Ecosystem Service Value Assessment of Wutong Mountain *Rhododendron moulmainense* Ecological Landscape Forest in Shenzhen City in 2021

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Abstract Taking Wutong Mountain *Rhododendron moulmainense* ecological landscape forest in Shenzhen City as an example, the value of the forest was assessed by constructing an ecological service value assessment system and accounting method. The assessment results showed that the total ecosystem service value of *R. moulmainense* ecological landscape forest was 13.195 billion yuan, and the top three services included the value of forestry products, the value of biodiversity maintenance and the value of leisure and recreation, indicating that the ecosystem service of Wutong Mountain *R. moulmainense* ecological landscape forest in Shenzhen has great ecological and economic value, especially in forestry products, biodiversity maintenance, and leisure and recreation.

Key words Wutong Mountain *Rhododendron moulmainense*; Ecological landscape forest; Ecosystem services; Value assessment

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Ecosystem services refer to the natural environmental conditions and utilities that are formed in ecosystems and ecological processes and sustain human survival. They can connect the structure, processes and functions of ecosystems and human well-being[1]. Ecosystem services have brought enormous benefits to humanity, but the value of many ecosystem services is difficult to directly reflect through the market and often overlooked, leading to serious damage to natural resources and the ecological environment. Therefore, evaluating the value of ecosystem services is a key link for connecting ecosystem research and management decision-making[2]. The Wutong Mountain *Rhododendron moulmainense* ecological landscape forest of Shenzhen City is an important forest resource in Wutong Mountain. Its ecological service functions are diverse, and it has quite important economic and ecological benefits. Assessing its ecosystem service value can provide a basis for protecting important forest resources and promoting the construction and sustainable use of ecological landscape forests.

General Situation of Study Area

Wutong Mountain Scenic Spot of Shenzhen Special Economic Zone (Wutong Mountain for short) is located in the south central part of Shenzhen, at 114°04′ – 114°06′ E, 22°17′ – 22°19′ N, with a total area of 31.82 km^2. It is a natural scenic spot with coastal mountains and natural vegetation as the main landscape. The main peak, Dawutong, 943.7 m above sea level, is the "first peak in Pengcheng"[3].

R. moulmainense is an evergreen shrub or small tree of the *Rhododendron* genus in the Ericaceae family. The plant is 3 – 12 m high, 5 – 30 cm in diameter at breast height, and its flowering period is from March to April. Its flowers are large and bright. *R. moulmainense* is a relatively rare species of alpine *Rhododendron*[4]. The Wutong Mountain *R. moulmainense* ecological landscape forest is the only alpine *Rhododendron* community with the southernmost natural distribution latitude and the lowest altitude in the world. It is a characteristic landscape of Wutong Mountain Scenic Spot in Shenzhen, with great ornamental and economic value[5]. The *R. moulmainense* ecological landscape forest has a small distribution area but is relatively concentrated. According to incomplete statistics, there are approximately 40 000 *R. moulmainense* plants with a plant height of over 2 m, distributed in the altitude range of 90 – 880 m. Among them, the enrichment area for the distribution of *R. moulmainense* is located in the altitude range of 400 – 700 m, especially at Xiaowutong and Wanhuaping, with nearly 5 000 and 500 plants respectively[6].

Study Methods

Based on the summary of previous studies on ecosystem service functions, combined with the actual situation of the Wutong Mountain *R. moulmainense* ecological landscape forest, according to the classification method of millennium eco-system assessment (MA)[7], the ecological service types of the *R. moulmainense* ecological landscape forest were divided into ecological products, ecological regulation, and ecological culture. The evaluation system and accounting method for the ecological service value of the *R. moulmainense* ecological landscape forest were constructed by combining functional quantity and value quantity (Table 1). The ecological service value of the *R. moulmainense* ecological landscape forest was the sum of various service types.

Results and Analysis

Value of forestry products

According to the survey by the Management Office of Wutong

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Mountain Scenic Spot, the Wutong Mountain *R. moulmainense* landscape forest has 1 *Rhododendron* king (height 10 m, ground diameter 0.6 m, crown width 7 m), about 500 mother trees, about 10 000 high-quality adult trees ($h > 4$ m), about 30 000 ordinary adult trees ($2 < h \leqslant 4$ m), and about 40 000 seedlings ($h \leqslant 2$ m), totaling about 80 501 trees.

Table 1 Evaluation system and accounting method for the ecological service value of *R. moulmainense* ecological landscape forest in Wutong Mountain

Service type	Service content	Service function	Evaluation method	Accounting method	Parameter description
Ecological products	Forest products	Providing natural products such as trees and seedlings	Market value method	$V_f = O \cdot P$	V_f is the value of forestry products (yuan); O is the yield of forestry products (per plant); and P is the price of forestry products (yuan/plant)
Ecoregulation	Conservation of water sources	Maintaining and conserving a large amount of water in forest land	Water balance method, alternative engineering method	$E_w = (R + I_w - E_r - O_w) \times P$	E_w is the total value of water source conservation (yuan); R is the total annual precipitation (m^3); I_w is the inbound water volume (m^3); E_r is the annual evaporation within the region (m^3), O_w is the outbound water volume (m^3); P is the investment price of the construction unit storage capacity (yuan/m^3)
	Water quality purification	Forest land purifies water quality by filtering through dead branches, fallen leaves, and organic matter	Alternative engineering method	$E_p = R \cdot S_g \cdot P_t \cdot 10$	E_p is the value of water quality purification in the ecosystem (yuan); R is the annual precipitation (mm); S_g is the vegetation coverage area (hm^2); and P_t is the cost of sewage treatment (yuan/m^3)
	Atmospheric purification	Producing negative ions	Price substitution method	$U_A = 5.256 \times 10^{15} \cdot AHK_AQ_A/L$	U_A is the value of negative ions produced by the ecosystem (yuan); A is the ecosystem area (hm^2); H is the vegetation height (m); K_A is the production cost of negative ions (yuan/ion); Q_A is the concentration of negative ions (number/cm^3); and L is the lifetime of negative ions (min).
		Absorbing pollutants such as SO_2 and NO_x	Price substitution method	$U_N = K_N \cdot Q_N \cdot A$	U_N is the value of SO_2 and NO_x absorption by the ecosystem (yuan/a); K_N is the cost of SO_2 and NO_x treatment (yuan/kg); Q_N is the amount of SO_2 and NO_x absorbed per unit area [kg/(hm^2 · a)]; and A is the area of the ecosystem (hm^2).
		Blocking dust	Price substitution method	$U_D = K_D \cdot Q_D \cdot A$	U_D is the annual value of dust retention (yuan/a); K_D is the cost of dust reduction and cleaning (yuan/kg); Q_D is the annual dust retention per unit area [kg/(hm^2 · a)]; and A is the area of the ecosystem (hm^2).
	Climate regulation	Regulating the climate of the region	Price substitution method	$E_v = G_a \cdot H_a \cdot \rho \cdot P_e$	E_v is the value of plant transpiration (yuan); G_a is the vegetation coverage area (km^2); H_a is the heat absorbed per unit green area (KJ/km^2); ρ is a constant, 1 KWh/3 600 KJ; and P_e is the electricity price (yuan/kWh).
	Carbon sequestration and oxygen production	Carbon sequestration	Price substitution method	$E_C = 1.62N_p \cdot A \cdot P_C$	E_C is the carbon sequestration value of the ecosystem (yuan/a); N_p is the net primary productivity of ecosystem [g/(m^2 · a)]; A is the area of ecosystem (km^2); and P_C is the carbon sequestration price (yuan/t).
		Oxygen production	Market value method	$E_O = 1.20N_p \cdot A \cdot P_O$	E_O is the oxygen production value of the ecosystem (yuan/a); N_p is the net primary productivity of ecosystem [g/(m^2/a)]; A is the area of ecosystem (km^2); and P_O is the price of industrial oxygen production (yuan/t).

(Continued)

(Table 1)

Service type	Service content	Service function	Evaluation method	Accounting method	Parameter description
	Soil conservation	The underground roots of forests are closely integrated with the soil, playing a role in soil consolidation; and they transport nutrients to surrounding land, thereby improving land productivity.	Shadow price method, alternative engineering method, reference analysis method	$E_f = \sum_i A_C \cdot C_i \cdot P_i$	E_f is the economic benefits of soil fertility protection (yuan/a); A_C is the soil conservation amount (t/a); C_i is the pure content of nitrogen, phosphorus and potassium in the soil; and P_i is the average price of chemical fertilizer (yuan/t).
	Noise reduction	Insulating and absorbing sound through trees	Replacement cost method	$E_n = S \times F \times C \times 15\%$	E_n is the noise reduction value of the ecosystem (yuan); S is the sum of forest land area and urban green space area (hm^2); F is the average afforestation cost (yuan/m^3); and C is stock volume per unit area of mature forest (m^3/hm^2).
	Biodiversity maintenance	Providing suitable venues for the survival and reproduction of various biological species	Opportunity cost approach	$E_b = S_i \times P_l \times 0.13$	E_b is the value of biodiversity maintenance (yuan); S_i is the vegetation coverage area (m^2); and P_l is the land value per unit area of construction land in the city where it is located (yuan/m^2).
Ecological culture	Leisure and recreation	Landscape has potential artistic and cultural values such as leisure, recreation, viewing, entertainment, and aesthetics.	Travel cost method	$E_t = P_t \times N_v$	E_t is the value of leisure and recreation (yuan); P_t is the highest cost that consumers are willing to pay (yuan/person); and N_v is the number of tourists (person).

According to the prices of relevant seedlings (*Rhododendron latoucheae*, *Rhododendron championiae*, *Rhododendron laponicum*, etc.) provided by authoritative seedling websites such as Chinese Garden Network, China Seedling Network, First Flowers and Trees Network, based on the fact that the mother trees, adult trees and most of *R. moulmainense* seedlings in Wutong Mountain are native trees, which are not artificially planted. It could be concluded that the unit price of the *Rhododendron* king is 10 million yuan/plant, the unit price of other mother trees is 1 million yuan/plant, the unit price of high-quality adult trees is 20 0000 yuan/plant, the unit price of ordinary adult trees is 10 0000 yuan/plant, and the unit price of seedlings is 50 000 yuan/plant. The output value of the forest products of the Wutong Mountain *R. moulmainense* landscape forest was calculated to be 7.51 billion yuan.

Water conservation value

According to the study of Tian[8], it could be inferred that the cost of a 1 m^3 reservoir project is 13.86 yuan. According to the 2021 *Shenzhen Statistical Yearbook*, the total area of Luohu District is 78.75 km^2, and the total area of the Wutong Mountain *R. moulmainense* forest is known to be about 227.4 hm^2. According to the 2020 *Shenzhen Water Resources Bulletin*[9], the total annual precipitation in Luohu District of Shenzhen is 120 million m^3, the annual inflow from overseas is 124 million m^3, the annual evaporation is 25 million m^3, and the annual outflow is 0 billion m^3. Therefore, the value of water source conservation was $227.4/7\,875 \times (1.20 + 1.24 - 0.25 - 0) \times 13.86 = 88$ million yuan.

Value of water-quality purification

According to the 2019 *Shenzhen Water Resources Bulletin*, the annual precipitation in Luohu District is 1 900.87 mm. The Wutong Mountain *R. moulmainense* forest is an evergreen broad-leaved forest with a total area of about 227.4 hm^2. According to *Charging Standards* for *Sewage Treatment*[10], the expense for sewage treatment in Shenzhen Special Economic Zone is 1.05 yuan/m^3. Therefore, the value of water quality purification was $1\,900.87 \times 227.4 \times 1.05 \times 10 = 4.538\,7$ million yuan.

Value of atmospheric purification

The value of negative ions produced, absorption of pollutants and interception of fugitive dust were mainly considered in the Wutong Mountain *R. moulmainense* forest.

The Wutong Mountain *R. moulmainense* forest is an evergreen broad-leaved forest with a total area of 227.4 hm^2 and a vegetation height of 3.42 m. According to the statistical data of Yantian Environmental Protection and Water Affairs Bureau in 2018, the average concentration of negative air ions in the forest land with evergreen broad-leaved trees as the main vegetation type is 2 666 ion/cm^3 (taking the average value of the annual mean value of the negative ion monitoring points in Enshang Village and Beidengdao), the cost of negative ions generated is 1.164×10^{-17} yuan per ion, and the life of negative ions is 8 min. Therefore, the value of produced negative ions was $5.256 \times 10^{15} \times 227.4 \times 3.42 \times 2\,666 \times 1.164 \times 10^{-17}/8 = 15\,856.05$ yuan.

Referring to *Economic Value of Urban Ecosystem Services: A Case Study in Shenzhe*[11], the annual absorption capacities per unit area of forest land and urban green space to SO_2 and NO_x are 88.65 and 380.00 kg/(hm^2 · a), respectively. The costs of industrial treatment for SO_2 and NO_x are 3 000 and 16 000 yuan/t, respectively. Therefore, the value of pollutant absorption (SO_2, NO_x) was calculated as $3\,000 \times 88.65 \times 227.4 + 16\,000 \times 380 \times$

227.4 = 1 443 100 yuan.

R. moulmainense trees have significant blocking, filtering and adsorption effects on dust. Referring to *Economic Value of Urban Ecosystem Services: A Case Study in Shenzhe*[11], the cost of industrial dust reduction is 170 yuan/t, and the annual amount of dust retention and reduction per unit area of forest land is 10.11 t/(hm^2 · a). Therefore, the value of dust retention was calculated as 170 × 10.11 × 227.4 = 390 832.38 yuan.

In summary, the value of atmospheric purification was 1.849 8 million yuan.

Climate regulation value

The cooling effect of forests can directly reduce the use of urban air conditioners, so the reduction in the electricity consumption of air conditioning can be used to measure the value of climate regulation. According to Gross ecosystem product: concept, accounting framework and case study[12], the heat absorption per unit area of green space is 8.11×10^4 KJ/(hm^2 · a). The electricity price refers to the average value of 0.87 yuan/KWh in the Shenzhen residents' daily electricity price list (2019). Hence, the value of climate regulation was $227.4 \times 8.11 \times 10^4 \times 1/3\ 600 \times 0.87 = 4\ 500$ yuan.

Value of carbon sequestration and oxygen production

The values of plant carbon sequestration and oxygen production equal to the products of the total amount of dry matter in the ecosystem and the prices of carbon sequestration and oxygen production, respectively. The net primary productivity (NPP) could be calculated as 947.25 g/(m^2 · a) by referring to *Vegetation carbon stocks and net primary productivity of the mangrove forests in Shenzhen, China*[13], and the prices for carbon sequestration and oxygen production are 1 200 and 1 000 yuan/t by referring to the *Specifications for assessment of forest ecosystem services*[14]. Therefore, the carbon sequestration value was 1.62 × 947.25 × 2.274 × 1 200 = 4 187 466.40 yuan, and the oxygen production value was 1.2 × 947.25 × 2.274 × 1 000 = 2 584 855.80 yuan, and the total value of carbon sequestration and oxygen production was 6.772 3 million yuan.

Soil conservation value

Firstly, the reference analysis method was used to calculate the soil conservation amount, which could be calculated using the difference between the potential soil erosion amount and the actual soil erosion amount. According to the *Soil Erosion in Shenzhen City Based on GIS and RUSLE Model*[15], the average erosion modulus values could be known within the slope range of 15° – 25° and of 25° – 35°, so the calculated soil conservation amount was 1 835.219 2 t/a.

Table 2 Soil conservation calculation table

Ecosystem type	Slope	Area//km^2	Average erosion modulus//t/(km^2 · a)		Soil conservation amount//t/a
			Actual	Potential	
Evergreen broad-leaf forest	15° – 25°	1.202	701.3	1 730.9	1 237.579 2
	25° – 35°	1.072	1 173.4	1 730.9	597.64

The main zonal soil of Wutong Mountain is lateritic red soil. The amount of soil nutrient retention was estimated based on the amount of soil retention and the contents of N, P and N in the soil. The contents of N and P in different soil types of Wutong Mountain could be inferred from the *Soil Carbon, Nitrogen and Phosphorus Contents and Fine Root Biomass under Different Vegetation Types and Building Densities in Shenzhen City*[16], and the content of K could be calculated from the *Vegetation Pattern and Protection of Landscape Diversity in Yantian District, Shenzhen City*[17]. In South China, urea is widely used as N fertilizer, superphosphate as P fertilizer, and potassium chloride as K fertilizer. According to data from the Guangdong Provincial Price Monitoring Center, the average selling prices of the three fertilizers are 2 320, 760, and 3 490 yuan/t, respectively. Therefore, the calculated value of soil conservation was 124 700 yuan.

Table 3 Calculation table for value of soil conservation

Content	Amount of soil conservation//t/a	Pure content mg/g	Chemical fertilizer price//yuan/t	Value//yuan
N	1 835.219 2	1.80	2 320	7 663.88
P		0.25	760	348.69
K		18.22	3 490	116 697.55

Noise reduction value

According to the tending, planting, maintenance and other afforestation projects invested in the Wutong Mountain *R. moulmainense* community from 2010 to 2020, the total afforestation cost was estimated to be 15.85 yuan/m^3. With reference to the *Economic Value of Urban Ecosystem Services: A Case Study in Shenzhen*, the volume of mature forest per unit area was calculated as 80 m^3/hm^2. After calculation, the value of noise reduction was 227.4 × 15.85 × 80 × 15% = 43 300 yuan.

Biodiversity maintenance value

According to the query of Shenzhen Land and Real Estate Trading Center, there were 2 cases of land transfer of park and green land types (Luohu District and Dapeng District) that had been transacted in Shenzhen between 2018 and 2020, so the value of construction land per unit area was 1 856.55 yuan/m^2. Therefore, biodiversity maintenance value was $1\ 856.55 \times 227.4 \times 10^4 \times 0.13 = 549$ million yuan.

Leisure and recreational value

The travel consumption method was used to calculate the ornamental and recreational value of an ecosystem, which refers to the highest cost that all consumers are willing to pay for the ornamental and recreational landscape, including the ticket cost of the landscape, transportation costs to and from the landscape, and other expenses during play.

According to the ticket fees collected by 10 well-known azalea festivals in China, such as Bijie Hundred-mile Azalea Festival of Guizhou Province, Tiantai Mountain Huading Azalea Festival, Nanchuan Mount Jinfo Mountain Azalea Festival of Chongqing

City, the average ticket fee was 117 yuan/person, which could be regarded as the highest ticket fee that consumers are willing to pay for Wutong Mountain *R. moulmainense* Festival. According to the survey questionnaire on willingness to pay for tourism landscape in Shenzhen and the ticket price statistics of similar scenic spots in Guangdong Province (Zhaoqing Xinghu, Foshan Xiqiao Mountain, Shaoguan Danxia Mountain, Guangzhou Baiyun Mountain, Huizhou West Lake, Huizhou Luofu Mountain, Zhanjiang Huguangyan), the transportation expenses to and from Wutong Mountain and other expenses during the tour were 49.45 yuan/person. Therefore, the maximum cost that each consumer is willing to pay was 166.45 yuan/person.

According to *Management Plan of Ecological Landscape Forest Management Model Base in Wutong Mountain Scenic Spot, Shenzhen* (2018 – 2028)[18], the number of tourists in 2016 was 8.083 6 million. Based on the analysis of the recent growth trend of tourist amount and the characteristics of the tourist market, the growth rate method was used to predict that the tourist volume in 2019 would reach 10.700 5 million. Due to the sharp increase in the number of tourists during the *R. moulmainense* Festival, which was twice the usual number, the number of tourists during the 2019 Flower Festival was approximately 1.646 2 million.

Therefore, the leisure and recreation value of Wutong Mountain *R. moulmainense* landscape forest was 274 million yuan.

Conclusions and Discussion

In this study, the evaluation method of ecosystem service value was applied to the evaluation of the Wutong Mountain *R. moulmainense* ecological landscape forest, Shenzhen, which is of great significance for the sustainable development of the ecological landscape forest. The evaluation results showed that the total ecosystem service value of the Wutong Mountain *R. moulmainense* landscape forest was 13.195 billion yuan. From the perspective of service types, the values of ecological product services, ecological regulation services and ecological cultural services were, respectively, 7.51, 5.411 and 0.274 billion yuan, accounting for 56.91%, 41.01%, and 2.08%, respectively. From the perspective of service content, the value of forestry products was highest at 7.51 billion yuan, followed by 549 million yuan in biodiversity maintenance, and the third value of leisure and recreation was 274 million yuan, accounting for 63.15%, showing that the ecosystem services of Wutong Mountain *R. moulmainense* ecological landscape forest in Shenzhen have great ecological and economic value, especially in forestry products, biodiversity maintenance, and leisure and recreation.

The value accounting of ecosystem services in this study only reflected the minimum value of natural capital, which is a preliminary scientific estimation. The research on various ecosystem service functions still needs to be improved, and the ecological service functions of some ecosystems (such as animals and microorganisms) cannot be quantitatively described. Meanwhile, the algorithm of homogenizing an ecosystem by multiplying the value of ecosystem services per unit area by the area ignores the spatial heterogeneity within the ecosystem. The deepening of research on spatial heterogeneity of ecosystem services requires determining the classification of various biological communities at different scales and the classification of various ecosystem services, so as to control errors at a reasonable level.

References

[1] YIN N, WANG S, LIU YX. Ecosystem service value assessment: Research progress and prospects[J]. Chinese Journal of Ecology, 2021, 40(1): 233 – 244. (in Chinese).
[2] YU YN, PENG SL. Review on evaluation of ecosystem services[J]. Ecology and Environment, 2010, 19(9): 2246 – 2252. (in Chinese).
[3] WANG DY. Investigation and planning of scenic forest in Wutong Mountain Scenic Spot[M]. Shenzhen: Publishing House of Shenzhen Press Group, 2011: 1. (in Chinese).
[4] WANG DY, SHI B, CHEN SQ, *et al.* Stand density index of scenic forest of *Rhododendron moulmainense* in Wutong Mountain, Shenzhen[J]. Subtropical Plant Science, 2019, 48(1): 31 – 35. (in Chinese).
[5] LIU YJ, CHEN SQ, YUAN Y, *et al.* Natural regeneration of *Rhododendron moulmainense* forest in Wutong Mountain of Shenzhen[J]. Subtropical Plant Science, 2015,44(1): 42 – 46. (in Chinese).
[6] SHI B, WANG DY, CHEN SQ, *et al.* Landscape quality evaluation of *Rhododendron moulmainense* Aesthetic Forest in Shenzhen Wutong Mountain[J]. Subtropical Plant Science, 2018, 47(4): 357 – 362. (in Chinese).
[7] HUANG RL. Study on the ecological product value assessment[J]. China Population, Resources and Environment, 2015, 25(3): 26 – 33. (in Chinese).
[8] TIAN GH. Investment control measures for various stages of reservoir engineering construction[J]. Henan Water Resources & South-to-North Water Diversion, 2019(2): 85 – 86. (in Chinese).
[9] Water Authority of Shenzhen Municipality. 2019 Shenzhen water resources bulletin[R]. 2020. (in Chinese).
[10] Water Authority of Shenzhen Municipality. Charging standards for sewage treatment[R]. 2021. (in Chinese).
[11] PENG J, WANG YL, CHEN YF, *et al.* Economic value of urban ecosystem services: A case study in Shenzhen[J]. Acta Scientiarum Naturalium Universitatis Pekinensis, 2005, 41(4): 594 – 604. (in Chinese).
[12] OUYANG ZY, ZHU CQ, YANG GB, *et al.* Gross ecosystem product: Concept, accounting framework and case study[J]. Acta Ecologica Sinica, 2013, 33(21): 6747 – 6761. (in Chinese).
[13] PENG CJ, QIAN JW, GUO XD, *et al.* Vegetation carbon stocks and net primary productivity of the mangrove forests in Shenzhen, China[J]. Chinese Journal of Applied Ecology, 2016, 27(7): 2059 – 2065. (in Chinese).
[14] LY/T 1721-2008, Specifications for assessment of forest ecosystem services[S]. (in Chinese).
[15] ZHANG YY, LI TH. Soil erosion in Shenzhen City based on GIS and RUSLE model[J]. Journal of Basic Science and Engineering, 2018, 26(6): 1189 – 1202. (in Chinese).
[16] MENG LH, ZENG H, XIONG YM, *et al.* Soil carbon, nitrogen and phosphorus contents and fine root biomass under different vegetation types and building densities in Shenzhen City[J]. Acta Scientiarum Naturalium Universitatis Pekinensis, 2013, 49(5): 899 – 907. (in Chinese).
[17] CAI WB, LI Z. Vegetation pattern and protection of landscape diversity in Yantian District, Shenzhen City[J]. Rural Eco-environment, 2002, 18(3): 16 – 20. (in Chinese).
[18] Management Office of Wutong Mountain Scenic Spot of Shenzhen Special Economic Zone. Management plan of ecological landscape forest management model base in Wutong Mountain Scenic Spot, Shenzhen (2018 – 2028)[R]. 2018. (in Chinese).

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