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Optimization of land use at Mt. Yuelu scenic area: an analysis using the ecological green equivalent

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ABSTRACT

This study applies the ecological green equivalent approach to evaluating the land use structure of Mt. Yuelu scenic area in Hunan Province, China. A mathematical model is established based on land use and land cover data, and then ArcGIS used to extract the spatial extent of the ecological green equivalent within each of the relevant elements. Results show that the area has a relatively reasonable land use structure even though the forest coverage rate is slight below the optimum. The overall green equivalent (1.13) was higher than the optimum forest coverage ecological green equivalent (1.00). The distribution of forest was uneven, with most of the forest within the site; the area's land use structure could thus be improved by extending the green area outside of Mt. Yuelu. We conclude by reiterating that landscape and infrastructure development should consider ecological system conditions.

Keywords: Ecological green equivalent, land use structure, landscape, scenic area, forest, China.

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Introduction

Many different methods presently exist to evaluate the utilization of ecotourism resources. Focused on the environmental impact of tourism, the ecological footprint of tourism and other concepts assess the environmental carrying capacity related to tourism (Wu, 2013). Such information provides an essential basis for the sustainable development of ecotourism, especially in China, but these methods have limitations and shortcomings (Gu and He, 2014). For example, the ecological footprint of tourism is hard to calculate. Given the inherent mobility involved in tourism, particularly regional tourism, it is hard to define the ecological footprint accurately. Moreover, tourism ecological footprint calculations often focus on analyzing the current multi-part footprint of energy, shopping, construction land, food, and other items, but the consumption footprint related to contaminated waste in environmental systems is not considered (Hu and Zheng, 2008; Yang et al, 2012). In this study, we try to develop a new evaluation method by using ecological green equivalent analysis to analyze and evaluate land use at Hunan Province's Mt. Yuelu scenic ecotourism area. This work should provide a scientific basis for the further development and utilization of ecotourism zones.

The rest of the paper proceeds as follows. Section 1 offers an overview of the green equivalent concept while Section 2 describes the research methods. Section 3 then presents results, which are used to inform the conclusions and recommendations of the final section.

1. The Green Equivalent Concept and Land Type Classification

Forests, the largest ecosystem on land, carry out key ecosystem services including climate regulation, soil and water conservation, and air purification. In the process of developing and using tourism resources, it is often difficult to avoid damaging forest ecosystems; such damage, in turn, affects the sustainable development of a region's ecotourism industry. Some scholars have thus suggested providing compensation for the destruction of or harm to regional forest ecosystems and their accompanying services (Hu and Zheng, 2008; Hardin and Jensen, 2007). Developing efficient and practical compensation measures, however, requires a means of estimating comparable ecological function "equivalents." The concept of "green equivalent" has been put forward to meet this need (Li and Bian, 2012).

The "green equivalent" is defined as the minimum amount of green space required to ensure sufficient green biomass to deliver the same ecosystem services essentially—that is, the ecological function "equivalent" (Mao, 1998). This biomass may occur in the form of a variety of green vegetation types, such as lawns, gardens, and farmland. The green equivalent is thus the ratio of the amount of other green vegetation to the green forest area that can deliver the same services (Zhang et al., 2012). Currently, ecological green equivalent analysis is mainly used to optimize land use structure when constructing regional development resources because land is typically the basis of the ecosystems on which tourism relies. Planners can thus analyze the ecological green equivalent to optimizing the use of tourism land resources or use it to evaluate the green resources available within the land use structure of the tourism ecosystem after changes are made (Sun, 2013).

Under the ecological green equivalent concept, traditional land use patterns can be divided into three categories (Zhao et al., 2011; Liu et al., 2002). First, there is ecological green equivalent land, characterized by its ability to be quantified regarding ecological mechanisms carried out by forest ecosystems. This includes farmland, woodland, orchards, and certain types of unused land. Second is the implicit green equivalent land. Quantification of this is difficult and must be done via qualitative research. The third is the non-green equivalent land (Table 1).

Table 1. Land classification under the ecological green equivalent approach.

Classification	Land type	Included land types
Green equivalent land	Paddy land	Paddy fields
	Garden plots	Garden plots
	Forest land	Forest land
	Grassland	Functional and waste grassland
	Other farmland	Cultivated land (excluding paddy fields)
	(Partially) unutilized land and urban green land	Sparsely vegetated land, urban land, and seven other types of unutilized green land
Implicit equivalent land	Wetlands	Marshes, reed areas, beaches, bodies of water, and other wetlands
Non-green equivalent land	Built land	Land used for commercial and service facilities, construction land, transport, traffic land, and partially unutilized land

2 Research Methods

2.1 Description of the Study Area

Mt. Yuelu scenic area is located in the Changsha City of Hunan Province (longitude 112º44'-112º48', latitude 28º20'-28º27'). It is about 4 km long in the north-south direction and about 1.5-2 km wide in the east-west direction; the main mountain area is 8 km^2, and the main mountain peak, Bi Xu, has an altitude of 300.8 m above sea level. The zone includes several scenic areas, including Yuelu Mountain, Tianma Mountain, Orange Isle, Peach Blossom Mountain, Shi Jialing, Zhai Zi Mountain, and Xianjia Lake. These combine with the surrounding protection zone for a total area of 38.4 km2. The area enjoys a humid subtropical monsoon climate, with an average annual temperature of 17ºC, rainfall of 1200-1400 mm, and relative humidity of 80%. It is one of China's rainier zones (Yang, 2004). The weather is damp or rainy and hot in spring and summer: July average and higher temperatures are 28.6ºC and 40.6ºC, respectively. In late autumn and early winter there is less rainfall, and January temperatures average 4.6ºC, plummeting to extreme lows of -11.3ºC.

Vegetation types in Mt. Yuelu scenic area are dominated by typical subtropical evergreen broadleaf forest and subtropical warm coniferous forest. According to species lists, the mountain hosts 285 kinds of forest plants (excluding foreign species) from 68 families and 159 genera; this accounts for 59.7%, 28.9%, and 14.3% of the respective families, genera, and species of Hunan Province's native forest plants (Yang, 2004).

2.2 Methods of Ecological Green Equivalent Calculation and Ecosystem Analysis

2.2.1 Spatial Analysis of the Study Area

In this study, we use ArcGIS 9.3 to extract the relevant factors under the spatial extent of ecological green equivalent given by the urban land use map (scale 1:10000, 2005); we combine this with the National Land Classification (Trial) to classify the area of each land use type (Zhao et al., 2011; Xiao, 2013). Using forest ecosystems as a standard, we then calculate the total ecological service function scores for all kinds of green land cover to obtain the green equivalent for each type of ecological system. By estimating the actual total area of green equivalent, we identify the lowest ecological optimization criterion to meet the minimum needs of the research area. Finally, the structure of the ecological land can be adjusted within the research area to achieve ultimately a reasonable regional land resource utilization structure and promote the sound development of ecotourism resources (Luo and Zhang, 2007).

2.2.2 Calculate Total Ecological Service Function Score

Land use patterns change, as do ecosystem processes and functions. Changes in land use patterns can have profound impacts on regional climate, soil, water, and biological processes. Therefore, considering the regulation and protection of natural, economic, and social subsystems, criteria must be used to select typical, representative, and systematic indicators. Table 2 lists 17 kinds of ecological functions of ecosystems, encompassing five aspects: the atmosphere, water, soil, biological processes, and natural disasters. We used the evaluations of Japanese experts, obtained via surveys (Mao, 1998), combined with the actual Mt. Yuelu context, to determine assessment scores of the various environmental features in the ecosystem (Mao, 1998).

The scores in Table 2 take into consideration the environmental sub-functions with appropriate weights to determine the cumulative summation of the total value of ecosystem services that derive from each sub-function (or index value):

$$P = \sum_{i=1}^{17} F_i$$

In the formula, the total value of ecosystem services is P, F is an index value, and the number of indicators in the index system is i.

Based on this, the ecological services value of forestland is estimated as 169.1, considering the full year and area. Under the same circumstances, the ecological services value of natural grasslands is 132.26, that of grasslands is 121.84, that of wetlands is 127.56, that of dry land is 113.55, and the garden plots is 124.53 (Zhao, 2006).

Table 2. The scores of different ecological system by environmental protection features

Function	Forest land	Paddy field	Other farmland	Garden plots	Grassland	Urban green space	Wetland
Atmospheric composition improvement -1	9.51	7.22	6.50	6.30	7.40	5.90	4.50
Atmospheric composition improvement -2	10.00	5.10	5.10	7.30	5.48	4.80	5.10
Atmosphere purification -1	9.13	6.23	5.80	6.58	5.33	4.30	6.54
Atmosphere purification -2	8.91	6.50	5.90	6.69	5.34	4.21	6.43
Climate moderation	9.45	6.20	5.40	6.46	4.90	3.98	9.32
Noise control	9.45	4.10	4.00	5.83	3.70	3.21	4.30
Flooding prevention	9.78	7.80	5.90	5.60	6.31	3.60	9.87
Water conservation	9.80	7.40	5.30	5.01	6.20	4.20	10.00
Water purification	9.45	7.30	6.70	5.83	6.43	4.65	9.80
Ground collapse prevention	9.58	8.13	5.40	7.15	7.18	3.67	8.50
Surface erosion prevention	9.78	8.75	5.30	6.78	7.73	6.32	6.70
Ground subsidence prevention	5.83	8.05	5.25	6.01	6.21	5.21	8.20
Pollutant removal	8.40	8.01	8.10	6.30	7.40	5.67	8.90
Disaster prevention	9.73	7.92	7.30	7.98	7.60	6.32	8.12
Refuge provision	8.58	7.01	9.50	9.23	6.75	7.85	3.10
Landscape maintenance	9.12	7.40	7.01	7.74	7.93	9.74	9.89
Entertainment space maintenance	8.23	3.73	4.70	6.78	8.70	9.12	7.86
Biodiversity conservation	10.00	4.90	4.60	5.01	5.10	3.44	8.65
Harmful animal and plant deterrence	6.95	6.01	6.11	5.83	6.17	4.51	6.78

Notes: *Evaluation significance: Optimal is 10, acceptable is 7.5, and minimal is 5. "Atmospheric composition improvement -1" indicates CO_2 sequestration functions. "Atmospheric composition improvement -2" indicates O_2 sequestration functions. "Atmosphere purification -1" and "Atmosphere purification -2" indicate dust capture and toxic gas cleansing ecological service functions, respectively.*

2.2.3 Determining Average Ecological Green Equivalents in the Ecosystem

According to the different estimated land ecosystem service values, we assume that optimal woodland forest coverage corresponds to green equivalent 1, under the premise of year-round, wholly green coverage. It follows that

$$X_i = F_i / F_L$$

The ecological services value score for woodland is F_L and the total score for all ecological services of the green surface cover of Class I is F_i. Thus, the surface green cover of Class I regarding ecological green equivalent in the ecosystem is F_i.

Based on Zhao et al. (2006), the green equivalent of garden plots is 0.73, that of the natural meadow is 0.76, grassland is 0.73, paddy land is 0.77, and ordinary upland is 0.68. However, due to climatic differences between regions, there are both interregional and intertemporal differences in green equivalents. Given the actual circumstances in each region, the above green equivalent results must be multiplied by a coefficient representing the growing period about a one-year-period. According to expert-recommended values (Table 3), when three crops are grown in a year in subtropical regions, the growing period parameter is 0.83 (Liu et al., 2002).

Table 3. Average green equivalent of cultivated land and grassland

Land use	Cardinality	Yield two crops a year	Three crops a year
Relative growing period parameter		0.67	0.83
Paddy field	0.77	0.50	0.62
Dry land	0.68	0.42	0.52
Natural meadow	0.76	0.51	0.63
Functional grassland	0.73	0.49	0.61

Notes: *Relative growing period parameter = (length of growing period (months) / 12). The harvest frequency and growing period are based on expert advice.*

2.3 Model for Optimizing the Land Utilization Structure Based on the Ecological Green Equivalent

We use the ecological green equivalent of optimal forest cover as the basis for ecosystem optimization. The total area of the research is S_T, the optimal forest coverage is R_{max}, regional forest area under the optimal forest coverage requirements is S_F, actual forest area is S_{RF}, S_i is the area of land used for land use type i (i is an integer, $i \in [1, 4]$), and ecological green equivalent is G_i. We can then use soil and precipitation data from the meteorological department and the agricultural sector to consider the benefits arising from ecological protection and apply the method of Yuanbo (Zuo and Ruan, 2009; Gong et al., 1996) to determine the optimal forest cover rate (R_{max}) (Liu eat al., 2009):

$$R_{\max}\% = (P \times S_1) / (W \times S_T) \times 100\%$$

In this formula, the region's total land area is S_T, the daily maximum precipitation (t/hm^2) within a year is P. $S1 = S_T$-(surface area of urban, mining, transport, and paddy field land) (hm^2), and the forest soil's saturated water storage capacity per unit area is W (t/hm^2) (Zuo and Ruan, 2009). $S_F = S_T \times R_{max}$, and the corresponding ecological green equivalent is $\bar{x}=1$.

The ecological green equivalent of the actual woodland area is given by:

$$x_F = \frac{S_{RF}}{S_F} \times 100\%$$

The region's green equivalent x is calculated as follows:

$$x = x_F + \sum_{i=1}^{4}\left[\frac{S_i \times Gi}{S_F} \times 100\%\right]$$

Comparing the sizes of X and A determines whether the measure is on target. If $x \geq \bar{x}$, then the standard is met. If $x < \bar{x}$, the areas of various types of green space must be adjusted, with the index recalculated for verification (Liu et al., 2002).

3. Results

The tourist ecosystem is shaped by a combination of factors involving land, the environment, technology, policy, human needs and behaviors, and ecology. Changes to any one factor will lead to changes in the existing ecosystem, altering its balance. Although the tourism ecosystem itself has a certain ability to recover, this is limited. Therefore, if the tourism industry engages in the excessive pursuit of economic benefits, the extent of land use for economic purposes will be overly emphasized. Such a process ignores environmental protection, eventually harming tourism itself. Through calculating the green equivalent of the tourism ecosystem (Wu et al., 2011;

Xiang and Meng, 2013), we will be able to address the problem of properly using tourism ecosystem land resources (via structural optimization) through a combination of qualitative and quantitative analysis. According to the region's endowment of natural resources and its environment, we determine the ecological minimum standards; we then use ecological green equivalent calculations for the area to protect the lowest stock of land required to maintain ecosystem functions. This procedure ensures that the degree of regulated land use does not exceed the capacity of the ecosystem, thereby achieving the coordination between ecological, social, and economic motivations that is the goal of sustainable development (Lu et al., 2013).

3.1 Ecological Green Equivalent

By drawing on previous research defining forest ecosystem services values, we quantitatively evaluate the ecological service value of various types of green spaces in the ecosystem (Hardin and Jensen, 2007). To investigate based on a "considerable green amount" of land area regarding the relationship between forest and farmland and gardens and lawns, we measure the ecological green equivalent of cultivated land, grasslands, and garden plots. This quantifies, compared to forests, the ecological functions of a given area of agricultural land (including cropping land, grassland, and garden plots) (Sun, 2013). Calculating the green coverage within the scenic area, we can thus explore how to optimize the structure of ecological standards within the scenic area. This insight can strengthen the construction of scenic environments (Zhang et al., 2011; Zhang et al., 2012; Li et al., 2014).

Based on the above approach, we determine that Mt. Yuelu scenic area has an ecological green equivalent of $x = 1.13$; as this is greater than 1.00, it implies a proper structure of land use. Among the contributors, the ecological green equivalent of cultivated land is 0.20, that of garden plots is 0.10, and that of Forest land is 0.84.

Table 4. Green equivalents in Mt. Yuelu scenic area

Optimal forest cover rate (%)	Optimal forest area (km^2)	Ecological green equivalent			
		Cultivated land	Garden plots	Forest land	Total
30.3	11.65	0.20	0.10	0.84	1.13

Despite this positive indication, to accelerate the development of the area in recent years, a large number of human landscapes have been built, causing massive destruction to forest vegetation. The woodland area and the total ecological green equivalent have both fallen. As a result, habitats have been destroyed for key species in the biological community and biodiversity has been reduced. Community characteristics and ornamental values have also declined, with inadequate connections within the area's greenbelt: some roads lack roadside greenery and proper green infrastructure or rely on solely a single species.

3.2 Land Use Structure

Land resources support various types of ecotourism resources. Therefore, this study seeks to apply the concept of ecological green equivalent to optimizing the allocation of ecotourism land use structures. This represents an application of systems theory thinking and the principles of ecosystem ecology. We thus ecologically optimize land use for ecotourism in the Mt. Yuelu scenic area to safeguard the ecological environment while balancing economic, social, and ecological benefits. According to a mapping survey of land use within the scenic area, which covers an area of 38.49 km^2, the land use structure is as given in Table 5.

Table 5. Land use in the Mt. Yuelu scenic area

Land Use	Area (km^2)	Share of the total land area (%)
Cultivated land	5.42	14.1
Garden plots	2.27	5.9
Forest land	9.78	25.4
Residential construction land	8.19	21.3
Transport infrastructure land	0.10	0.26
Tourism land	4.91	12.8
Residential land	0.29	0.57
water areas	7.53	19.6
Total	38.49	100

Using this current land use structure for Mt. Yuelu scenic area and basic data on the area (e.g., $P = 1165$ t/hm^2, $W = 2500$ t/hm^2, and $S_l = 2500$ hm^2), we calculate that optimal ecological protection benefits are achieved when there is 30.3% forest cover. Although Mt. Yuelu scenic area's forest coverage rate was 25.4%, lower than optimal, results show that its overall green equivalent (1.13) is higher than the green equivalent of the optimal forest cover rate (1.00), indicating that the scenic area currently has an extremely reasonable land resource utilization structure. However, Mt. Yuelu's woodlands are unevenly distributed; on the mountain itself, for example, total forest area is 5.33 km^2 of an area of only 8.00 km^2; 20.8% of the total scenic land area thus accounted for 54.5% of the woodland area.

4 Conclusions and Recommendations

4.1 Conclusions

The essence of landscape pattern optimization is using landscape ecology principles to achieve reasonable land use by jointly considering natural and social data. By analyzing the appropriate and reasonable distribution pattern of landscape types, one can adjust the landscape distribution (in both location and scope) to maximize the total ecological value of the landscape. The results of this research indicate that the Mt. Yuelu scenic area has a proper land resource utilization structure but with less-than-optimal forest cover. This suggests a need for the area's managers to optimize land use through structural adjustment.

This study investigated ecological green equivalent to considering ecotourism resource allocation. Further research could consider combined optimization of both the land quantity resources for ecotourism and the spatial structure based on a comprehensive model of quantity optimization and spatial pattern analysis. To facilitate real-time monitoring of Mt. Yuelu's ecotourism resources and environment and provide dynamic warnings on ecological security, research should also take advantage of "3S" technology for analysis and monitoring.

4.2 Recommendations

To promote the ecological health of the Mt. Yuelu scenic area, we suggest four areas for further optimization based on the problems found in this research. First, this study is the first to apply the green equivalent analytical model to ecotourism resources for the purpose of determining scientific and operable land use planning guidance (Jim, 2001; Li et al., 2012). Results indicated that the area's land resource utilization structure was reasonable, but the area's woodlands are unevenly distributed. Their scope should thus be increased outside of the core scenic area to support the forest coverage rate to reach the desired level. Moreover, the use of the forest ecological environment quality as the overall situational indicator reflects regional limitations; there is thus a need for continued research to improve the computational model and select better indicators (Hu and Zheng, 2008; Yang et al, 2012). It should also be noted that the *quality* of woodland is not entirely reflected in the regional green equivalent, highlighting a further need to improve the index method as part of future research efforts (Xiao, 2013).

Second, optimization of land use structures helps improve ecosystem functions and services, thereby realizing regional ecological security objectives. As the scenic area's woodlands are unevenly distributed, woodland resources should be reallocated, and the green area outside of the Mt. Yuelu scenic area should be increased. By optimizing the structure of construction land and safeguarding the ecological health and regional ecological security through the land use pattern (Yang et al, 2012), the scenic area's ecological green equivalent can be targeted to meet requirements while maximizing eco-efficiency in line with the needs of economic and social development.

Third, we note that, in recent years, the Mt. Yuelu area's environment has been damaged, impinging upon the sustainable social, economic, and environmental development. The development of the area's cultural landscape through the construction of infrastructure such as roads must thus be done in compliance with ecological priorities (Jim, 2001). This should be based on existing roads and should aim to widen green spaces, optimize species distributions, and increase the scenic area's green space.

Finally, these results have also revealed that there is scope for improving the consistency of land use and ecological landscape functions in the Mt. Yuelu area. The landscape spatial pattern should be aligned to local conditions, with space allocation made in a manner that is reasonable for a given project, fully aligning the project's properties and functions with the functions and spatial characteristics of the land, thus achieving ecological coordination, system harmony, and scenario blending (Hardin and Jensen, 2007). Future work in the area should also consider the renewal and transformation of the area's tree species distributions to include some ornamental (e.g., flower, foliage, and concept tree) species, such as magnolia, ginkgo, and *Elaeocarpus decipiens*. The goal of this work should be to enhance the natural colors of the forest and thus achieve coordination between ecological functions of the forest and its landscaping and greening structure, thereby improving the area's landscape efficiency. Simultaneously, it may be appropriate to develop additional tourism options, such as agriculture and horticulture tours (e.g., tourist farms), and to adjust the industrial structure actively to promote the balanced development of the ecosystem (Ye et al., 2012; Zhu, 2011; Chi et al., 2014).

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References

Chi, W., Shi, W. and Kuang, W. (2015). Spatio-temporal characteristics of intra-urban land cover in the cities of China and USA from 1978 to 2010. Journal of Geographical Sciences, 25(1), 3-18. doi: 10.1007/s11442-015-1149-z

Gong, Y.B, Zhang, J. and Chen, L.W. (1996). Sichuan Basin hilly district level best protection benefits of forest cover quantitative research. *Journal of Sichuan Agricultural University,* (2), 231-236.

Gu, W.P. and He, Q.Y. (2014). Advantages, opportunities, and countermeasures Dongting Lake ecological economic zone development of tertiary industry. Research of Agricultural Modernization, 35(3), 281-285.

Hardin, P.J. and Jensen, R.R. (2007). The effect of urban leaf area on summertime urban surface kinetic temperatures: a Terre Haute case study. *Urban Forestry & Urban Greening,* 6(2), 63-72.

Hu, H.K. and Zheng, C.Y. (2008). Environmental Impact Assesment of Land Use Change Based on Ecological Green Equivalent--A case study of Meizhou. *Research of Agricultural Modernization,* 29(6), 743-746.

Jim, C.Y. (2001). Managing Urban Trees and Their Soil Envelopes in a Contiguously Developed City Environment. Environmental Management, 28(6), 819-832. doi: 10.1007/s002670010264

Li, B. and Bian, J. (2012,). Optimization of Land Use Structure Based on Ecological Green Equivalence in Fuling District of ChongQing. Journal of Hainan Normal University: (Natural Science Edition), 25 (2), 212-220.

Li, Q.Q., Zhang, X. and Gao, X.S. (2014). Counties in the hilly land use degree coupled with the benefits of coordination pattern analysis. Research of Agricultural *Modernization,* 35(1), 97-102.

Li, Z., Wang, J. and Bai, Z.K. (2012). Guizhou Province land use and ecosystem service value and gray prediction. Advances in Geographic, 31(5), 577-583.

Liu, Y.F., Ming, D.P. and Yang, J.Y. (2002). The Land Use structure based on ecological green equivalent optimization. Wuhan University Journal (Information *Sciences),* 27(5), 493-500.

Liu, Y.J., Ma, H.L. and Ma, Y.G. (2009). Changes in environmental impact assessment based on ecological green equivalent of Meizhou City Land Use. Southern Gardening, 20(2), 34-36.

Lu, M., Fei, W. and Li, D.H. (2013). Based on the green equivalent of Jinan city green building programs of ecological compensation. Journal of Shandong Architecture University, 28(2), 95-100.

Luo, Z.J. and Zhang, J. (2007). Ecological green equivalent and its application to land use structure optimization - A case study of Xinjian County. Journal of Jiangxi Agricultural University, 29(5), 851-856.

Mao W.Y. (1998). An introduction to ecological impact assessment. Beijing: China Environmental Science Press.

Sun, Y. A. (2013). The Land Use Structure Based on Ecological Green Equivalent - Taking Yongchuan District of Chongqing City Chongqing. Southwestern University.

Wu, D. H. (2013). Land use Master Plan Environmental Impact Assessment. Nanning: Guangxi University.

Wu, Z.J., Ni, J.P. and Wei, C.F. (2011). Cultivated Land Use Change and Its Mechanism Chongqing Three Gorges Project Reservoir under stress. Journal of Southwest University (Natural Science Edition), 33(3), 50-57.

Xiang, Y.Y. and Meng, J.J. (2013). The Land use structure-based ecological benefits of Wuhan city circle optimization. Resources and Environment in the Yangtze, 22(10), 1297-1304.

Xiao, Q. (2013). On Optimizing Land Use Structure Based on Ecological Green Equivalent in Yongchuan District, Chongqing. Journal of Southwest China Normal University (Natural Science Edition), 38(8), 46-49.

Yang, D., Zheng, F.J., Pan J H., Zhou, W. and Liu, H. (2012). Improved TOPSIS Method in the Evaluation of Rationality of Land Use Structure--A Case Study of Lanzhou City. Chinese Journal of Soil Science, 43(1), 120-124.

Yang, D.H. (2004). The Landscape analysis and evaluation research of Mt. Yuelu Scenic Spot. Changsha: Central South Forestry University.

Ye, T.P., Liao, W. and Li L. (2012). The land-use structure and pattern of Danjiangkou reservoir optimization. *Research Soil and Water Conservation,* 19(1), 11-16.

Zhang, B.L., Yang, Q.Y. and Feng, Y.B. (2011). T Effects of land use change on regional economic development in Chongqing. Journal of Southwest University (Natural Science Edition), 33(4), 151-155.

Zhang, G., He, D. and Yang, Q. (2012). Optimization of the Sanxia reservoir area land use structure based on ecological green equivalent - A Case Study of Yunyang County in Chongqing City. Journal of Southwest Agricultural University (Social Sciences), 10(8), 5-9.

Zhang, X.H., Sun, Q. and Zhang, H.B. (2012). Typical urban land use change and its ecological effects - A case study in Daqing. *Research of Agricultural Modernization,* 34(4), 465-469.

Zhao, D., Li, F. and Wang, R.S. (2011). Urban land use structure optimization based on ecological green equivalent - A case study in Ningguo. Journal of Ecology, 31(20), 6241-6250.

Zhao, Y.Q. (2006). Regional landscape ecological planning. *Chongqing, Southwestern University.*

Zhao, Y.Q., Yang, Q.Y., Yan, L. and Yang, Y. (2006). The Application of Ecological Green Equivalent on Land Use Structure Optimization -A Case Study of Jiangbei District, Chongqing. Journal of Southwest China Normal University (Natural Science Edition), 31(1), 170-174.

Zhu, G.F. (2011). Ecological landscape pattern changes Nanjing Xianlin University town planning and optimization research. Nanjing: Nanjing Agricultural College.

Zuo, Z. and Ruan, X.L. (2009). The Application of Ecological Green Equivalent on Land Use Structure Optimization and Example. Heilongjiang Environmental Journal, 33(3), 11-13.