STUDY ON ECOLOGICAL DIVERSITY AND RESOURCE STRUCTURE OF A FOREST PARK IN CHINA UNDER THE INFLUENCE OF TOURISM

NIU, Z. C.

Department of Tourism and Commerce, Xuancheng Vocational and Technical College, Xuancheng, Anhui 242000, China
e-mail: niuzcn@hotmail.com

(Received 10th Jan 2024; accepted 26th Mar 2024)

Abstract. This paper aims to understand the influence of tourism on ecological diversity and resource structure of forest parks in order to provide guidance for the development and utilization of forest parks. Taking a forest park in China as an example, the degree of tourism impact was divided into three types, and sample plots were arranged. Plant and soil data were collected to analyze vegetation diversity, soil physicochemical properties, enzyme activities, and microbial diversity. In the highly impacted plots (HI), the importance values of dominant species increased, and its Margalef richness index and Shannon-Wiener diversity index values were significantly different from those of the moderately impacted plots (MI) and the lowly impacted plots (LI) ($p < 0.05$). In HI, the soil bulk density was 1.58 ± 0.15 g/cm^3, the moisture content was $6.87 \pm 0.56\%$, the pH value was 8.26 ± 0.15, the electrical conductivity was 93.29 ± 6.12 μs/cm^2, and the content of organic matter was 12.77 ± 0.78 g/kg. The various enzyme activities were lower in HI, which were significantly different from MI and LI. The bacterial, fungal, and actinomycete communities of HI were less similar to those of LI. Under the influence of tourism, the vegetation diversity of the forest park decreased, soil properties changed, and microbial diversity decreased, which was not conducive to ecological stability. Therefore, it is necessary to reduce the intensity of tourism and protect the environment in the park.
Keywords: *Shannon-Wiener diversity index, dominant species, soil physicochemical property, soil enzymatic activity, microbial diversity*

Introduction

With the increasing popularity of forest tourism, forest park has become the choice of more and more tourists. Forest park serves not only as a prominent sightseeing spot but also plays a significant role in conserving natural resources and fostering economic growth (Muntifering et al., 2018). However, there is a strong vulnerability of tourism resources (Jiang, 2018). As the number of tourists continues to grow and tourism construction continues to expand, the negative impact of tourism activities on forest parks is becoming more and more obvious. Unreasonable development and construction and overloading due to tourism lead to changes in the ecological diversity and resource structure of forest parks (Zhang and Pu, 2020), causing vegetation damage and soil pollution. In order to coordinate the relationship between tourism activities and ecological protection, it is necessary to understand the impact of tourism on forest parks. At present, the influence of various tourism activities on ecological environment has been widely concerned by researchers. Luo et al. (2018) explored the effects of various tourism disturbances on habitat quality and population size of giant salamanders and found that high levels of tourism disturbances (more than 100,000 tourists per year) would cause an increase in noise and aquatic microorganisms, which would affect the survival of giant salamanders. Gundersen et al. (2019) investigated 66 wild reindeer and visitor data from three Norwegian national parks and found that wild reindeer migrate to areas that are less susceptible to human disturbance. Jiao et al. (2018) analyzed water samples from 12

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

freshwater lakes around Nanjing, China, and found that tourism activities would change the physicochemical properties of water bodies and the community structure of planktonic bacteria. Fantinato (2019) analyzed the impact of tourism on the pollination network in the coastal dune ecosystem and found that moderate human disturbance was positively correlated with the richness of animal pollinated plants and pollinated species, but strong human disturbance would damage the structure and function of the ecosystem. This paper took a forest park in China as an example to analyze its ecological diversity and resource structure under the influence of tourism, aiming to provide references for the subsequent development and management of the park, as well as theoretical support for its protection and utilization.

Materials and methods

Overview of the study site

The study site is situated on the boundary between Hunan and Jiangxi provinces, which is an AAAA level national forest park covering an area of over 46.7 square kilometers and containing rich animal and plant resources. The plants include 23 groups, including protected plants such as *Taxus chinensis*, and more than 60 species of wild animals, including protected animals such as *Neofelis nebulosa* and *Manis pentadactyla*. Among them, the forest landscapes such as alpine rhododendron and Huangshan Songtao have great ornamental value.

This park is mainly visited during the spring and autumn seasons, attracting a large number of tourists. During the May Day holiday in 2023, the number of tourists reached 75,000, and the total number of visitors received 1.08 million throughout the year. The Rhododendron Festival and camping activities are popular among tourists. During the blooming season of rhododendrons, the influx of a large number of tourists has had a certain impact on the ecological diversity and resource structure of the park. An investigation has revealed that there is significant trampling and picking damage near the hiking trail, causing considerable harm to the surrounding shrubs and herbs. In addition, the situation of littering is also serious. Due to the large area of the flower sea, it is difficult to clean up, and the residual garbage has also caused a certain impact on the soil.

Sample selection

The ornamental activities of rhododendron sea were mainly carried out along the walking trails (*Fig. 1*), and the closer the distance to the walking trails, the more affected by the ornamental behavior. However, beyond a distance of 30 meters from the hiking trail, there are no traces of human activity, indicating that it remains unaffected by human presence. Therefore, the degree of tourism impact was divided into three types.

(1) High impact (HI): 0-10 m distance from the walking trail, with obvious trampling and picking phenomena.

(2) Moderate influence (MI): 10-20 m away from the trail, with slight trampling and picking phenomena.

(3) Low impact (LI): 20-30 m away from the trail, almost without trampling or picking phenomena.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

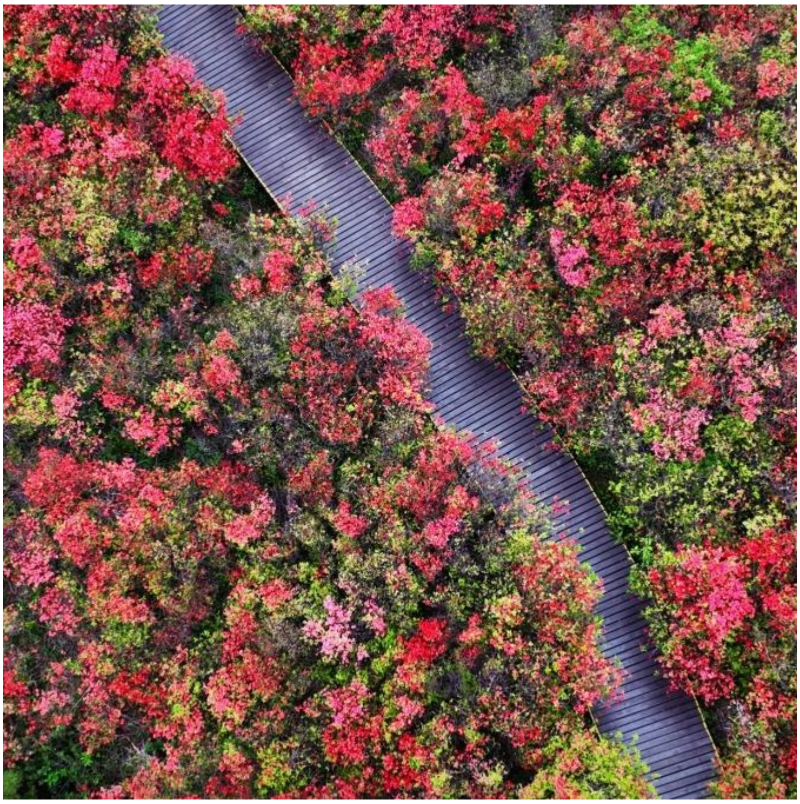

Figure 1. *Rhododendron sea and walking trail*

The sampling area is shown in *Fig. 2*. Three 10×10 m plots were arranged in each impacted area, and three 3×3 m shrub quadrats and three 1×1 herb quadrats were set in each sample plot. The data of shrub and herb species, height, coverage, and frequency in the quadrats in October 2022 and May 2023 were recorded.

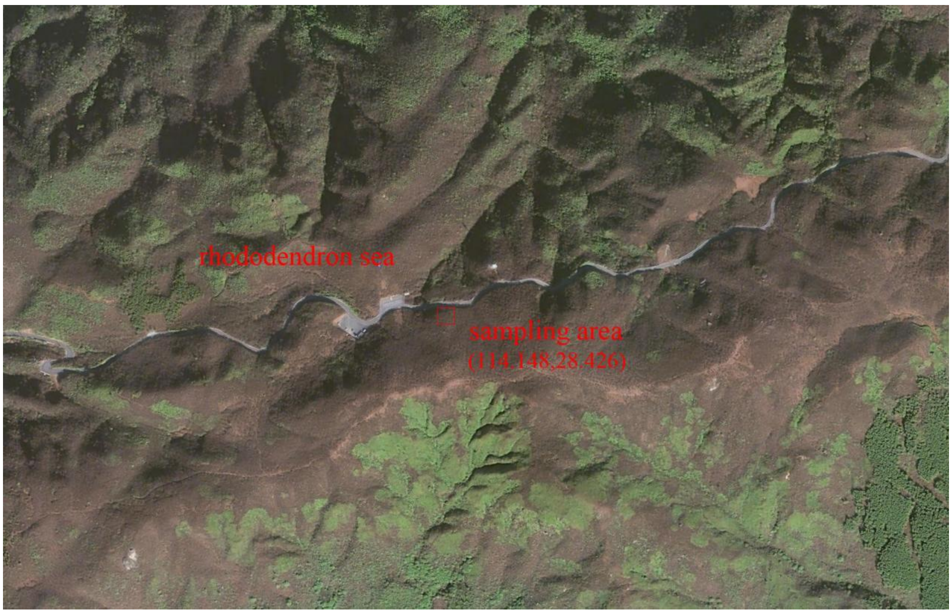

Figure 2. *The sampling area*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

Determination of ecological diversity and resource structure

The determination of ecological diversity and resource structure in the sample plot was mainly considered from aspects of vegetation and soil. Firstly, according to the current study (Sina and Zulkarnaen, 2019), the determination of vegetation in the sample plot is shown in *Table 1*.

Table 1. *Determination of vegetation conditions*

Measure	Calculation formula
Importance value	Importance value = (relative abundance + relative coverage + relative frequency)/3 Relative abundance = (abundance of a species/sum of abundance of all species) × 100 Relative coverage = (coverage of a species/sum of cover of all species) × 100 Relative frequency = (frequency of a species/sum of all species) × 100
Margalef richness index	$R = \frac{(S-1)}{\ln N}$ (Eq.1) S: the number of species N: The number of individuals of all species
Simpson dominance index	$D = 1 - \sum \frac{N_i(N_i-1)}{N(N-1)}$ (Eq.2) N_i: the number of individuals in species i N: the sum of the number of individuals of all species in the community
Shannon-Wiener diversity index	$H' = -\sum p_i \ln p_i$ (Eq.3) $p_i = \frac{N_i}{N}$ (Eq.4)
Pielou evenness index	$J = \frac{H'}{maxH'}$ (Eq.5) $maxH' = \log S$ (Eq.6) S: the total number of species in the community

To determine the soil condition in the sample plot, the first step is to collect soil samples. After the completion of plant statistics within the sample plot, soil sampling was conducted immediately. The five-point sampling method was used. A soil drill with a diameter of 5 cm was used to take the soil at the depth of 0-10 cm. After 500 g was taken by the quartering method, it was screened. Part of the soil was stored in the environment of -80 °C for the determination of microorganisms, and the remaining part was air-dried and passed through the 60 mesh screen for the determination shown in *Table 2*.

Soil microbial diversity was determined following *Table 3*.

Data processing and analysis

All data were recorded and organized in Excel 2016 software, followed by processing and analysis using SPSS 18.0 software. Significant differences in various indicators were tested to compare the changes in plant and soil conditions across different levels of tourism impact. The significance level was set at 0.05.

APPLIED ECOLOGY AND ENVIRONMENTAL RESEARCH 22(3):2389-2400.
http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

Table 2. *Soil physicochemical properties and enzyme activity determination*

Content of determination	Determination method	
Bulk density	Cutting-ring method	100 cubic ring cutter (Cangzhou China Net)
Moisture content	pH meter	HS-3B pH acidity meter (Shanghai Lida)
pH	Drying method	HS-3B pH acidity meter (Shanghai Lida)
Electrical conductivity	Soil multi-parameter tester	LD-TY (Shandong Leaneed Intelligent Technology)
Rapidly available potassium	Flame photometry (Kamble et al., 2021)	WGH6400 flame photometer (Shanghai Changxi)
Alkali-hydrolyzale nitrogen	Alkaline hydrolysis diffusion (Li et al., 2019)	
Organic matter	Potassium dichromate volumetric method (Contó and Camarini, 2022)	ESJ180-4 electronic balance (Shenyang Longteng)
Urease	Nesslerization method (Shahreyar et al., 2021)	Eppendorf micropipettor (Germany)
Sucrase	3, 5-dinitrosalicylic acid colorimetric method (Chen et al., 2021)	T6 ultraviolet and visible spectrophotometer (Shanghai Run-qee)
Phosphatase	Disodium phenyl phosphate hydrate colorimetric method (Zheng et al., 2020)	J-HH-2A precision thermostatic water bath pan (Shanghai Guansen) Medical reefer (Shandong Kebo)

Table 3. *Determination of soil microbial diversity1*

Content of determination	Determination method
Bacterial 16S rDNA amplification (Kowsalya et al., 2021)	Universal primers 63F and 1387R were used for amplification.
Fungal 18S rDNA amplification (Wylezich et al., 2018)	Primers 1TS1 and 1TS4 were used to amplify fungal 1TS sequence.
Aetinomycelial 16S rDNA amplification (Zanane et al., 2018)	Universal primers ACF and ACR were used to amplify the sequences of actinomycete.

Results and analysis

Analysis of the influence of tourism on vegetation

The importance values of shrubs and herbs in different plots are presented in *Table 4*.

The species ranked in the top five based on their importance values within the sample plot were classified into dominant species, and the remaining species were non-dominant species. The classification results are shown in *Table 5*.

From *Table 4* and *Table 5*, it can be found that the dominant species of shrubs in the forest park were *Rhododendron simsii* Planch., *Eucommia ulmoides* Oliver, etc., and with the increase of the degree of tourism impact, the importance values of these dominant species also increased to a certain extent. This may be because these species are protected and managed rigorously in the forest park, resulting in less interference from tourism. For example, *Eurya muricata* Dunn and *Coriaria nepalensis* Wall. have disappeared in the HI area, which may be because of tourists' trampling and picking, or because of the uneven distribution of species.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

Table 4. *Species importance value analysis*

Species	Plot		
	HI	MI	LI
Shrubs			
Rhododendron simsii Planch.	0.306	0.247	0.249
Eucommia ulmoides Oliver	0.141	0.134	0.111
Euphorbia humifusa Willd. ex Schlecht.	0.071	0.053	0.051
Rubus idaeus L.	0.045	0.043	0.036
Eurya muricata Dunn	-	0.041	0.037
Coriaria nepalensis Wall.	-	0.031	0.022
Symplocos hunanensis Hand.-Mazz.	0.091	0.081	0.073
Ilex szechwanensis Loes.	0.071	0.058	0.046
Sorbus folgneri (C. K. Schneid.) Rehd*er*	0.016	0.015	0.014
Rosa multiflora Thunb	0.065	0.071	0.055
Hydrangea chinensis Maxim.	0.016	0.016	0.015
Herbs			
Miscanthus sinensis Anderss.	0.068	0.048	0.055
Mentha haplocalyx Briq.	-	0.041	0.035
Hosta ventricosa (Salisb.) Stearn	0.031	0.042	0.026
Polygonum chinense L.	0.043	0.025	0.026
Parathelypteris glanduligera	-	0.035	0.021
Selaginella uncinata	0.071	0.061	0.055
Oxalis corniculata L.	-	0.046	0.045
Paederia foetida	0.048	0.045	0.037
Pimpinella diversifolia DC.	-	0.056	0.036
Carex cruciata Wahlenb.	0.125	0.088	0.075
Sinosenecio jiuhuashanicus	0.068	0.058	0.061
Borreria latifolia (Aubl.) K. Schum.	0.068	0.039	0.039

The dominant species of herbs in the forest park were *Carex cruciata* Wahlenb., *Selaginella uncinata*, and *Sinosenecio jiuhuashanicus*. With the increase of tourism impact degree, the importance values of these dominant species also increased to a certain extent, while *Mentha haplocalyx* Briq., *Parathelypteris glanduligera*, *Oxalis corniculate* L., and *Pimpinella diversifolia* DC. disappeared in the HI area. The increase of the importance values of dominant species may be related to the death of plants due to trampling and the decrease of species number.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

Table 5. *Division of dominant species and non-dominant species*

	Plot		
	HI	MI	LI
Dominant species of shrubs	*Rhododendron simsii* Planch. *Eucommia ulmoides* Oliver *Symplocos hunanensis* Hand.-Mazz. *Euphorbia humifusa* Willd. ex Schlecht. *Ilex szechwanensis* Loes.	*Rhododendron simsii* Planch. *Eucommia ulmoides* Oliver *Symplocos hunanensis* Hand.-Mazz. *Rosa multiflora* Thunb *Ilex szechwanensis* Loes.	*Rhododendron simsii* Planch. *Eucommia ulmoides* Oliver *Symplocos hunanensis* Hand.-Mazz. *Rosa multiflora* Thunb *Euphorbia humifusa* Willd. ex Schlecht.
Non-dominant species of shrubs	*Rosa multiflora* Thunb *Rubus idaeus* L. *Sorbus folgneri* (C. K. Schneid.) Rehder *Hydrangea chinensis* Maxim. *Eurya muricata* Dunn *Coriaria nepalensis* Wall.	*Euphorbia humifusa* Willd. ex Schlecht. *Rubus idaeus* L. *Eurya muricata* Dunn *Coriaria nepalensis* Wall. *Hydrangea chinensis* Maxim. *Sorbus folgneri* (C. K. Schneid.) Rehder	*Ilex szechwanensis* Loes. *Eurya muricata* Dunn *Rubus idaeus* L. *Coriaria nepalensis* Wall. *Hydrangea chinensis* Maxim. *Sorbus folgneri* (C. K. Schneid.) Rehder
Dominant species of herbs	*Carex cruciata* Wahlenb. *Selaginella uncinata* *Miscanthus sinensis* Anderss. *Sinosenecio jiuhuashanicus* *Borreria latifolia* (Aubl.) K. Schum.	*Carex cruciata* Wahlenb. *Selaginella uncinata* *Sinosenecio jiuhuashanicus* *Pimpinella diversifolia* DC. *Miscanthus sinensis* Anderss.	*Carex cruciata* Wahlenb. *Sinosenecio jiuhuashanicus* *Selaginella uncinata* *Miscanthus sinensis* Anderss. *Oxalis corniculata* L.
Non-dominant species of herbs	*Pimpinella diversifolia* DC. *Polygonum chinense* L. *Hosta ventricosa* (Salisb.) Stearn *Parathelypteris glanduligera* *Oxalis corniculata* L. *Pimpinella diversifolia* DC.	*Oxalis corniculata* L. *Pimpinella diversifolia* DC. *Hosta ventricosa* (Salisb.) Stearn *Mentha haplocalyx* Briq. *Borreria latifolia* (Aubl.) K. Schum. *Parathelypteris glanduligera* *Polygonum chinense* L.	*Borreria latifolia* (Aubl.) K. Schum. *Paederia foetida* *Pimpinella diversifolia* DC. *Mentha haplocalyx* Briq. *Hosta ventricosa* (Salisb.) Stearn *Polygonum chinense* L. *Parathelypteris glanduligera*

The diversity of vegetation in different plots is presented in *Table 6*.

According to *Table 6*, the vegetation diversity of both shrubs and herbs showed the characteristic of HI < MI < LI, but there was no remarkable difference between the simpson dominance index and Pielou evenness index values in the plots with different tourism impact degrees, while there was a remarkable difference between the Margalef richness and Shannon-Wiener diversity index values. Specifically, in shrubs, the Margalef richness index value of HI was 2.07 ± 0.09, which was significantly lower than that of MI and LI ($p < 0.05$), and there was also a remarkable difference between MI and LI. The Shannon-Wiener diversity index value of HI was 2.11 ± 0.15, which was significantly lower than that of MI and LI ($p < 0.05$), and there was also a remarkable difference between MI and LI. These findings suggested that the higher the degree of tourism impact, the lower the diversity of shrubs.

As to the herbs, the Margalef richness index value of HI (2.03 ± 0.11) exhibited a statistically significant decrease compared to both MI and LI ($p < 0.05$), and the Shannon-

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

Wiener diversity index value of HI (2.07 ± 0.11) was also significantly lower than that of MI and LI ($p < 0.05$). These results indicated that the higher the degree of tourism impact, the lower the diversity of herbs.

Table 6. *Analysis of vegetation diversity*

Plot	*R*	*D*	*H′*	*J*
		Shrub		
HI	2.07 ± 0.09c	0.86 ± 0.05a	2.11 ± 0.15c	0.82 ± 0.31a
MI	2.26 ± 0.13b	0.87 ± 0.14a	2.31 ± 0.11b	0.85 ± 0.21a
LI	2.64 ± 0.08a	0.88 ± 0.18a	2.49 ± 0.41a	0.85 ± 0.15a
		Herb		
HI	2.03 ± 0.11*#	0.85 ± 0.22	2.07 ± 0.11b	0.89 ± 0.08a
MI	2.45 ± 0.15	0.86 ± 0.16	2.44 ± 0.14a	0.91 ± 0.08a
LI	2.52 ± 0.16	0.87 ± 0.11	2.51 ± 0.17a	0.92 ± 0.08a

Note: 2R: Margalef richness index; D: Simpson dominance index; H': Shannon-Wiener diversity index, J: Pielou evenness index; a, b, c: same letters indicate no significant difference between data, while different letters indicate a significant difference ($p < 0.05$)

Analysis of the impact of tourism on soil

The findings pertaining to the physicochemical characteristics of soil and enzyme activities across various plots can be observed in *Table 7*.

Table 7. *Soil physicochemical properties and enzyme activities3*

	HI	MI	LI
Bulk density/(g/cm^3)	1.58 ± 0.15c	1.26 ± 0.05b	1.31 ± 0.04a
Moisture content/%	6.87 ± 0.56b	20.26 ± 0.45a	21.33 ± 0.33a
pH value	8.26 ± 0.15c	8.02 ± 0.16b	7.67 ± 0.33a
Electrical conductivity (μs/cm^2)	93.29 ± 6.12c	85.77 ± 7.76b	77.21 ± 6.57a
Rapidly available potassium/(mg/g)	0.03 ± 0.00a	0.04 ± 0.00a	0.05 ± 0.00a
Alkali-hydrolyzale nitrogen/(mg/g)	34.56 ± 5.12a	33.64 ± 2.64a	32.76 ± 3.27a
Organic matter (g/kg)	12.77 ± 0.78b	14.64 ± 0.11a	15.07 ± 0.68a
Urease (mg·g^{-1}·d^{-1})	0.12 ± 0.08c	0.35 ± 0.12b	0.52 ± 0.13a
Sucrase (mg·g^{-1}·d^{-1})	85.67 ± 21.26c	113.64 ± 29.88b	141.17 ± 36.87a
Phosphatase (mg·g^{-1}·d^{-1})	131.64 ± 21.26c	191.45 ± 31.77b	230.72 ± 36.72a

According to *Table 7*, firstly, in different plots, except for rapidly available potassium and alkali-hydrolyzale nitrogen, other physicochemical and enzyme activities of the soil were different to varying degrees. The bulk density of HI (1.58 ± 0.15 g/cm^3) was higher than that of MI and LI ($p < 0.05$), while the bulk density of MI was lower than that of LI ($p < 0.05$). The moisture content of HI (6.87 ± 0.56%) was significantly lower than that of MI and LI, and the pH value of HI (8.26 ± 0.15) was significantly higher than that of MI and LI. There was also a significant difference in moisture content and PH value between MI and LI. The electrical conductivity of HI (93.29 ± 6.12 μs/cm^2) was

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

significantly higher than that of MI and LI ($p < 0.05$), and MI was also significantly higher than that of LI ($p < 0.05$). The organic matter content of HI (12.77 ± 0.78 g/kg) was significantly lower than that of MI and LI ($p < 0.05$). In addition, the enzyme activity results consistently demonstrated the characteristic of HI < MI < LI. The enzyme activities of HI were significantly lower than those of MI and LI ($p < 0.05$), and the enzyme activities of MI were also lower than those of LI ($p < 0.05$). These findings indicated that under the influence of tourism, the bulk density of soil increased, the moisture content decreased, the pH value and electrical conductivity increased, the organic matter decreased, and the enzyme activity decreased.

Table 8 presents the diversity of soil microorganisms in different plots.

Table 8. *Soil microbial diversity*

Similarity coefficient of the community structure of bacteria			
	HI	MI	LI
HI	1.000		
MI	0.775	1.000	
LI	0.632	0.636	1.000
Similarity coefficient of the community structure of fungi			
	HI	MI	LI
HI	1.000		
MI	0.432	1.000	
LI	0.381	0.487	1.000
Similarity coefficient of the community structure of actinomycetes			
	HI	MI	LI
HI	1.000		
MI	0.691	1.000	
LI	0.562	0.677	1.000

Table 8 showed that the similarity of bacterial communities between HI and MI plots was 0.775, the similarity between HI and MI was 0.632, and the similarity between MI and LI was 0.636, indicating that there were certain differences in bacterial community structures in plots under different tourism impacts. Similarly, in terms of the fungal community and actinomycete community, there were also certain differences in the samples under different tourism impacts. In general, HI and LI had the lowest similarity in the microbial community, indicating that the microbial structure of these two places was greatly different. Under the influence of tourism, the microbial community structure changed, and the overall stability of the community decreased, leading to the difference in similarity.

Discussion

The impact of tourism on the ecological diversity and resource structure in forest parks is almost inevitable, and the difference is only the degree of impact. In addition to the construction of tourism development itself, in the process of tourists playing, the behavior of trampling will cause soil compaction, change its physicochemical properties, affect the survival and growth of plants, and leave more hardy plants (Ren et al., 2021). Picking behavior can disrupt the organizational structure of plants, and excessive picking may

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

result in plant death. Additionally, indiscriminate waste disposal can cause air and soil pollution (Curcic et al., 2019), impacting soil biological activity (Dupont et al., 2019) as well as plant growth. Under the influence of too heavy tourism activities, the ecological diversity and resource structure in the forest park will be disturbed and changed, which is not conducive to the long-term development of the forest park. Therefore, it is necessary to study the degree of tourism impact.

Based on the analysis of the plant and soil conditions of the plots under different tourism impacts, it was found that, first of all, the diversity of plants decreased under the influence of tourism. In the HI plots, the importance value of dominant species increased with the decrease of the number of species, and the indicators of diversity decreased. The R and H′ values of HI showed obvious differences with those of MI and LI. As the level of tourism impact increases, there is a corresponding decrease in the diversity of vegetation. The influence of tourism on vegetation diversity may be due to the fact that tourists' trampling, picking, and other behaviors affect the root development of plants and the survival of seeds. Some species with weak vitality are not resistant to trampling and disappear due to the interference of tourists' activities. In addition, tourist activities will also affect the ability of plant resistance to pests and diseases and physiological metabolism, which is not beneficial to the healthy growth of plants. Consequently, this results in a decline in both the diversity of plant species and the overall biodiversity within plant communities.

Under the influence of tourism, the physicochemical properties, enzyme activities, and microbial diversity of the soil also showed certain changes. The results showed that in the HI plots, the bulk density of the soil increased, the moisture content decreased, the pH value increased, the electrical conductivity decreased, the organic matter decreased, and the enzyme activities decreased, showing significant differences compared with MI and LI ($p < 0.05$). These changes may be attributed to the trampling and littering by tourists, resulting in alterations in soil structure, impaired permeability, reduced fertility, and diminished intensity of carbon and nitrogen cycling. These factors are detrimental to the healthy growth of plants. According to the analysis of microbial diversity, the structure of microbial community changed, and the diversity decreased under the influence of tourism. Microbial community is a very important part of the ecological environment. The decline in community similarity indicates a decrease in community resistance and poor community stability, which affects the physical environment of soil.

Compared with other types of nature reserves, forest parks focus on showcasing forest vegetation as the main attraction. Consequently, the negative impacts of tourism activities on ecological diversity and resource structure become more prominent. Particularly during the annual rhododendron festival held in the research area, a large influx of visitors within a short period burdens local tourism facilities significantly. The behavior of tourists trampling and damaging plants becomes harder to control, resulting in a decline in plant diversity as well as changes in soil physicochemical properties, enzyme activity, and microbial diversity.

In general, under the influence of tourism, the ecological diversity and resource structure of the forest park have been degraded to varying degrees. Certain measures should be taken to control the number of tourists (Feng et al., 2019) and restore the ecological environment. Meanwhile, the park should also impose more regulations on visitor behavior, intensify supervision over tourists, strictly delineate the scope of sightseeing, and enhance the protection of existing species. Additionally, it should

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

introduce new species through artificial planting methods to realize its continuous development.

Conclusion

This study examined the changes of ecological diversity and resource structure under different tourism impacts within a forest park in China. Through the analysis of different plots, it was found that in the HI, the importance value of dominant species of the shrubs and herbs increased, the vegetation diversity decreased, the soil bulk density increased, the moisture content decreased, the organic matter decreased, and the enzyme activity decreased. Microbial diversity was also degraded, which proved that tourism activities had a negative impact on ecological diversity and resource structure. Therefore, tourism activities should be controlled to restore the ecological environment in the forest park.

REFERENCES

[1] Chen, J., Farajtabar, A., Jouyban, A., Acree, W. E., Zhu, P., Zhao, H. (2021): Solubility Measurement, Preferential Solvation, and Solvent Effect of 3,5-Dinitrosalicylic Acid in Several Binary Aqueous Blends. – Journal of Chemical and Engineering Data: the ACS Journal for Data 66(9): 3531-3542.

[2] Contó, M. B., Camarini, R. (2022): Spectrophotometric assay for the quantification of plasma ethanol levels in mice through chromium-ethanol oxidation-reduction reaction. – Advances in Bioscience and Biotechnology 13(4): 175-187.

[3] Curcic, N., Milinčić, U., Stranjančević, A., Milinčić, M. A. (2019): Can winter tourism be truly sustainable in natural protected areas? – Journal of the Geographical Institute Jovan Cvijic SASA 69(3): 241-252.

[4] Dupont, L., Pauwels, M., Dume, C., Deschins, V., Audusseau, H., Gigon, A., Dubs, F., Vandenbulcke, F. (2019): Genetic variation of the epigeic earthworm [Lumbricus castaneus] populations in urban soils of the Paris region (France) revealed using eight newly developed microsatellite markers. – Applied Soil Ecology 135: 33-37.

[5] Fantinato, E. (2019): The impact of (mass) tourism on coastal dune pollination networks. – Biological Conservation 236: 70-78.

[6] Feng, L., Gan, M., Tian, F. P. (2019): Effects of grassland tourism on alpine meadow community and soil properties in the Qinghai-Tibetan Plateau. – Polish Journal of Environmental Studies 28(6): 4147-4152.

[7] Gundersen, V., Vistad, I., Panzacchi, M., Strand, O., Moorter, B. V. (2019): Tourism Management Large-scale segregation of tourists and wild reindeer in three Norwegian national parks: Management implications. – Tourism Management 75: 22-33.

[8] Jiang, P. (2018): Dynamic influence of the regional tourism overexploitation impact on ecological resources and environment. – International Journal for Engineering Modelling 31(1): 125-132.

[9] Jiao, C. C., Zhao, D., Huang, R., Cao, X. Y., Zeng, J., Lin, Y., Zhao, W. (2018): Abundant and rare bacterioplankton in freshwater lakes subjected to different levels of tourism disturbances. – Water 10(8): 1-16.

[10] Kamble, D., Chavan, P., Jondhale, V. (2021): Study of PotaBium and sodium content of mahad-raigad tertiary soil by flame photometry. – Asian Journal of Research in Chemistry 14(6): 417-420.

[11] Kowsalya, R., Sujatha, K., Karthikeyansekar, Nagaraj, D., Rajesh, S. (2021): Physico-chemical and bacterial analysis of textile effluents from kanchipuram, tamilnadu. – Pollution Research 40(2): 590-592.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400

[12] Li, J., Yin, X., Liu, Z., Gu, Z., Niu, J. (2019): Reaction yield model of nitrocellulose alkaline hydrolysis. – Journal of Hazardous Materials 371: 603-608.
[13] Luo, Q. H., Song, Y. J., Hu, X., Zhu, S. H., Wang, H., Ji, H. (2018): Effects of tourism disturbance on habitat quality and population size of the Chinese giant salamander (*Andrias davidianus*). – Wildlife Research 45(5): 411-420.
[14] Muntifering, J. R., Linklater, W. L., Naidoo, R., Uri-Khob, S., Preez, P. D., Beytell, P., Jacobs, S. M., Knight, A. (2018): Sustainable close encounters: integrating tourist and animal behaviour to improve rhinoceros viewing protocols. – Animal Conservation 22(2): 189-197.
[15] Ren, H., Wang, F., Ye, W., Zhang, Q., Han, T., Huang, Y., Chu, G., Hui, D., Guo, Q. (2021): Bryophyte diversity is related to vascular plant diversity and microhabitat under disturbance in karst caves. – Ecological Indicators 120: 106947.
[16] Shahreyar, S., Islam, S., Hossain, D., Mozumder, S. I. (2021): Influence of minerals on control measurement of ammonium, nitrite, nitrate, and phosphate using UV-spectrophotometer. – Malaysian Journal of Analytical Sciences 25(2): 311-323.
[17] Sina, I., Zulkarnaen, I. (2019): Margalef index, Simpson index and Shannon-Weaiver index calculation for diversity and abundance of beetle in tropical forest. – Statmat Jurnal Statistika Dan Matematika 1(2): 83-93.
[18] Wylezich, C., Herlemann, D., Jürgens, K. (2018): Improved 18S rDNA amplification protocol for assessing protist diversity in oxygen-deficient marine systems. – Aquatic Microbial Ecology 81(1): 83-94.
[19] Zanane, C., Zahir, H., Latrache, H., Duponnois, R., Ferhout, H., Kaoutar, E., Ellouali, M. (2018): Screening of actinomycetes isolated from the soils of the Beni Amir region of Morocco by the 16S sequencing of the rDNA gene. – International Journal of Scientific and Engineering Research 9(5): 2363-2368.
[20] Zhang, R., Pu, L. (2020): Influence of tourism development on the eco-environment of scenic spots and countermeasures for tourism development management. – Journal of Environmental Protection and Ecology 21(6): 2323-2332.
[21] Zheng, S., Gu, H., Yin, D., Zhang, J., Li, W., Fu, Y. (2020): Biogenic synthesis of AuPd nanocluster as a peroxidase mimic and its application for colorimetric assay of acid phosphatase. – Colloids and Surfaces A Physicochemical and Engineering Aspects 589: 1-9.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2203_23892400