and metrics in sustainable landscape planning. Landscape and Urban Planning 59: 65-93.

Linton S, Boulder R (2000) Botanical conservation value related to origin and management of ponds. Aquatic Conservation: Marine and Freshwater Ecosystems 10: 77-91.

Marzluff JM, Ewing K (2001) Restoration of fragmented landscapes for the conservation of birds: A general framework and specific recommendations for urbanizing landscapes, Restoration Ecology, 9 (3): 280-292.

McCulloch W, Pitts W, (1943) A logicial calculus of ideas immanent in nervous activity. The Bulletin of mathematical biophysics.

McGarigal K, Cushman SA, Neel MC, Ene E (2002) FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps, Computer software program produced by the authors at the University of Massachusetts, Amherst, Massachusetts, USA.

Oertli B, Joye DA, Castella E, Juge R, Cambin D, Lachavanne J (2002) Does size matter? The relationship between pond area and biodiversity, Biological Conservation 104: 59-70.

Osborne PE, Alonso JC, Bryant RG (2001) Modelling landscape-scale habitat use using GIS and remote sensing: a case study with great bustards, Journal of Applied Ecology, 38 (2): 458-471.

Ozesmi U, Tan CO, Ozesmi SL, et al. (2006) Generalizability of artificial neural network models in ecological applications: Predicting nest occurrence and breeding success of the red-winged blackbird Agelaius phoeniceus, Ecological Modeling, 195 (1-2): 94-104.

Paracuellos M, Telleria JL (2004) Factors affecting the distribution of a waterbird community: The role of habitat configuration and bird abundance, Waterbirds, 27 (4): 446-453.

Paracuellos M (2006) How can habitat selection affect the use of a wetland complex by waterbirds? Biodiversity and conservation, 15 (14): 4569-4582.

Weyrauch SL, Grubb TC (2004) Patch and landscape characteristics associated with the distribution of woodland amphibians in an agricultural fragmented landscape: an information-theoretic approach, Biological Conservation, 115 (3): 443-450.

Table 1 Descriptive statistics for four habitat variables

	Mean	*Med*	*SD*	*Min*	*Max*	*Q25*	*Q75*
PS(m^2)	83727.1	84747.7	50404.4	2026.0	204732.0	49873.2	109177.4
MPFD	1.27	1.26	0.05	1.22	1.51	1.24	1.29
%FARM	72.50	68.95	11.69	35.14	86.92	75.60	80.09
%BUILD	11.37	7.06	11.08	1.00	46.40	4.28	13.97

Table 2. Number individuals detected and species richness of avian guilds in irrigation ponds of Taoyuan, Taiwan

	Dates	11/15, 2003	12/20, 2003	01/31, 2004	02/28, 2004
Guild	Waterside birds	2192(10)	1776(14)	1775(11)	1465(15)
	Shorebirds	240(6)	261(10)	212(10)	94(6)
	Waterfowl	85(6)	209(6)	157(7)	132(5)
	Air feeders	96(5)	248(7)	90(6)	79(4)
	Grassland birds	31(4)	127(3)	9(2)	12(4)
	Scrubland birds	233(11)	213(9)	354(9)	296(8)
	Woodland birds	844(18)	1438(18)	1303(17)	1082(17)
	Total	3721(60)	4272(67)	3900(62)	3160(59)

Notes:

No. of individuals (Species richness): *Number of individuals detected in each group (the value in parentheses is species richness).*

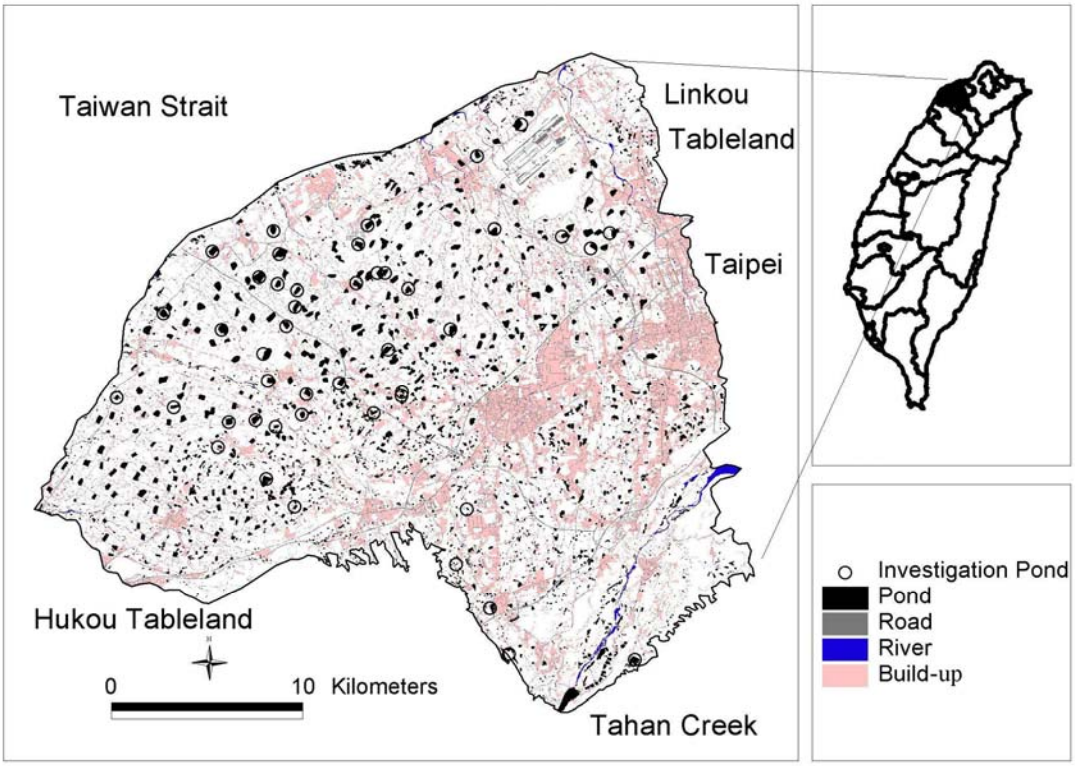


Figure 1. Spatial distribution of irrigation ponds and land use pattern in the Taoyuan Tableland of Taiwan.

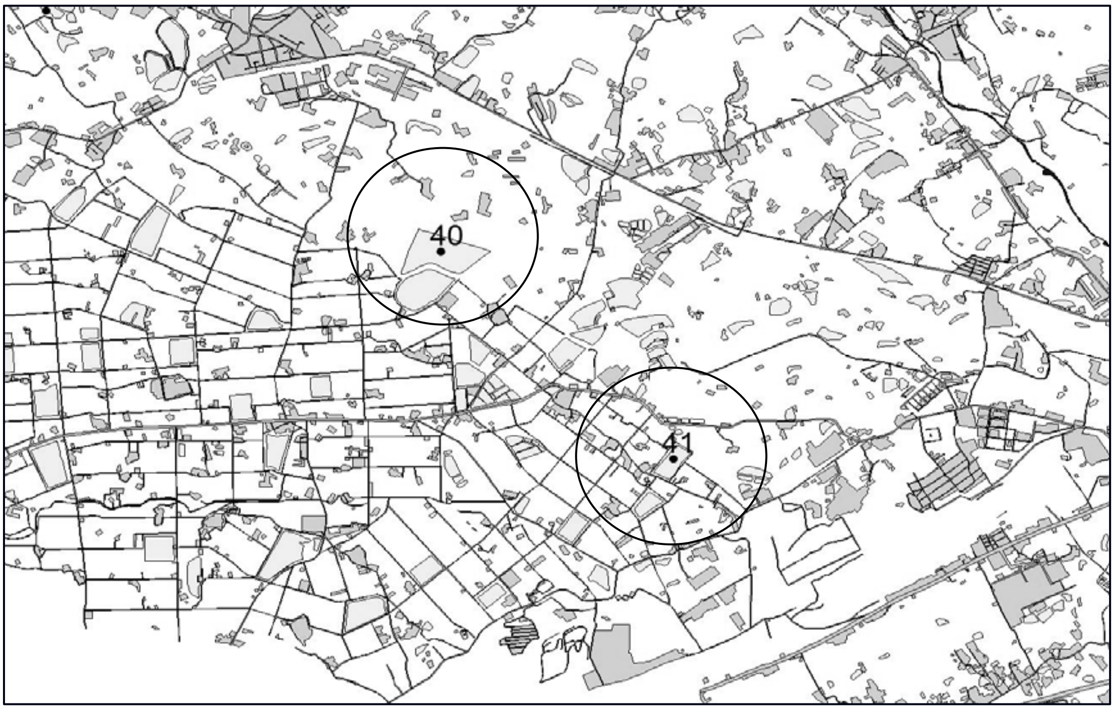


Figure 2. Studied circles with a 564.19-m radius to delineate an area of 100 ha.

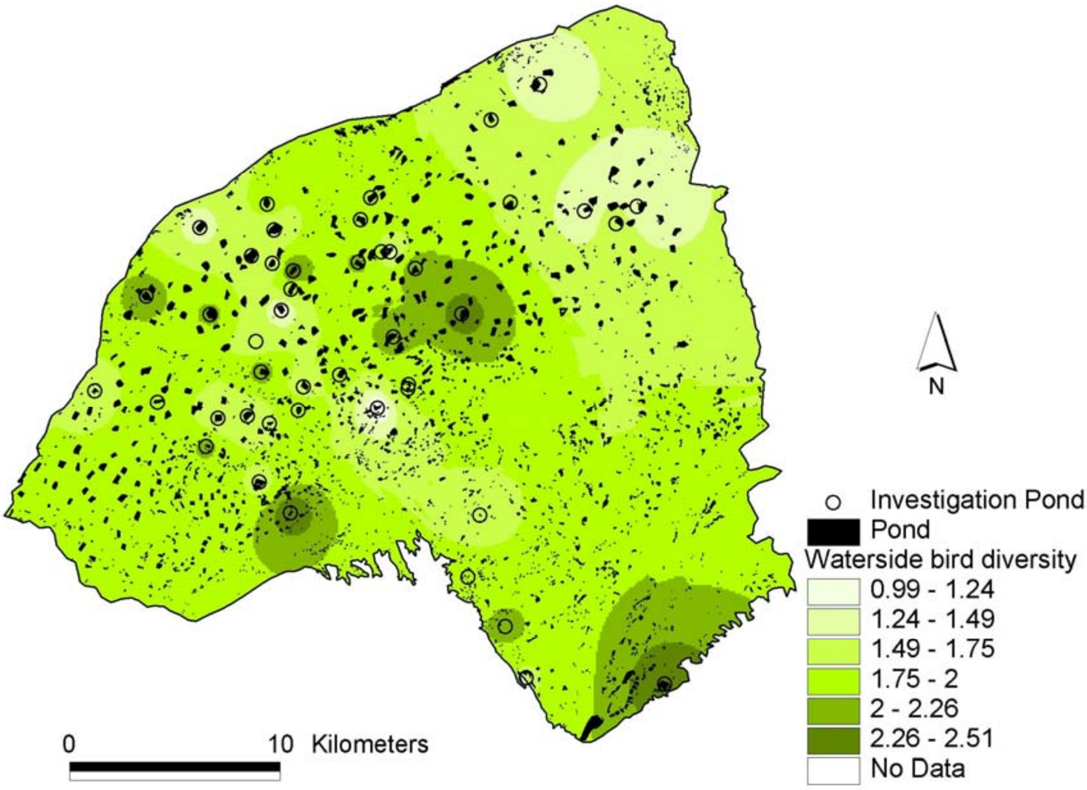


Figure 3. Waterbird diversity map in the study area.

Note:

Wei-Ta Fang, Honejay Chu, and Biyo Cheng. 2009. Modelling waterbird diversity in irrigation ponds of Taoyuan, Taiwan using an artificial neural network approach. Paddy and Water Environment 7:209-216. (SCIE)（NSC 98-2410-H-216-017）

國科會補助專題研究計畫項下出席國際學術會議

心得報告

日期： 99 年 7 月 12 日

計畫編號	NSC 98-2410-H-216-017		
計畫名稱	以環境變項類神經方法預測桃園台地冬季埤塘鳥類多樣性及觀鳥遊憩資源規劃之應用		
出國人員姓名	方偉達	服務機構及職稱	中華大學助理教授
會議時間	99 年 6 月 28 日至 99 年 7 月 2 日	會議地點	美國猶他州鹽湖城
會議名稱	(中文)國際濕地科學家學會 2010 年研討會 (英文)2010 SWS Annual Meeting		
發表論文題目	(中文)桃園埤塘冬季候鳥島嶼生物地理學原理 (英文) Could island biogeographic concept support wintering bird population in Taoyuan´s farm ponds		

出國報告

一、參加會議經過

本計畫期望透過2010年SWS年會出國計畫、辦理濕地保育國際交流工作坊、濕地期刊亞洲專刊出書計畫、臺江國家公園申請拉姆薩公約國際級濕地之相關作業等國際交流活動，以落實我國濕地保育的目標。經費補助部分感謝行政院國家科學委員會補助機票等費用，其工作內容如下：

一、協助內政部營建署城鄉發展分署辦理2010年SWS年會出國研習訓練：

本年度SWS年會預計以濕地研討會及參訪方式進行，研討會形式包含口頭專題報告及海報發表2種方式。目前臺灣濕地學會已經由方偉達助理教授進行投稿，介紹臺灣濕地的研究，以符合研討主題「山峰到湖濱」，探討臺灣內陸濕地、湖泊及池塘等主題研究。

（一）參加人員：營建署城鄉發展分署派員1人及臺灣濕地學會人員4人，共5人與會。

（二）辦理時間：預定2010年6月25日至7月4日。

（三）辦理地點：美國猶他州鹽湖城，行程如下表。本計畫SWS年會相關活動細節已參考SWS網站http://www.sws.org/ 等相關國際網站；及亞洲理事會網站http://www.swsasia.org/

（五）行程概述：赴美行程規畫如表一所示。

表一 赴美行程表

日期	行程內容	備註事項
6/25	去程旅途 臺北→洛杉磯→鹽湖城 （6/25 19:06 抵達）	無
6/26	**拜會「拱門國家公園」（Arches National Park）**	■ 安排拜會國家公園

6/27	**1.拜會「拱門國家公園」(Arches National Park)** 2.「2010 年國際濕地科學家學會聯合年會」迎賓晚宴	■ 安排拜會國家公園
6/28-7/2	1. 2010 年國際濕地科學家學會聯合年會： ■ 6/29 論文發表 ■ 6/30 田野參訪 2.其他行程： ■ **7/1 拜會美國土地管理局(US Land Management Bureau)：預計 PM 3:00~5:00** ■ 7/2 參觀猶他州羚羊島州立公園(Antelope Island State Park)	■ 安排拜會美國土地管理局
7/3-7/4	鹽湖城(7/3 11:15 出發)→洛杉磯→臺北	無

(六)參觀及拜會行程：參觀及行程規畫如表二所示。

表二 參訪行程表

時間	行程	說明
6/26(六) 6/27(日)	Arches National Park 拱門國家公園	猶他州東南方，佔地 76,519 英畝，以地質出名，具有天然石拱、平衡岩、尖塔岩柱、石化沙等豐富風化岩層地形。適合傍晚前往，石景輝映晚霞呈一片紅澄色，本次參訪團將參觀著名拱門景觀及擷取國家公園觀光遊憩經營經驗。
6/30(三)	Provo 普洛佛	1999 年猶他州在 Provo 開始一系列的河川復育計畫，在 Jordanelle 壩及 Deer Creek 水庫間建立自然的生態工法，在規劃的過程中，有濕地生物學家、植物學家等參與，經過一連串的討論其中的地理學、生態學、流體力學等各個環節，除了考慮河川律動及洪泛概念，並重建動物棲地環

		境，使得生態系重現，本次參訪團將參觀Provo 鱒魚復育工程以提供國內保護河川參考經驗。
7/1(四)	US Land Management Bureau 美國土地管理局	談論主題: 1.美國州政府土地登記制度 2.美國州政府土地利用制度 3.濕地及邊際土地在緩解銀行的角色 4.該州緩解銀行(mitigation bank)的實例分析
7/2(五)	Antelope Island State Park 猶他州羚羊島州立公園	羚羊島是美國西部的鹽湖中最大的島嶼，1981 年成立州立公園，有度假碼頭和沙灘露營區等，此區草原地形是北美最多美洲野牛的棲息區，而湖岸豐富有機鹽孕育豐富動植物，為候鳥遷徙，如綠頭鴨(Mallard)、琵嘴鴨(Northern Shoveller)、雪雁(Snow Geese)等太平洋地區鳥類遷徙時重要所經路徑必經之處。本次參訪團將參觀美國在濕地保護及營造鳥類遷徙廊道上經驗。

二、與會心得

（一）、大會時間與地點：國際濕地科學家學會（SWS, Society of Wetland Scientists)在 2010 年 6 月 27 日至 7 月 2 日於美國猶他州鹽湖城的卡爾文蘭普頓鹽宮會議中心(Calvin L. Rampton Salt Palace Convention Center)召開 2010SWS 年會。

（二）、大會目的：2010 年 SWS 年會的主要目的是要讓世界各地關心濕地議題的人士能夠藉此會議交流各項訊息，將召集研究人員、學生、科學家、政府、私營部門的顧問等作出對濕地的利用、保護和養護等各項議題。

（三）、大會的舉辦方式 ：會議的舉辦方式主要遵循以往會議經驗，包括大會、專題討論會、口頭陳述、海報發表等，並規劃濕地相關廠商參展攤位、無聲拍賣(silent auction)和濕地實地考察等活動。SWS 的與會人員可以得到濕地科學家的專業學分認證。共有 18 個共同主題演講（Plenary Session)，每日上、下午各一場由國際上對濕地研究卓著的科學家演講，並有 13 個平行進行的分題焦點主題演講（symposium)，其下又包含了共 30 個子課題。

（四）、會議的議題：本次國際濕地科學家年會會議主題是濕地連結(Wetland connections)。議題分為連結科學家、決策者、管理者、農人、政治人物、法官、律師以及一般大眾。濕地連結陸地的水以及全球的水，包括湖、池塘、溪流、河口及海洋。此外，濕地連結基礎研究、應用以及管理，又涵蓋生態、生地化、以及以科學為基礎的社會教育。

（五）、SWS 大會的組織與經營管理：國際濕地科學家學會為全球性非營利專業者組織，目前分佈世界各國有 3500 位會員，國際濕地科學家學會除總部設在美國之外，並於世界各國成立分會，近年來每年以 20％的會員國成長率成長。濕地科學家學會成立至

今，每年出版四期濕地期刊(Wetlands)，為國際性最重要的濕地科學期刊。今年已經是成立第31年。參加本次會議的人數多達800多人，因此在經營管理上，大會組織了一個委員會，由埃里克麥卡利教授(Eric McCulley)擔任2010年會的主席，並設置八大計劃部門，由聯合主席Ann Neville負責統籌執行整個大會籌畫，從會議前時間地點的選擇、預算多寡的考量、配套折扣的協商、背景多元的考量、會員服務的提供、行政細節的準備、通關便捷的安排、媒體安排…等，委員會視情況授權各項目負責人，而在委員會之下分別設置項目，依序為會議議程(Program)及論文摘要(Abstracts)、Poster 海報發表(Session)、共同主題演講(Plenary Session)、座談會(symposium)、濕地田野考察(Field Trips)、濕地工作坊(Workshops)、事務安排(Events & Local Arrangements)、孩童節目(Children's Program)、濕地廠商參展(Sponsors & Exhibitors)、無聲拍賣(Silent Auction)、公關及網頁(Publicity & Website)、授獎(SWS Awards)、學生之旅(Student Travel)、學生論文(Student Paper)、國際之旅(International Travel)等，每一個項目有一位至四位負責人，維持規劃及執行上之彈性，並依規劃時間完成各項進度，與會人士可由SWS網頁得到清楚資訊。在大會舉辦會議過程中，會員可以感受到賓至如歸的接待、服務人員的勤快、時間掌控的精準、議事規則的落實、安全措施的完備、安全人員危機處理的機制、生態保育形象的提升。

（六）、舉辦國際會議可供借鏡之經驗：SWS 年會舉辦選擇風景優美的猶他州鹽湖城，從地點到濕地議題，可見到主辦單位藉由發揮規畫專業能力，更有效率地吸引與滿足既有和潛在目標市場(主要包括觀光客、會議人士、產業、廠商代表..等)，來間接促進

猶他州鹽湖城當地地區的發展。

1、經濟面：參加國際會議的人士，皆具特殊專長，其收入亦較高，因此具有一定的消費能力。國際濕地科學家年會參加的人士及工作人員總計近千人，若以每人會議期間消費一萬元，則將有一千萬臺幣的消費因該國際會議而湧入鹽湖城市內相關產業中，例如：旅館、餐飲、航空、印刷、會議顧問、視聽、廣告、保險、翻譯、裝潢..等。展覽、舞臺設計等，因此舉辦國際會議，可為當地帶進外匯及相關營收，促進經濟的繁榮。

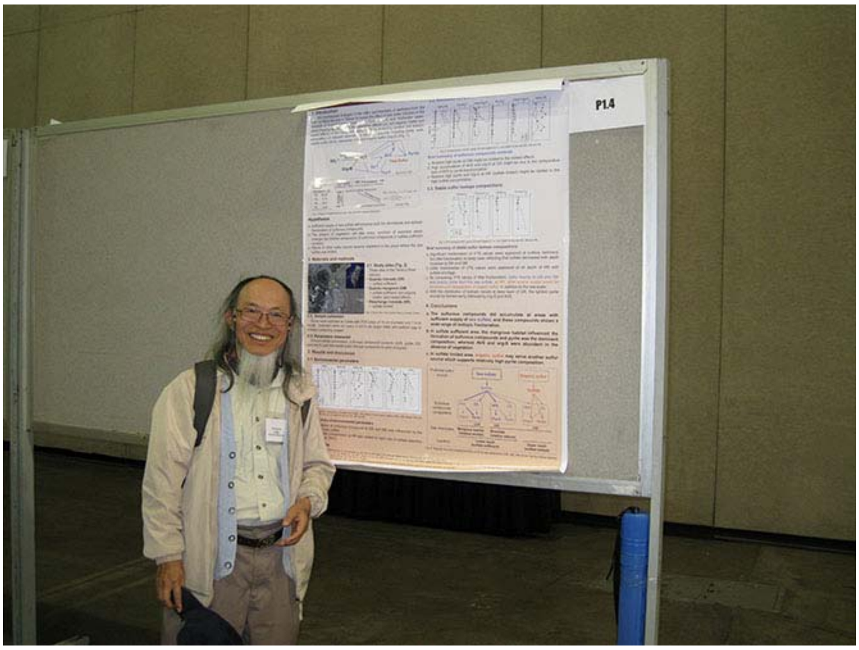
2、學術面：參與的會員們吸收最新的濕地新知，參與討論議題相關之活動，並提供世界級專家交流之最佳管道，藉由召開國際會議可以掌握世界最新資訊。

3、宣傳面：濕地科學家學會年會的舉辦，藉由著名國內外媒體之宣傳報導及國際與會人士交流訪問，提昇了麥迪遜市之國際地位及知名度。

4、層次面：藉著國際會議的召開，可以見識來自世界的參展攤位，與會人士對於各種濕地相關服務品質的要求，可以直接刺激提昇其品質步上國際水準，達到產業昇級的目標。

（七）、本次交流由濕地學會秘書長方偉達助理教授發表臺灣濕地論文，由行政院國家科學委員會補助研究計畫，題目為“Could island biogeographic concept support wintering bird population in Taoyuan´s farm ponds”，埤塘是臺灣桃園地區獨特且珍貴的濕地地理景觀，大小埤塘散布於此，也間接地塑造出當地成為多種水鳥的棲息地，使得生態景觀更加多樣化，方偉達教授以臺灣的埤塘為例，藉由研究中鳥類數量的分佈位置，印證島嶼地理生態之概念。

濕地學會方偉達秘書長發表濕地論文



中研院陳章波教授論文海報發表

三、後續工作

本次國際交流活動暫定自 99 年 10-11 月辦理，預計邀請日本 Dr. Keita Furukawa（古川惠太）博士及美國 SWS 新任會長 Prof. Glenn Guntenspergen 來臺參加濕地工作坊。本次考察團與古川惠太博士及 SWS 新任會長 Prof. Glenn Guntenspergen 討論來臺工作事項，並擬商討臺江國家公園的海域規劃與管理，及 2011 年國際交流合作方向。

謝正昌副分署長、方偉達助理教授與古川惠太博士討論工作坊合作事項

方偉達教授與古川惠太博士討論工作坊合作事項

四、考察參觀活動

本次活動考察團於 6 月 30 日參訪普洛佛河。Provo 一系列的河川復育計畫，在 Jordanelle 壩及 Deer Creek 水庫間建立自然的生態工法，在規劃的過程中，有濕地生物學家、植物學家等參與，經過一連串的討論生態學、流體力學等各個環節，除了考慮河川律動及洪泛概念，並重建動物棲地環境，使得生態系重現。

V 型壩可以阻擋水流，進行滯流工作

Provo River **採用生態工程進行營造，例如倒立柯木**

矗立於草原地形的遊客管理中心

草原地形是北美最多美洲野牛的棲息區

本次出國研習，於 7 月 2 日特別前往參訪羚羊島州立公園。羚羊島是美國西部的鹽湖中最大的島嶼，1981 年成立州立公園，此區草原地形是北美最多美洲野牛的棲息區，而湖岸豐富有機鹽孕育豐富動植物，為候鳥遷徙，如琵嘴鴨(Northern Shoveller)、雪雁(Snow Geese)等太平洋地區鳥類遷徙時重要所經路徑必經之處。在整體課題安排

上，主辦單位讓與會的各國代表了解到美國生態保育工作上的用心，值得我們效法。

五、建議

未來推動國家重要濕地保育作業、增進國際保育經驗與知識的交流，爾後能夠持續透過國際會議參與之方式執行，建立我國濕地組織與國際濕地組織永續發展之平臺機制，推廣復育、保育、教育之永續目標，持續與國際保育組織交流並建立合作伙伴關係，共同推動國際性或區域性濕地保育事務，將臺灣濕地納入全球濕地保育之一環。

本年度計畫目標為在 2011 年內政部營建署能夠贊助國際濕地科學家學會出版亞洲濕地專刊（WETLANDS ASIAN SPECIAL ISSUE)，以建立我國濕地研究在國際期刊的品牌和知名度。並且透過會議邀請美國及日本專家赴臺協助國際濕地工作坊的推動。

六、攜回資料名稱及內容

Wetlands Journal of the Society of Wetland Scientists Volume 1(1981)-Volume 19(1999) (光碟版)

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：■已發表 □未發表之文稿 □撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

1.本論文係我國第一篇以類神經理論研究發表的景觀論文，投稿於國際期刊並獲刊出（出版於 2009 年 9 月）。

2.本論文著作發表於 2010 年美國濕地科學家學會年會，衍生作品經由 Springer 建議，將收錄於 Springer book "Landscape Ecology in Asian Cultures"（亞洲文化之景觀生態學）及 INTECH Book “Artificial Neural Networks”國際出版專書中，為台灣學者唯一被收錄之景觀研究作品。

無研發成果推廣資料